# CONTROL OF CUTGRASS (*LEERSIA HEXANDRA* SWARTZ PROD) IN DIRECT-SEEDED LOWLAND RICE (*ORYZA SATIVA* L) IN THE SOUTHERN GUINEA SAVANNA OF NIGERIA


**BY**

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**A thesis submitted to the Postgraduate School**
**Ahmadu Bello University**
**in partial fulfilment of the requirement for**
**the Degree of**
**Doctor of Philosophy in Agronomy**


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**DECEMBER,1989**

# D E C L A R A T I O N

I hereby declare that this thesis has been written by me and that it is a record of my own research work. It has not been presented before in any previous application for a higher degree.

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# C E R T I F I C A T I O N

This thesis entitled CONTROL OF CUTGRASS LEERSIA HEXANDRA SWARTZ PROD IN DIRECT-SEEDED LOWLAND RICE NIGERIA by Peter Ose Imeokparia meets the regulations governing the degree of Doctor of Philosophy of Ahmadu Bello University Zaria, and is approved for its contribution to scientific knowledge and literary presentation.

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# D E D I Ç A T I O N

This thesis is dedicated to my Brother,
Mr. J.E. Imeokparia whose foresight, sacrifice and support has brought me to this academic status.

ACKNOWLEDGEMENT

The author is most grateful to Dr. S.T.O. Lagoke of the Department of Agronomy Ahmadu Bello University Zaria for the guidance and helpful suggestions throughout the course of this study and in the preparation and review of this manuscript.

Appreciation is also extended to Dr. T.D. Sinha and Dr. O.P. Kataria both formerly of the Department of Agronomy A.B.U. Zaria for their initial suggestions and encouragement. Sincere thanks go to Dr. B.A. Olunuga now of Ogun State Agricultural Development Project for the guidance in the conduct of the trials and the data collection. The author is indebted to Dr. O.E. Asiribo and Mr. M. Otitoju, both of Data Processing Unit, Institute of Agricultural Research, A.B.U. Zaria for the analyses of the data.

I am also thankful to the Director of National Cereals Research Institute Badeggi for sponsoring the programme.

ABSTRACT

The effectiveness of various herbicide treatments **for** season-long control of weeds in three cultivars of rice (Oryza sativa L) was investigated in 1983 wet and 1983-84 dry seasons at Badeggi (09° 45'N and 06° 30'E,, 70.5m above mean sea level) in the Southern Guinea Savanna ecological zone of Nigeria. During the 1986 wet and 1985-86 and 1986-87 dry seasons, field trials were conducted to evaluate herbicide combinations for the control of cutgrass (Leersia hexandra Swartz Prod) in direct-seeded lowland rice.

The rice cultivars consisted of FARO 15, FARO 27 and FARO 29 which were tall, short and of medium height, respectively. The rice cultivars had significant effect on weed infestation at crop harvest and on qrain yield. Plots sown with FARO 27 consistently had the highest infestation of weeds in the two seasons. In 1983 wet season, FARO 15 and FARO 29 resulted in similar grain yields that were significantly higher than that of FARO 27. However, in the 1983-84 dry season, FARO 29 produced higher grain yield than FARO 15 and FARO 27 which were similar in grain yield.

The effect of weed control treatments on weed infestation, % weed coveraqe was also significant as reflected in dry weed weight at 30 and 60 days after

herbicide application (DAH) and at harvest. Mixtures of propanil with highest rate of benthiocarb plus silvex at 3.23 + 1.80 + 0.75kg a.i./ha and butachlor at 1.02 + 3.6 kg a.i./ha resulted in comparable weed dry weight to the hand-weeded control in the 1983 wet season, while in the 1983-84 dry season, the former treatment caused significantly lower weed dry weight. Except in 1983-84 dry season when benthiocarb + propanil + silvex at 1.80 + 3.24 + 0.75 kg a.i./ha caused comparable grain yield to hand-weeding, all the herbicide treatments resulted in lower grain yield than hand-weeding.

The interaction between cultivar and weed control treatments was significant on dry weight of sedges, number of panicle, spikelets at harvest and grain yield in the 1983 wet and 1983-84 dry seasons.

In dry-seeded bunded rice, sown in 1986, glyphosate at 0.5 and 1.0 kg ae/ha similarly reduced cutgrass dry weight while in 1985-86 and 1986-87 dry seasons, cutgrass dry weight decreased significantly with increasing rate of glyphosate* in all the trials, both rates of glyphosate resulted in significantly higher grain yield and other yield attributes of rice compared with no glyphosate treatment. Pre-emergence application of oxadiazon at 0.75 kg a.i./ha resulted in lower cutgrass dry weight and higher rice grain yield compared with no oxadiazon treatment in all the trials. post-emergence applications of mixtures of propanil with oxadiazon at 2.0 + 0.75 kg a.i./ha and dimethametryn at 2.0 + 0.75 kg a.i./ha applied 14 days

after seeding (DAS) resulted in similar rice grain yield to hand-weeded control in 1986 wet season. In 1985-86 and 1986-87 dry seasons, all the post-emergence herbicide treatments resulted in significantly higher cutgrass dry weight and lower rice grain yield than the hand-weeded control except on plots treated with glyphosate at 1.0kg ae/ha.

The interaction between pre-plant glyphosate and pre-emergence oxadiazon was significant on cutgrass dry weight at 60 DAH in the 1986 wet season and on rice plant height at 56 DAS in 1986-87 dry season. Significant interaction was also obtained between preplant glyphosate and post—emergence weed control treatments on cutgrass dry weight, growth, and grain yield and yield attributes of rice in 1986 wet, 1985-86 and 1986-87 dry seasons. Similar trend on interaction was obtained between pre-omergence oxadiazon and pos-t—emergence weed control treatments on cutgrass dry weight, growth, grain yield and yield attributes of rice in all the trials*

The major growth and yield contributing attributes were plant height, number of tillers/ha, number of panicles/ha and spikelets/panicle. uncontrolled weed growth throughout the crop life cycle resulted in complete crop loss in 1983 wet season and 90% yield reduction in 1983-84 dry season.

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## ABBREVIATIONS AND SYMBOLS

| | | |
|---|---|---|
| kg | = | Kilogram |
| g | = | gram |
| mg | = | milligram |
| ha | = | hectare |
| m | = | metre |
| dm | = | decimetre |
| cm | = | centimetre |
| mm | = | millimetre |
| % | = | percent |
| DAS | = | Days after seeding |
| DAH | = | Days after herbicide application |
| ae | = | acid equivalent |
| a.i. | = | active ingredient |
| r | = | simple correlation |
| $r^2$ | = | Coefficient of determination |
| WAT | = | Weeks after transplanting |
| DAP | = | Days after planting |
| DMRT | = | Duncans Multiple Range Test |
| Max | = | Maximum |
| Min | | |
| SE | = | Stan... |

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# Chapter 1. INTRODUCTION

## 1.1. Production

Rice is the most important staple food of about half of the human race. It ranks third after wheat and maize in production on world basis (FAO, 1981). In 1980, about 280 million metric tons of rice was produced from 245 million hectares all over the world. The most extensive areas of cultivation are within latitudes 53°N and 40°S of the equator. The highest yields are recorded between 30° and 45°N of the equator in countries like Japan, China, South Korea, Pakistan and Spain.

The earliest cultivation of rice in Nigeria was about 1890 when upland varieties were introduced to the high forest zone in Western Nigeria (Grist, 1965). The shallow swamp varieties from British Guiana and Sri Lanka also replaced the swamp varieties of red rice (Oryza glaberrima Steud) which was most extensively grown in the lowland of several rivers in the country about the same time. In Nigeria, 0.7 million metric tons of rice was produced from 0.45 million hectares in 1980. About 0.3 million hectares of wetland is currently under lowland rice production (Ayotade and Okereke, 1984). This accounts for about 75% of the national rice production. The country's potential lowland area which is between 4.6 m ha and 4.9 m ha is characterised by annual rainfall of 700 to 2000mm distributed over 3 to 7 months with an average of 200mm per month. In order to maintain high water depth for rice production, the lowland areas are usually bunded.

Though Hardcastle (1959) recognised four types of lowland where rice could be cultivated, only the areas which are flooded by fresh water from rivers, streams and rainfall are currently being used for rice cultivation. The mangrove areas have not been developed for rice cultivation because of the high water salinity (Ayotade and Okereke, 1984).

## 1.2 Uses

Rice is a universal source of cabohydrates. It is usually cooked by boiling in water or steaming and eaten with soup adorned with fish or meat, green vegetables and spice. Ground rice is also eaten as rice pudding. It is prepared as rice flakes, puffed and parched rice which is usually consumed during breakfast. Rice bran which is about 14% of paddy when milled (Purseglove, 1979) is a valuable livestock feed. The bran oil could be used for cooking meals, for soap manufacture, a carrier for insecticides and also as anticorrosive and rust resistant oil. In India, China, Japan and Korea, wines, beers and spirits are manufactured from rice. In the United States of America (U.S.A.) rice is also used for malting in the brewing industries. Ground rice is used in the confectionary industry while rice starch is used as laundry starch, as component in cosmetics and for textile manufacture.

Rice straw is used as a source of fuel, in the manufacture of strawboards, for thatching and for making

hats and mats. The husk is used for fuel for rice mills and a component for common concrete, for making hardboard and as building abrasive.

### 1.3 Nutritive value of rice

The nutritive value of rice depends on the variety and agro-ecology in which it is grown. The carbohydrate content is high, while the fat and protein content is low but comparable in amount to the quality in wheat (Grist, 1965). From analysis of ten cultivars of rice obtained from different parts of Nigeria, it was reported that rice contains 75.5% carbohydrates, 8.6% protein, 0.8% fat, 0.7% ash, 0.7% fibre and 13.9% water (Anon., 1986). The amino acid content of milled rice is comparable to that of other cereals except that it is low in lysine (Grist, 1965). Rice grain contains considerable amount of vitamin E while the fat soluble vitamins A and D are negligible. Vitamin B is present in high content but the riboflavin is low while vitamin C is practically absent (Anon, 1965). Rice grain also contains several minerals including the most essential ones like iron, iodine and calcium which are present in sufficient quantity to meet human nutritional requirements. Paddy rice is usually parboiled before milling in order to retain most of the nutrients and vitamins and reduce grain breakage during milling and for better storage qualities.

## 1.4 Constraints to rice production in Nigeria

In the lowlands of Nigeria, rice is the major crop during the wet season. Grain yields under these conditions have remained low - 1.2 to 2.5t/ha (Anon, 1983a). A number of factors have been found to be responsible for inadequate rice production in the country. These include the use of varieties which are low yielding, non-fertilizer responsive and are susceptible to pests and diseases. Cultural practices such as low plant population, low soil fertility and inadequate weed control also cause poor grain yields in lowland rice production in Nigeria.

### Losses due to weed competition in rice

Under wetland conditions in Nigeria, weeds constitute the major limiting factor to optimum yields in rice. The hydromorphic conditions which are required for the establishment of lowland rice favour the proliferation of weeds in rice culture especially where water control is not completely or only partially achieved. The extent of losses due to weed competition in rice cultivation depends on the moisture status in the soil, land preparation, rice cultivar and the weed floristic composition. Depending on the composition of the weed flora between 60 and 100% losses in grain yield have been attributed to weed competition (IRRI, 1965; Noda *et al*. 1968; Smith and Reynolds, 1965; Smith, 1974; Okafor and De Datta, 1974; De Datta, 1977c; Sharma *et al*, 1977; Okafor, 1982; Anon, 1982; Anon, 1983a; Anon, 1984).

At the Central Rice Research Institute in India, weeds caused 46% and 20% loss in grain yield of rice sown directly on dry soil and that sown on puddled fields respectively (Mana unpublished). Rice grain yield losses of 90%, 10% and 100% were reported when the weed community was grass weeds only, sedges and broad-leaved weeds, and when the weed community was made up of grasses, sedges and broadleaved weeds respectively (IRRI, 1967). Okafor and De Datta (1974) reported a yield reduction of 42 to 83% for drilled rice and 67 to 82% for broadcast seeded rice under upland conditions. The weed community of annuals and Cyperus rotundus L. resulted in the highest yield reduction of 83% and 32% under drilled and broadcast seeding respectively. Akobundu and Ahissou (1984) reported that the yield of tall OS6 which was only weeded once in a hydromorphic soil was reduced by 39% while a semidwarf cultivar ANDY 11 suffered a yield reduction of 63% at the same spacing and weeding frequency.

## 1.5 Weed control

In wetland areas in Nigeria, the traditional methods of controlling weeds in rice by hoe-weeding and hand-pulling are both laborious, slow and expensive. For instance two labour-intensive hand-weedings and a third light operation would require 480 to 720 man hours per hectare for six hour working days or 640 to 960 man hours per hectare for eight hour working days. At the current rate of labour cost in Nigeria, this would represent

about ₦480.0 to ₦720.0 per herctare. In addition to the cost, unavailability of farm labour at the peak period of farming activity also poses a serious problem causing delay in the operation with resultant crop loss (Schwaar, 1983). Lowland rice is usually inaccessible for various operations at the peak of the rains because of the rising level of flood water. Being a closely spaced crop, losses could even be caused by hoe-weeding and hand-pulling operations through crop injury and stand losses. Okafor (1986) cautioned on the use of hoe weeding and hand pulling as weed control measures; since unemerged weeds reappear soon after weeding. Weeds which have similar morphological characteristics as rice plant easily escape hand-pulling. Since they are found within the crop row, their competition greatly reduce crop yield. Hoe-weeding also helps to aggravate the aggressiveness of perennial weeds such as Cyperus spp., Speargrass (Imperata cylindrica L. Beauv) and cutgrass (Leersia hexandra Swartz Prod) due to their propagation by underground rhizomes, stolons, bulbs and tubers.

In effect, a less labour-intensive method devoid of the problems enumerated will be desirable to boost lowland rice production in Nigeria. Chemical weed control is a practical and economical alternative to hand-weeding. It was estimated that only 10% of the areas cropped to rice in Nigeria is treated with herbicides (Anon., 1982). If applied appropriately,

herbicides would prevent weed competition from planting to harvesting and promote higher yields by allowing closer crop spacing and therefore higher plant population. It is economical since a single herbicide application may replace two or three cultural operations. The advantages of chemical weed control in increasing the yields of rice and other arable crops and reducing the labour cost in the tropics and Nigeria in particular have been demonstrated (Furtrick, 1970; Parker, 1972; Akobundu and Fagade, 1978; Lagoke et al., 1982; Ogungbile and Lagoke, 1986; Lagoke et al., 1987, Lagoke et al.,1988). In tropical Asia and India where rice is grown under rainfed conditions with fluctuating water control, the pre-emergence use of herbicides like benthiocarb, butachlor and pendimethalin for selective weed control have given promising results (De Datta and Bernasor, 1973; Pillai, 1973; Bhan, 1978; Mukopadhyay et al.,1971; Mukopadhyay, 1978).

In Taiwan, Korea, Japan and Philippines, the use of herbicides has replaced manual weeding because of high wage rates and also ameliorated the problem of labour shortage (De Datta and Barker, 1977).

Herbicide mixtures have been recommended in various crops for effective control of broader spectrum of weeds and improved tolerance to the low rates of the mixtures used (Colby, 1967; Fadayomi, 1979; Lagoke et al.,1981; Lagoke et al. ,1983). For instance, propanil when used

alone has no effect on seedlings prior their emergence. It is therefore necessary to delay the application until weeds grow to reach 3.0 to 5.0 leaf stage if sufficient herbicidal efficacy is to be expected by one application. Delayed application, allows weeds to grow without interference for certain period of time, exposing the rice plant to severe competition at a most critical period of growth therefore reducing crop yields.

Long term chemical weed control using specific rice herbicides, poor land preparation and water management could cause proliferation of certain weed species such as cutgrass, Oryza longistaminata Linn, Oryza barthii A. Chev. and Echinochloa pyramidalis Hitchc and Chase which are resistant to commonly used selective rice herbicides. Under high infestation of such noxious weeds, severe yield losses could result through competition with rice plants. In an attempt to reduce yield losses through weed competition the project was therefore conceived with the following objectives.

1. To evaluate herbicide mixtures for weed control in three cultivars of rice.
2. To evaluate herbicide combinations for the control of cutgrass in lowland rice production.

Chapter 2

# LITERATURE REVIEW

## 2.1 Common weeds of wetland rice

Cook (1968) classified weeds of wetland rice into free floating, emergent and marginal plants. Lawrence (1966), reported that such plants are adapted to grow and reproduce under aquatic environment. Akobundu and Fagade (1978) had earlier identified the common weeds of African lowland rice ecosystems (Table 2:1). In another report, Akobundu and Poku (1985) observed that the major weeds of inland valley bottoms and flooded plains were Cyperus spp, Commelina spp, Paspalum spp, Cynodon dactylon Pers Ischaemum ruqosum Salisb Ic Strip, Echinochloa spp, Sacciolepsis spp, Sphenochlea zeylanica Gaertn, Ipomoea spp, with Panicum spp and Hyparrhenia spp. predominating in the savanna regions in the dry season. Williams (1975) carried out a survey of the common weed flora in swamp rice at Badeggi in the Southern Guinea Savanna ecological zone of Nigeria (Table 2.2) while Okafor (1978) repeated the survey (Table 2.3). There was a consensus in the classification of the weeds into broad-leaved weeds, grasses and sedges. The grass weeds identified by Williams (1975) were not included in the survey carried out by Okafor (1978). Sedge weeds (45%) and broad-leaved weeds (45%) identified by Williams (1975) were omitted in the survey carried out by Okafor (1978**b**). This was an indication of rapid shifts or succession of weed flora in swamp rice ecology at Badeggi as was later confirmed by Okeleye et al. (1979) to be due to the effects of long-term chemical weed control in the flooded rice belt.

A similar survey carried out by Okafor (1978b) at the irrigated lowlands of Edozhigi and Loguma in the southern Guinea Savanna showed that majority of the weed species which were present at Badeggi were also present at Edozhigi and Loguma. In the irrigated lowlands of Kadawa and Bakura in the Sudan Savanna, the survey carried out by Okafor (1978b) showed that the weed species were not as many as in the southern Guinea Savanna but Panicum maximum Jacq, Elusine indica Gaertn. Fruct, Cyperus esculentus Linn. and Cyperus rotundus Linn. were of economic importance. At Birnin Kebbi in North-western Nigeria, Oryza barthii and Oryza longistaminata were the predominant weeds associated with cultivated rice under deep water ecology (Okafor, 1978b; Nyoka, 1983). In the mangrove swamps of Southern Nigeria; Cyperus difformis L. predominates while in the lowlands of south-eastern Nigeria, Monochoria vaginalis (Burm. F.) Presl and Digitaria sanguinalis Stapf. are the most common weed species (Okafor, 1978b). In the irrigated lowlands of Ngala in north-eastern Nigeria Cyperus esculentus, Cyperus rotundus and Sorghum aethiopicum Stapf. were the most common weeds observed by Okfaor (1978b).

Table 2.1. Common weeds of African lowland rice ecosystems

| | |
|---|---|
| Amaranthaceae | *Alternanthera* spp. |
| Azollaceae | *Azolla* spp. |
| Commelinaceae | *Commelina* spp. |
| Cyperaceae | *Cyperus difformis* L. |
| | *Cyperus distans* L.f. |
| | *Cyperus haspan* L. |
| | *Cyperus sphacelatus* Rottb. |
| | *Fimbrystilis* spp. |
| | *Kyllinga* spp. |
| | *Pycreus* spp. |
| | *Mariscus* spp. |
| Gramineae | *Brachiaria* spp. |
| | *Cynondon datylon* (L) Pers |
| | *Echinochloa colona* (L) Link |
| | *Echinochloa crus-pavonis* Schult. |
| | *Echinochloa pyramidalis* (Lam.) |
| | *Leptochloa coerulescens* Steud. |
| | *Paspalum* spp. |
| | *Sacciolepis* spp. |
| Onagraceae | *Ludwigia* spp. |
| Pontedariaceae | *Heteranthera callifolia* Rchb. S Kanth |
| Polygonaceae | *Polygonum* spp. |
| Rubiaceae | *Pentodon pentandrus* (Schum. & Thonn). |
| Sphenochleaceae | *Sphenoclea zeylanica* Gaertn. |

Table 2.2 The Common weed flora in irrigated lowland of Badeggi in the southern Guinea savanna of Nigeria (Williams, 1975)

| Grasses | Sedges |
|---|---|
| Brachiara lata (Schumach.) | Cyperus difformis Linn |
| Digitaria debelis Desf. Willd | Cyperus incompresus C.B. Cl. |
| Echinochloa pyramidalis Lam | Cyperus reduncus Linn |
| Leptochloa coerulescens Steud | Cyperus sphacelatus Rottb. |
| Paspalum orbiculare Forsk. | Cyperus tenuicumlmis Boeck. |
| Sacciolepis africana C.E. Hubbard. | Eleocharis ocutangula (Roxb.) |
| | Eleocharis erecta(Schumach) |
| Schizachrium brexifolium (Sw.) Nees ex Buse | Fimbristylis dichotoma(Linn.) |
| | Mariscus alternifolius Vahl. |
| | Pycreus lanceolatus(Poiret) C.B. Cl. |
| | Scirpus jacobii C.E. Fisher |

Broad-leaved weeds

Ageratum conyzoides Linn.
Alternanthera sessilis Linn.
Ammannia auriculate Willd.
Bacopa crenata (P. Beauv.)
Celosia trigyna Linn.
Cleome ciliata Schum.
Corchorus aestruens Linn.
Eichornia natans P. Beauv.
Ipomoea aquatica I. reptans Poir
Jussiaea linifolia Vahl.
Jussiaea stenorraphe Brenan
Jussiaea suffructicosa var. brevisepala Brenan
Jussiaea suffructiocasa var. piloso-linearis
Jussiaea suffructiocasa var. linearis (Willd.)
Nymphaea lotus Linn.
Oldenlandia lancifolia Schumach.
Sphenoclea zeylanica Gaertn.

Table 2.3 Weed species of the irrigated lowlands of Badeggi (Okafor, 1978b).

| | |
|---|---|
| **Broad-leaved weed** | |
| Ageratum conyzoides Linn. | Eclipta alba Hassk. |
| Eichhornia natans P. Beauv. | Euphorbia hirta Linn. |
| Nymphaea lotus Linn | |
| Sphenochlea zeylanica Gaertn | Cleome ciliata Scham & Thenn. |
| | Lindernia diffusa Wettst. |
| Bacopa calyxcina Engl. | Nymphaea mainlata A. Cheve. |
| Alternanthera sessilis R.B. Ktze | Oldelandia lancifolia Schweinf. |
| Ammania preuriane Guill & Perr | Scoparia dubcis Linn |
| Hygrophila barbata | Stachytarpheta angustifalia Vahl. |
| Inomoea reptans. Poir | Torrenia specala Engl. |
| | Tenagocharis latifolia Buchenau |
| **Grasses** | |
| Panicum repens Linn. | Echinochloa colona Link |
| Digitaria debilis Willd. | |
| Eragrostis gangetica Steud | Echinochloa pyramidalis Hitchc & Chase. |
| Leersia hexandra Swatz Prod. | Elytrophorus spicatus A. Camus |
| Oryza barthii A. Chev. | Leptochloa coerulenscens Steud. |
| Sacciolepsis interrupta Stapf. | Schizachyrium brevifolium Buse |
| Cynodon dactylon Pers. | |
| **Sedges** | |
| Cyperus difformis Linn. | |
| Cyperus incompressus C.B. Cl. | |
| Fimbristylis dichotoma Linn. | |
| Pycreus lanceolatus (Poiret) C.B. Cl. | |
| Scirpus praelongatus F.W.T.A. | |
| Cyperus sphacelatus Rottb. | |
| Cyperus tenuispica Steudel | |
| Cyperus rotundus Linn. | |
| Fuirena umbellatus Rottb. | |

## 2.2 Weed control methods in lowland rice

### 2.2.1 Land preparation

The obvious benefit of land preparation particularly of puddling is minimised weed growth (Kupiers, 1963). In Nigeria, local farmers carry out all operations for land preparation manually using the hoe. Land preparation procedure depends on the type of rice culture and the method of planting. A typical land preparation procedure for dry-seeded rice cultivation consists of ploughing followed by two harrowings at two weeks interval (Navasero et al., 1985). In wet-seeded rice, land preparation consists of two rotavations. Land levelling could be done manually or by means of a small power tiller. Levelling provides uniform surface condition which contributes to the efficacy of later weed control practices. Vargas (1978) working with IR34 and IR36 under three tillage treatments in broadcast seeded rice found that as the tillage level increased from one harrowing to three harrowings dry weed weight decreased. When ploughing was followed by one harrowing IR34 had dry weed weight of 76g/$m^2$ while IR36 had dry weed weight of 450g/$m^2$. At three harrowings the average weed weight was 35g/$m^2$ for the two cultivars.

The use of cultivation alone to control weeds for example perennial grasses could be very expensive, ineffective and deleterious to the soil texture when erosion is not controlled (Lagoke, 1978). Its use could also be

limited by weather and terrain of the site as is the case under wetland conditions. However, cultivation could be used as a supplement to the use of chemicals (Cussans and Wilson, 1970; Ivens, 1973; Lagoke, 1978). For instance, when herbicides are applied on old swards of perennial grasses they vary in their efficacy (Childs, 1956; Sagar, 1966; Hughes, 1966). A major limitation to the efficacy of herbicides to control old swards had been attributed to the presence of large number of dormant buds on the rhizomes and stolons of these swards. If these buds could be induced to sprout enhanced herbicidal activity could be effected. Rotary cultivation for example has been used to effect rhizome fragmentation and thus encourage bud sprouting (Fail, 1956; Proctor, 1960). If enough time is allowed for active regrowth of sprouting buds before spraying, enhanced effect of the herbicide might occur (Darting et al., 1972; Lagoke, 1978). The importance of good land preparation therefore as a control method for cutgrass cannot be over-emphasised.

### 2.2.2 Water Flooding

In countries like Japan and the U.S.A. where regular water supply is guaranteed, good water management is recognized as an integral part of weed control in rice (Schwaar, 1983). Many weeds will not germinate under flooded conditions. Emergence of weeds and types of weed are closely related to the moisture status of the soil

and the depth of irrigation water (Yamada, 1965). Lack of water control is a major management constraint that increases the labour required for weeding (Moomaw et al., 1966). When water flooding is present, it could be very effective in suppressing grass weeds in flooded rice (Smith and Shaw, 1966; De Datta, 1973).

In Nigeria, water flooding cannot be used successfully by local farmers to control weeds because most irrigation systems in the developed inland valley swamps are of the diversion type that supplement existing rainfall (Savvides, 1981). They depend only on available stream flow whose level is determined by the amount of rainfall. Sometimes weed infestation is aggravated since adequate water flooding cannot be maintained for weed suppression. In most wetlands of Nigeria, for example, Yola along upper Benue river, Jebba along lower Niger river and Wurno along upper Sokoto river, there is practically no water control (Schwaar, 1983), Floods move freely into open flat lowlands spreading out in paddy fields over extensive areas. Sometimes flooding is delayed which leads to the proliferation of serious weed problems.

For water flooding to succeed as a weed control measure in Nigeria, the farmers need guidance and education on water management and irrigation agriculture (Ayotade and Okereke, 1984). The diversion system of

irrigation could modified to make room for water storage in the time of excess rainfall. This would provide regular flow in time of scarcity. The difficulty of maintaining uniform depth would be eliminated.

### 2.2.3 Mechanical weeding

The rotary weeder is the most efficient mechanical tool for controlling weeds in rice (De datta, 1973). Weeding by mechanical method is only feasible when rice is planted in rows. The major problem with the rotary weeder is the inability to remove weeds within rice hills or close to them (De Datta, 1981). Some modifications of this basic devise may be needed by rice farmers in Nigeria (Navasaro et al., 1985).

Several hand tools, such as double bladed weeding knives, narrow spade, cutlass and animal-drawn implements are being used with limited success in many developing tropical countries such as Nigeria, Thailand, Philippines and Burma (Navasero et al., 1985). Mechanical control of cutgrass could be integrated with chemical control to reduce the severity of late season competition with cultivated rice.

### 2.2.4. Hand-weeding

Hand-weeding among local farmers in Nigeria comprises of hoe-weeding and hand-pulling. The degree of hand-pulling and the problems associated with it is largely dependent

on the type of rice culture. Hand-pulling in many rice producing countries has been estimated to require 250 to 780 man-hours/ha depending on the ecosystem, frequency of weeding, water management and the environmental conditions during cropping (Dadey, 1973; De Datta et al. 1973; Matsunaka, 1975). For instance, in Taiwan, the labour requirement for a single hand-weeding 30 days after seeding is 400 man-hours/ha (Chang, 1968) while in Korea a single hand-weeding at 30 days after seeding requires 300 man-hours (Kim, 1969). At Dadin Kowa and Lake Geriyo irrigation projects of Upper Benue River Basin Development Authority (UBRBDA) in the northern Guinea Savanna ecological zone of Nigeria, the labour requirement for a single hand-weeding 30 days after seeding ranged between 240 man-hours/ha and 480 man-hours/ha (Avav, 1987). At the International Rice Research Institute, Philippines (IRRI, 1967) it was found that a single hand-weeding done beyond 42 days after seeding significantly resulted in grain yield reduction and increased man-hours for weeding. Early hand-weeding at 21 days after seeding requires fewer man-hours because the weed population at that stage is lower (Tauro, 1970). Hand-weeding could be effective in controlling weeds in dry-seeded rice (Bhan, 1978) when rice is sown in rows but is extremely time consuming, laborious and expensive where cheap labour is not available. Economically, hand-weeding could be used as a supplement to chemical control of perennial weeds such as cutgrass and where farm sizes are small.

## 2.3 Response of rice cultivars to weed management practice

For years, rice farmers in Nigeria depended on tall, vigorous, tillering plants to provide weed competition. With the introduction of modern semi-dwarf rice cultivars weed problems became more serious and the need for weed control became more obvious. For instance in Sri Lanka more intensive hand-weeding is generally practiced with modern than with traditional cultivars both in transplanted (Hoque et al., 1976a) and in direct-seeded rice (Hoque et al., 1976b). Hoque et al., (1978) reported that the weight of weeds growing in association with dry-seeded i rice was less for Dharial - a tall traditional cultivar than BR-3 a short statured modern cultivar. The weed species growing in association with the cultivars also differed. Cyperus iria L, Cyperus difformis L and Fimbristylis littoralis Gaudich were the major weeds growing in association with BR-3 while with Dharial, sedge growth was much reduced and Echinochloa crusgalli L. Beauv a grass was the dorminant weed. In IRRI, Moody (1977c), tested two traditional cultivars, and several breeding lines of modern cultivars of various plant height and tillering capacity in a weed control screening programme and observed a significant but negative correlation between plant height and grain yield reduction. A close examination of the data did not show a clear advantage of plant height, because many tall and short rice cultivars also tillered heavily which minimised weed growth. Working with the short-statured IR30, semi-dwarf IR 1632-93-2-2 and the intermediate statured

IR 34, it was reported that the dry weight of Paspalum distichum L. was lowest in IR 34 plots (IRRI, 1978). This showed that the intermediate statured variety competed better than semi-dwarf rice varieties in a difficult weed situation. IR1632-93-2-2 had the lowest total weed dry weight because of low infestation of annual weeds which indicates that the cultivar can suppress late growing weeds by shading them out.

However, breeders and agronomists usually evaluated yield potentials of rice cultivars under weed free conditions often without reference to the ability of the improved variety to compete with weeds under conditions in which the farmers will grow the crop. Increased yields cannot be obtained from use of improved rice cultivars without efficient weed control methods.

2.4 Chemical control of weeds in rice

At the farmer's level in Nigeria, very little chemical weed control is practised. Avav (1987) attributed the low level of chemical weed control to unavailability of herbicides in the rural areas where majority of Nigerian farmers live and the low level of education among Nigerian farmers. However, research conducted at the National Cereals Research Institute, Badeggi has identified both single herbicides and herbicide mixtures which could be applied pre-emergence and post-emergence to weeds in different rice cultures in Nigeria. In the irrigated lowland of Badeggi, in the Southern Guinea Savanna of Nigeria,

Fluorodifen at 4.0 kg a.i./ha resulted in grain yield that was comparable to two hand-weedings and significantly higher than that of the untreated control(Anon, 1970). Propanil at 6.7 kg a.i./ha also resulted in significantly higher yield than the untreated control in the same trial. When the same herbicide was used at the rate of 5.0 kg a.i./ha, it resulted in comparable grain yield to two hand-weedings (Anon, 1973a). In another trial at Badeggi, butachlor at 3.3 kg a.i./ha, nitrofen at 2.6 kg a.i./ha, fluorodifen at 4.0 kg a.i./ha produced comparable grain yield to two hand-weedings (Anon, 1971). At the irrigated lowlands of Bakura, Kano I and Kano II of northern Nigeria, fluorodifen applied at 2.0 kg a.i./ha produced comparable grain yield to two hand-weedings (Williams, 1975). Under flooded rice conditions at Bende, south-eastern Nigeria, Okafor (1978a)obtained good weed control and high grain yield comparable to yield from the hand-weeded plots when propanil at 3 kg a.i./ha and fluorodifen + propanil at 1.0 + 1.5 kg a.i./ha were applied 21 days after weed emergence. In direct-seeded irrigated rice at Ngala in the Chad Basin of Nigeria, (Okafor, 1986) found that thiobencarb at 5.0 kg a.i./ha, propanil + bromoxynil (octanoate ester) at 3.6 + o.4 kg a.i./ha and propanil + oxadiazon at 3.0 + 1.0 kg a.i./ha resulted in excellent weed control with comparable grain yield to hand-weeding.

In the Peoples Republic of China, Zanstra et al. (1977) found that when thiobencarb plus propanil at 1.5 + 1.6 kg a.i./ha was applied at seven days after seeding, 90% kill of weeds was achieved when the treatment

followed a pre-emergence application of chlornitrofen at 2.4 kg a.i./ha on moist soil. Chlornitrofen applied alone was only 80% effective against annual weeds and it had a residual effect for 20 days. One supplementary hand-weeding was essential to obtain optimum yields. Arceo and Mercado (1980) working in the Philippines found in a field trial in the dry season, that a tank mixture of butachlor + propanil at 1.0 + 3.0 kg a.i./ha applied at 15 and 20 days after seeding gave better selectivity and weed control than applications six days after seeding. Manipon et al. (1980) at IRRI observed that pre-emergence treatments of butachlor, pendimenthalin and thiobencarb each at 2.0 and 4.0 kg a.i./ha reduced grass weed population in direct-seeded lowland rice but none gave adequate weed control but had to be supplemented with hand-weeding 35 days after emergence.

In Japan, weed control system based on weed ecology, time of weed emergence and low crop phytotoxicity was developed for direct-seeded rice (Yamane, 1976). This consisted of ploughing one month before the application of paraquat at 10 to 20 days and harrowing before seeding. After emergence a mixture of propanil and thiobencarb at 2.0 + 2.0 kg a.i./ha and 1.6 + 2.5 kg a.i./ha was applied at 0.5 to 1.5 leaf and 3 to 4 leaf stage of rice seedlings, both herbicide treatments gave season-long weed control.

Other workers who have recommended chemical control of weeds in direct-seeded rice in various rice growing regions include (Vega, 1954; Smith and Shaw, 1966;

De Datta, 1974, 1977b, 1977c, 1977d; De Datta and Lacsina, 1974; Moody, 1977a; Sharma et al., 1977; Singh and Singh, 1977; Arceo et al., 1978; Bhan, 1978; Lubigan and Moody, 1980; Moody, 1980; Akobundu, 1981).

## 2.5 Integrated control of weeds

Development of integrated weed control practices in all the different systems of rice cultivation is the goal of all weed management strategies, because no single method will control weeds in all rice ecologies (Akobundu and Poku, 1985). Velasco et al. (1961) reported that the most feasible and economical schedule for weed control in direct-seeded rice is one that involves both mechanical, cultural and chemical practices. The stale seed bed techniques which combine tillage with properly timed application of herbicides to destroy the first flush of weeds following tillage is a good example of integrated control of weeds (Castin and Moody, 1981). At the International Rice Research Institute, (IRRI, 1968, 1973, 1977) experiments were carried out to test the effect of water management, tillage treatments and herbicides on weed control and yield of two rice cultivars. Grain yields were not significantly affected by water depth and tillage treatments but showed highly significant differences with weed control treatments. Tauro (1970) was able to reduce the time of rotary weeding in transplanted rice from 112 hours/ha to 65 hours/ha when rotary weeding followed an application of MCPA. Other workers who have recommended an integrated approach in the control of weeds in rice include Decomampo and Baker (1969), Jereza and De Datta (1977), Moody and De Datta

(1977), Noda (1977), Clarete and Mobbayed (1978).

## 2.6 The biology and ecology of cutgrass

### 2.6.1. Morphology

Cutgrass belongs to the family Gramineae, the sub-family Panicoideae and the tribe Oryzeae. There are only two Nigerian genera in this tribe, Leersia and Oryza, the latter tribe includes the cultivated rice. Cutgrass is the only Nigerian representative of the small genus Leersia. It is a straggling aquatic perennial with stolons rooting at the nodes. It also has slender and upright stems up to 1m or more high (Anon, 1966). This allows the plants to avoid water suppression during the reproductive stage. The leaf blade which is linear to linearlanceolate is stiff, about 15cm long and slightly 1cm broad tapering gradually to a sharp tip. On the abaxial portion of mid rib, there are spines which readily lacerates the skin of exposed legs when walking through cutgrass infested fields. The inflorescence is a narrow 5 to 15cm long panicle with 2 to 5cm long branches. The 2 to 4 mm long spikelets are overlapping, flattened and assymetrical with short spiny bristles along the margins (Hutchinson and Dalziel, 1931; Akobundu and Agyakwa, 1987).

The importance of cutgrass as a lowland weed stems from its ability to reproduce by means of seeds, underground rhizomes and surface creeping stolons. The above three methods of reproduction by cutgrass has made the plant an aggresive weed in lowland rice ecology in Nigeria.

The seeds when mature, are easily dispersed by wind, running water and animals. The rhizomes and the stolons also start rapid propagation after fragmentation during land preparation. The new buds formed are capable of surviving on the reserved carbohydrates of the reproductive propagules while the tough glabrous sheath surrounding the stolons helps prevent rapid desication of the reproductive propagules when moisture is limiting.

Apart from being an aquatic weed which survives under flood conditions in the wet season, it is also capable of existing as an upland weed, surviving on residual moisture in lowland areas in the dry season. The massive root system surrounding the rhizomes enable the plants to efficiently utilise underground water in the dry season.

2.6.2 Distribution

On nearly 40,000 hectares of hydromorphic land in north-western Nigeria, cutgrass infestation reaches about 0.2 to 20 plants/$m^2$ (Imeokparia, 1983). Okafor (1978b) reported the presence of cutgrass in the irrigated lowlands of Badeggi, Edozhigi and Loguma in the Southern Guinea Savanna ecological zone of Nigeria. Hutchinson and Dalziel (1931) also reported the presence of cutgrass in Ikoyi plains, Lagos in the forest zone of Nigeria. He also reported the presence of cutgrass in damp places in Sierra Leone and Guinea on the West Coast of Africa. In Ghana it was found as a waterside grass occurring in flood and coastal plains. Smith (1981) classified cutgrass as a weed of world-wide importance especially in

the lowlands and hydromorphic uplands where rice is cultivated.

### 2.6.3 Importance of cutgrass in lowland agriculture

There is very little published literature on the importance of cutgrass as a weed of lowland agriculture in Nigeria. However, local Nupe farmers at Badeggi in the southern Guinea Savanna of Nigeria, have long recognised cutgrass as a noxious weed which causes severe yield reduction in rice grain yield at harvest. It competes with rice for space, nutrients, sunlight and water. Local farmers claim that it makes hand-weeding operation difficult since the spines on the back of the leaves lacerate the skin as the farmers move through the fields. It reduced harvesting efficiency since the farmers spend more time to select rice plants from cutgrass tillers in infested fields. As a weed of irrigation canal and paddy fields it contributes to enourmous loss of water through transpiration. Like other perennial weeds it increases the cost of land preparation since the rhizomes and stolons are capable of rapid propagation.

## 2.7 Control of cutgrass

### 2.7.1 Cultural methods

Local farmers in Nigeria control cutgrass and other weeds of lowland rice before planting by making heaps of soil about four to eight weeks before planting and burying the regrowth of cutgrass a few days before transplanting. This does not appear to be an effective control method since the stolons and rhizomes soon start growing

after the initial operation. The use of various soil tillage practices aimed at either absolute removal, fragmentation, deep burying or exposure of rhizome and stolons of perennial grasses to dryness (Cussans and Wilson, 1970; Adegbola et al., 1970) may not be feasible for the effective control of cutgrass because of the flooded conditions under which it exist. Slashing, an operation which is occasionally employed by rice farmers using hand-sickles have been reported by Chancellor (1968) to be a factor which prevents apical dominance in Agropyron repens Linn and causes increase in concentration of the gibberellic acid content of the dormant buds to induce their sprouting. Repeated slashing as practised in some upland crops for the control of speargrass cannot be successfully used for the control of cutgrass because of the difficulty of walking under flooded conditions. Rice being a closely spaced crop will not allow slashing operations on a continuous basis after crop establishment. When done manually, slashing is a very tedious and labour intensive operation. Rotary weeding as practised by Asian farmers (De Datta, 1978) does not appear to be an effective control method for cutgrass since most of the stolons remain in the mud and germinate later on. Hand-pulling as practised by local farmers is tedious, expensive and labour intensive.

2.7.2 Chemical control

Various groups of chemicals when applied alone or in combination with other control methods could be successfully

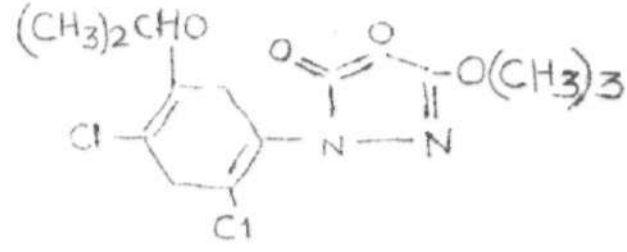
used to control cutgrass. Chemicals such as sodium arsenite (Childs, 1956), aromatic oil (Suwunnamek, 1965), sodium salt of trichloroacetic acid (Riepma, 1968), dalapon (Olunuga, 1975), paraquat (Suwunnamek and Parker, 1975) and glyphosate (Lagoke, 1978) have been recommended for the control of speargrass under upland conditions. The prohibitive cost of application to achieve successful control and poor weed control efficacy militate against the successful adoption of some of these herbicides for weed control in rice cultivation. For instance the use of sodium arsenite has been banned in several countries because of allergy problems (Soerjani, 1970). Poor control of speargrass was reported by Ivens (1973) and Olunuga (1975) when paraquat at 0.5 to 1.0 kg a.i./ha was used. Sequential application up to five times at 0.2 to 0.7 kg a.i./ha was recommended by Seth (1970). Although dalapon provides satisfactory control of speargrass (Olunuga, 1975; Lagoke, 1978), much time is lost to delay in planting after application of dalapon. In the irrigated lowlands of Birnin Kebbi in the Sudan Savanna of Nigeria, significant reduction in the infestation of Oryza longistaminata was obtained when glyphosate at 2.0 kg ae/ha was applied alone compared with the untreated control (Anon, 1980). Paspalum paspaloides Linn a perennial weed of wetland rice in Laguna, Bulacan and Nueva Ecija provinces in the Phillipines (Lubigan and Mercado, 1977) was successfully controlled when glyphosate at 2.0 kg ae/ha was applied alone (De Datta et al.,1979). Excellent weed control

with high grain yield was obtained when this treatment was followed by plowing in the same trial. Paraquat alone caused the proliferation of Paspalum paspaloides L. after the initial control. A combination of glyphosate at 1.0 kg ae./ha, followed by paraquat at 1.5 kg a.i./ha was however, effective compared with the untreated control. Effective control of cutgrass could be obtained if cultural control is integrated with chemical control.

## 2.8. Selective rice herbicides

### 2.8.1 Oxadiazon

Oxadiazon belongs to the group of compounds called oxadiazole. The chemical structure is as shown below. The molecular weight is 345.2




3-/2, 4-dichloro-5- Cl-methylethoxy) phenyl7 -5-(, 1-dimethylethyl) -1, 3, 4-oxadiazol-2(3ch) one.

It is soluble in methanol, ethanol, acetone and benzene. At 20°C it is practically insoluble in water. It is formulated as an emulsifiable concentrate and is stable in excess of two years. It is of very low order of mammalian toxicity but toxic to fish. The acute oral LD50 rats is greater than 8000mg/kg (Anon, 1983b).

It is readily absorbed by foliage but the site of uptake is through the emerging shoot. In very susceptible species such as annual grasses and some broad-leaved weeds,

the compound may be translocated to the roots when applied post-emergence. It is rapidly diffused to the apical meristem when weeds are young and actively growing. It acts by contact activity on susceptible weed species as it grows through the treated zone in pre-emergence application and by complete coverage in post-emergence application. Achhireddy et al. (1985) reported that the mode of action of oxadiazon is the inhibition of $Co_2$ fixation and the export of fixed carbon from the source leaves to the growing points in susceptible weeds. It causes stunted growth and death of such plants. Selectivity of this compound is as a result of many factors. Audus (1976) reported that the selectivity of oxadiazon is based on the low solubility of the compound causing it to be adsorbed on the soil colloids. Achhireddy et al. (1985) attributed the tolerance of rice to slower penetration of oxadiazon into the leaf tissue of the treated region of rice plants than that of the susceptible weeds. Other workers who have reported differential uptake of herbicides by susceptible species and tolerant species as responsible for species selectivity are (Smith and Sheets, 1967; Hoque and Warren, 1968; Roeth and Lavy, 1971; Strang and Rogers, 1974). Differences in translocation after uptake have also been speculated as one of the factors responsible for the selectivity of oxadiazon in rice and susceptible weeds. (Frank and Switzer, 1969; Stroller, 1970; Binghan and Shaver, 1971). Ishizuka et al. (1975) found that seven days after

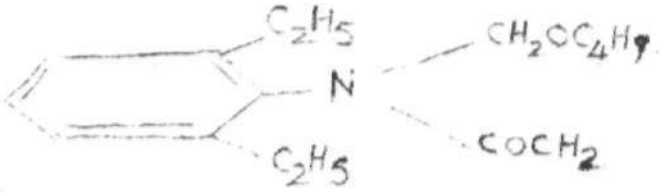
application of 14C oxadiazon to leaf blades or leaf shoots of rice plants translocation was mainly to the shoot and no translocation occurred to the roots or tillered shoots.

Richard and Street (1984) in a three year field study in the Mississippi delta of U.S.A. reported good to excellent control of barnyardgrass (Echinochloa crus-galli (L) Beauv.,) hemp sesbania (Sesbania exaltata (Ruf). Cory,) tall morningglory (Ipomoea purpurea (L) Roth.) pitted morningglory (Ipomoea lacunosa (L)) and tighthead sprangle top (Leptochloa panicoides Presl. Hitch) with high grain yield when oxadiazon alone at 1.1 kg a.i./ha and in mixture with propanil at 0.8 + 3.4 kg a.i./ha was applied early post-emergence to the weeds. In field evaluation trials in the Philippines, excellent weed control with high grain yield was obtained when oxadiazon was applied pre-emergence to weeds at 1.0 and 0.75 kg a.i./ha (IRRI, 1978 and 1979). In Taiwan (Chang, 1973a) and Japan (Chisaka and Noda, 1981) oxadiazon is recommended as one of the rice herbicides for commercial usage nation-wide. Okafor (1979) working at the irrigated fields of Lake Chad Basin Nigeria, found that oxadiazon at 0.5 kg a.i./ha resulted in comparable grain yield to two hand-weedings. In a field trial conducted at Ibadan, south-western Nigeria, pre-emergence oxadiazon at 0.5 kg a.i./ha and post-emergence oxadiazon plus propanil at 0.5 + 2.4 kg a.i./ha were found to be more effective in reducing weed infestation compared with propanil alone at 4.5 kg a.i./ha and two hand-weedings (Anon, 1981).

2.8.2 Butachlor

Butachlor belongs to the ∝ chloroacetamides. The chemical structure is as shown below.

N-(butoxymethyl)-2-chloro-N-(2, 6-diethylphenyl), acetamide.




It has a molecular weight of 311.8. At 20°C its solubility in water is 20ppm. It is soluble in ether, acetone, benzene, alcohol, ethylacetate and hexane at room temperature. Butachlor is slightly toxic by ingestion and practically non toxic by dermal applications. The acute oral LD50 rats is 2000 mg/kg and the dermal LD50 rabbits is greater than 13000mg/kg (Anon, 1983b). It is not readily absorbed by roots but the site of uptake is through the emerging shoot. Translocation is throughout the whole plant with high concentration in vegetative parts than in reproductive parts. The major site of action is the vegetative part of plants, there is less action in the reproductive parts. The mode of action of butachlor is that of inhibition of growth of shoots, roots as well as inhibition of mesocotyls' development. This could be attributed to inhibition of auxin induced cell expansion. It also inhibits protein synthesis possibly by preventing the transfer of amino-acids from amino-acyl-t-RNA to the polypeptide chain. Nucleic acid synthesis also appears to

be inhibited. It is broken down in plants to glycolic acid and probably diallylamine before further metabolism to normal plant constituents (Ashton and Grafts, 1973).

The basis of selectivity of butachlor in rice is physiological. Tolerant crops are capable of degrading the herbicide into non-phytotoxic components at recommended rates. Another basis of selectivity is by conjugation. The chemical forms conjugate with some natural products which are non-toxic and non-translocatable (Anon, 1983b). Butachlor does not persist in the soil from one season to the next in sufficient quantity to injure sensitive crops when applied at recommended rates. A residual efficacy period of 20 to 60 days was reported in field trials in Taiwan (Anon, 1981). The rate of application was 1.5 to 2.0 kg a.i./ha. Beestman and Deming (1974) pointed out that microbial decomposition was the major avenue of degradative dissipation from soil. Another avenue was photo-decomposition (Chen and Chen, 1979).

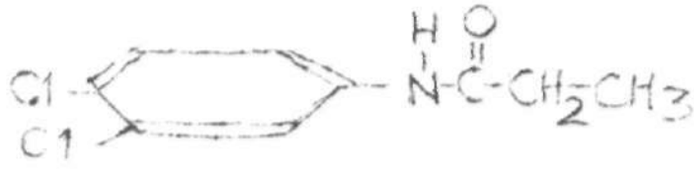
Richard and Street (1984) working at the Mississippi delta of U.S.A. reported excellent control of barnyardgrass, tighthead sprangle top, tall and pitted morningglory and hemp sesbania when butachlor plus propanil was applied at 4.2 + 3.4 kg a.i./ha. De Datta and Lacsina (1974) reported that butachlor alone, when applied at 1.5 kg a.i./ha before weed emergence resulted in excellent control of Scirpus maritimus L. compared with the untreated control. Chang (1973a) working in Taiwan reported that the performance of butachlor alone in flooded rice culture

depended on the time and rate of application. He found that butachlor at 1.0, 1.5 and 2.0 kg a.i./ha resulted in good weed control up to 30 days after application when herbicide treatments were applied at 15 days after transplanting but weed control was maintained up to 60 days after application when butachlor was applied at six days after transplanting. He also reported that when butachlor was applied at 2.5 and 3.0 kg a.i./ha alone, excellent weed control was achieved throughout the crop life cycle when applications were made at 6 and 15 days after transplanting.

Chang and De Datta (1974) found that butachlor at 1.5 kg a.i./ha alone was ineffective in the control of weeds under high infestation of broad-leaved weeds. The grain yield obtained was not significantly different from the untreated control. They also found that butachlor at 1.5 kg a.i./ha was moderately toxic to rice, resulting in yield reduction but there was only slight toxicity when the treatment was carried out at 12 days after seeding. At Ibadan, South-western Nigeria, butachlor applied alone at 3.0 and 4.0 kg a.i./ha at 14 days after seeding caused high weed infestation throughout the crop life cycle with comparable grain yield to the untreated control (Anon, 1980)

2.8.3 Propanil

Propanil belongs to the amide-type of herbicides. The chemical structure is shown below




3', 4'-dichloropropionanilide

It is a light-brown to greyblack solid with a water solubility at 20°C of about 500ppm. It is formulated as an emulsifiable concentrate with an acute oral LD50 rates of 1200mg/kg. It is highly soluble in most common organic solvents such as toluene, xylene, isopropyl alcohol, isophorone and methylethyl ketone (Anon, 1983b). Propanil is absorbed by leaves when it is applied post-emergence in rice to control several annual grasses and a limited number of annual broadleaved weeds and sedges. Translocation within the leaf or from the treated leaves to the rest of the plants is very limited (Yih et al., 1968a) The site of action is the foliage of treated leaves. Propanil inhibits the Hill reaction in plants (Good, 1961). It causes chlorosis followed by necrosis to the leaves of susceptible species. The basis of selectivity is biochemical. An enzyme aryl acylamidase in the leaves of rice plants rapidly detoxifies propanil by oxadative metabolism and hydrolysis to 3, 4-dichloroaniline (DCA) and propionic acid (Fear and Still, 1968). Young rice leaves contain approximately 60 times as much aryl acylamidase as young barnyardgrass leaves. Roots of rice and barnyardgrass contain the same low concentrations of the enzyme. In propanil treated rice, the 3, 4-dichloro-ancline becomes tightly bound in carbohydrate and lignin consistituents of the cell walls of the rice plants, from which it can be released only by extreme caustic treatment (Still 1968a; Yih et al.,1968b). Dichloroanaline was

found at higher concentrations in the straw than in the grain. The propionic acid formed by the hydrolysis of propanil is further metabolised to carbon dioxide and water by beta-oxadiation (Still, 1968b).

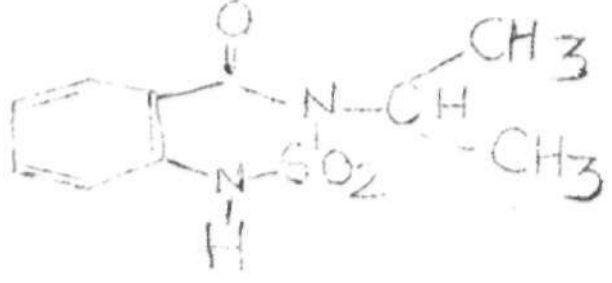
A number of workers have reported successful use of propanil either singly or in mixture with other herbicides to control weeds in rice. Smith et al. (1971) working in Stuttgart Ark. in Southern U.S.A. found that propanil applied at 3 to 5 kg a.i./ha controlled barnyardgrass at 1 to 4 leaf stage of growth with little or no injury to rice. He also reported that propanil was ineffective as a pre-emergence application or when it was applied to barnyardgrass in the tillering stage of growth or later. Other weeds that were similarly controlled were Sphenoclea zeylanica, Ammania auriculata Willd. Eleocharis spp, Leptochloa spp 4cm tall, Setaria glauca (L) Beauv. Poor control of Ipomoea spp about 5cm tall was reported. Smith et al. (1971) also in Stuttgart Ark. U.S.A., Richard and Street (1984) in the Mississippi delta of U.S.A. reported excellent broadspectrum weed control and high grain yield when propanil was applied in two splits at 4.0 + 3.0 kg a.i./ha and at 3.4 + 3.4 kg a.i./ha respectively. In the southern Guinea Savanna ecological zone of Nigeria, where good water management is non-existent, mixtures of propanil with butachlor, benthiocarb, fluorodifen and oxadiazon applied post-emergence to weeds at 2 to 3 leaf stage controlled grass weeds, broadleaved, aquatic and

sedge weeds that have emerged at treatment and those that would germinate four weeks after treatment (Akobundu, 1981; Anon, 1983a). Its mixture with dimethametryn and piperophos was essential to obtain good control of weeds that have become resistant to single application of propanil with acceptable grain yield in the irrigated lowlands of Edozhigi in the southern Guinea Savanna of Nigeria (Anon., 1984).

Rice may be injured when carbamate and organophosphate insecticides such as carbaryl, carbofuran, parathion are applied with propanil or within a few days of each other (Bowling and Hudgins, 1964; Bowling and Flinchum, 1968).

2.8.4 Bentazon

Bentazon belongs to the thiadiazine group of compounds, the structural formular is as shown below.




3-Isopropyl-1H-2, 1, 3-benzothiadiazin-4(3H)-one-2, 2-dioxide.

It is not soluble in water but is soluble in organic solvents like acetone, benzene, chloroform, cyclohexane, ethanol, ether-ethylacetate and olive oil. Results of the toxicity studies show that bentazon has a relatively low toxicity to mammals, oral LD50 rats is 850mg/kg body weight, while the dermal toxicity LD50 rats is greater than 2,500mg/kg body weight. The formulated

product is less toxic. It is tolerated by fishes; the LC50 is 510ppm. It is absorbed mainly by green plants since it is a contact type of herbicide. For good control, both the leaves and the stem of the treated plant must be adequately wetted with the spray mixture. The active ingredient is absorbed by the foliage and could be translocated to the roots (Anon, 1973b). The amount absorbed and the direction in which it is translocated could be affected by temperature, relative humidity, soil moisture and the weeds controlled (Anon, 1973b). The pre-emergence activity of bentazon is weak. The basis of selectivity of bentazon in rice is physiological. The active ingredient is bound to structural elements of the plant (Anon, 1983b). Recent investigations show that the complexes are conjugates of mono - or oligosaccharides with bentazon molecule hydroxylated in the aromatic ring.

Bentazon applied alone and in combination with other herbicides is used for weed control in lowland (Okafor, 1981) and upland rice culture. De Datta and Lacsina (1974) reported excellent control of Scirpus maritimus with bentazon at 2.0 and 3.0 kg a.i./ha when applications were made at 20 days after transplanting. Okafor and De Datta (1976) in a field evaluation trial in the Philippines reported poor weed control with poor grain yield when bentazon alone at 2.0 kg a.i./ha was applied seven days after crop emergence. In the same trial, bentazon at 2.0 kg a.i./ha in combination with butachlor at 2.0 kg a.i./ha and dymrone at 8.0 kg a.i./ha combined excellent broadspectrum weed

control with comparable grain yield to two hand-weedings. In a dry season trial under a mixed population of burnyardgrass and Scirpus maritimus, bentazon at 1.5 kg a.i./ha resulted in excellent control of Scirpus maritimus but control of barnyardgrass was unsatisfactory (IRRI, 1975). In a field trial at Edozhigi Okeleye et al. (1979) found that bentazon at 4.7 kg a.i./ha caused the proliferation of grass weeds but control of sedge growth was satisfactory. The efficacy of bentazon at 4.7 kg a.i./ha to control broadleaved weeds could not be proved in the trial because of the low infestation of broadleaved weeds in the untreated control plots.

2.8.5 Dimethametryn.

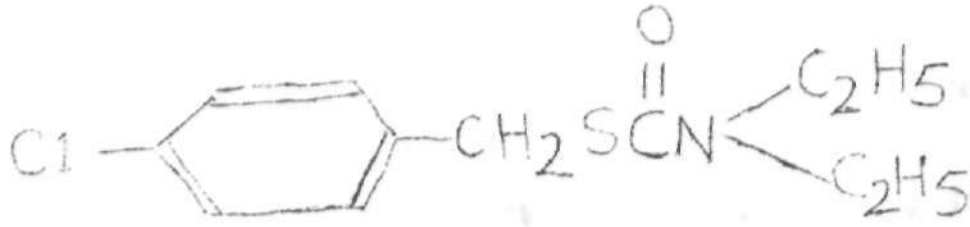
Dimethametryn belongs to the group of herbicides called triazines. The chemical name is 4-(1,2-dimethyl-n-propyl-amino)-2-ethylamino-6-methylthio-s-triazine. It is a solid at room temperature, with a water solubility of 50mg/litre. It is highly soluble in organic solvents. Its melting point is 65$^{o}$C while the boiling point is 151-153$^{o}$C at 0.5 mm Hg. By oral and dermal administration dimethametryn is slightly toxic to mammals. The oral LD50(rat), is 3000mg/kg body weight while dermal LD50 (rat) is greater than 2150mg/kg body weight. Dimethametryn is devoid of any oncogenic, carcinogenic or mutagenic potential in the studied species. In laboratory trials dimethametryn is toxic to trout but slightly toxic to crucian carp and channel catfish (Anon, 1985).

Dimethametryn enters the plant through the treated root and leaf in pre- and post-emergence application. The mode of action is the inhibition of the Hill reaction of photosynthesis in susceptible plants, thereby causing depressed growth and subsequent death of the treated plants (Audus, 1964). The basis of selectivity in rice plants is physiological. Rice plants are capable of converting dimethametryn to harmless metabolites which form some conjugates with plant constituents.

There is very little published information on the use of dimethametryn alone for weed control in rice. However, dimethametryn in mixture with other herbicides such as piperophos, propanil, bentazon and MCPB is used with varying degree of success in many rice growing regions of the world (Anon, 1985). Dimethametryn was reported by Martins and Worthing (1974) to be effective against broadleaved weeds in rice. In a site infested with Cyperus spp, Monochoria vaginalis and Echinochloa spp., it was reported that dimethametryn mixture with piperophos at 0.5 + 0.5 kg a.i./ha applied four days after transplanting rice during the wet season, gave yield similar to the hand-weeded check. At Ibadan in the southern Guinea Savanna of Nigeria, satisfactory weed control with high grain yield was obtained when dimethametryn plus piperophos plus propanil was applied at 0.2 + 0.8 + 1.8 kg a.i./ha (Anon, 1986). The weed infestation consisted of Euphorbia heterophylla Linn., Digitaria horizontalis Willd, Brachiaria spp. and Ageratum conyzoides. L. Similar results were obtained at the irrigated lowlands of Edozhigi (Anon, 1984).

2.8.6 Benthiocarb

Benthiocarb belongs to the group of herbicides called carbamates. The chemical structure is as shown below.




S-(4-chlorobenzyl)-N, N-diethyl thiolcarbamate. It is an oily liquid with pale amber to light yellow colour. At 20°C and pH 6.7, its solubility in water is 27.5ppm. It is soluble in xylene, alcohols, acetone and sparingly soluble in glycerol. Benthiocarb is of low oral toxicity in mammals LD50 rats is 1289mg/kg; likewise in fish TLM 48 Carp is 3.4ppm. Absorption in pre-emergence treatment is through the mesocoytl, coleoptile and the first leaf as the foliage passes through the treated layer, In post-emergence application, absorption is through the roots, leaves and stem. Translocation of benthiocarb is mostly in the upward direction and partly in the downward direction in the symplast (Anon. 1977a). Mode of action of benthiocarb is inhibition of protein synthesis of plants. It is also classified as a growth inhibition type of herbicide. It inhibits the biosynthesis of gibberellin-induced $\alpha$-amylase in aleurone layer of germinating seeds. The morphological changes induced in plants depends on the rate of application. For instance in barnyardgrass, at low dosages the growth of leaf blade and leaf sheath is

slightly checked while at higher dosages, elongation of first leaf is inhibited before the weed is eventually induced to death (Anon, 1977a). The selectivity of benthiocarb in rice plants is physiological. Rice plants are capable of metabolising benthiocarb into non-toxic metabolites while susceptible weeds detoxify benthiocarb much more slowly. Differences in absorption and translocation of benthiocarb by susceptible weeds and rice plants is another factor for species selectivity.

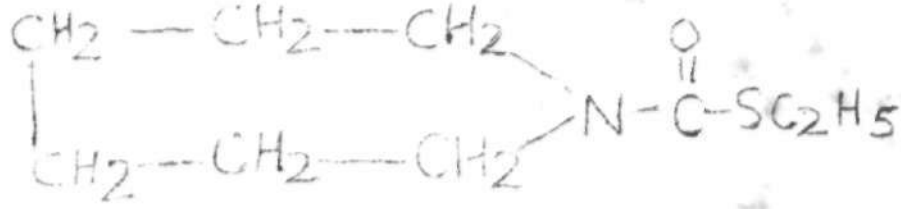
In Taiwan, Chang (1973b) reported excellent weed control when benthiocarb alone was applied at 2.5 and 3.0 kg a.i./ha in transplanted rice. Chang and De Datta (1974) working in Taiwan also reported good weed control when benthiocarb alone was applied at 1.5 kg a.i./ha under a high population of broad-leaved weeds. Excellent weed control with high grain yield was obtained when benthiocarb at 3.0 kg a.i./ha was applied alone in dry seeded rice (IRRI, 1977). At Ibadan, unsatisfactory weed control was obtained when benthiocarb alone at 4.0 kg a.i./ha was applied pre-emergence to weeds and the grain yield obtained was not significantly different from the untreated control (Anon, 1980). Okeleye et al. (1979) in a field trial at Edozhigi reported satisfactory control of sedges with benthiocarb at 3.0 kg a.i./ha but control of perennial grasses and broad-leaved weeds was unsatisfactory. Richard and Street (1984) at the Mississippi delta of U.S.A. reported poor control of hemp sesbania and morningglory when benthiocarb alone was applied at 4.5 kg a.i./ha. In the same trial excellent control of

sprangele top and barnyardgrass was obtained. Okafor (1979) reported excellent weed control with high grain yield when bentiocarb alone was applied pre-emergence at 6.0 kg a.i./ha at the Lake Chad Basin of Nigeria. The weed composition was made up predominantly of sedges.

Benthiocarb in mixture with propanil, 2, 4-D-IPE and silvex have shown promising results when applied post-emergence to weeds in various rice growing regions in the tropics (Anon, 1977a; Anon, 1980; Richard and Street, 1984). Since benthiocarb in mixture with propanil controls weeds residually, it is effective for weed control in rice grown on problem soils and in areas where flooding immediately after treatment is none existent.

2.8.7 Molinate.

Molinate belongs to a group of herbicides called thiocarbamates. The chemical structure is shown below.



S-ethylhexahydro-1 H-azepine-1-carbothioate.

It is liquid at room temperature with water solubility of 880ppm. It is highly soluble in common organic solvents such as kerosine, xylene and methyliobutyl ketone. Technical molinate has an acute oral LD50 (rats) of 750kg/kg body weight which is low. The dermal toxicity $LD_{50}$ (rats) is greater than 4640mg/kg body weight (Anon, 1983b). Molinate may be absorbed by weed seed during the early

stages of germination. Seeds that are not germinating apparently do not absorb molinate. It may also be absorbed by roots, coleoptiles and basal shoot tissue. Once molinate is absorbed, it is readily translocated in the apoplast system throughout the whole plant. The site of action is the meristems of root and shoot where it accumulates in large quantity. It is rapidly metabolised in plants and soils (Fang, 1969; Mueller and Oelke, 1975). The carbon dioxide metabolites are assimilated in natural plant consistituents such as organic acids, carbohydrates, cellulose, amino-acids and proteins. Its persistence in soil is relatively short, usually less than one month (Klingman et al., 1975).

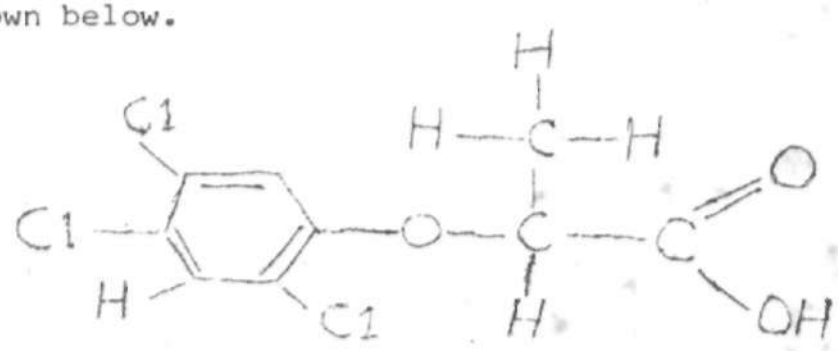
The mode of selectivity of molinate in rice is on the basis that some plant species detoxify molinate more rapidly than others. For instance, in experiments in California U.S.A., it was found that molinate at 0.3ppm reduced the length of barnyardgrass shoots 29%, but 7ppm reduced the length of rice shoots only 30% (Oelke and Morse, 1968). Another basis of selectivity might be due to the fact that susceptible weed coleoptiles absorb molinate more than rice coleoptiles (Chem et al., 1968).

Molinate is used for the selective control of annual grasses in rice (Klingman et al., 1975). Smith (1970a) in a field evaluation trial at Stuttgard Ark, U.S.A. found that molinate at 4.0 kg a.i./ha applied pre-emergence to weeds in drill-seeded rice resulted in satisfactory control of

barnyardgrass with high rice grain yield which was significantly different from the untreated control. Similar results were obtained when applications were made at 3-4-leaf stage of barnyardgrass. In experiments at Biggs California U.S.A., molinate at 3.0 kg a.i./ha applied pre-emergence to weeds controlled barnyardgrass effectively with high rice grain yield, which was significantly different from the untreated control (Smith, 1971). In other rice growing regions of U.S.A. sequential treatments of propanil and molinate control barnyardgrass better than other herbicides applied alone (Smith, 1970b). In Japan herbicide mixture of molinate, MCPB and simetryn are used for foliage and soil treatment in order to obtain broad-spectrum weed control (Takematsu and Takeuchi, 1981).

2.8.8 Silvex

Silvex belongs to the group of compounds called synthetic growth regulators. The chemical structure is as shown below.




2-(2, 4, 5-trichlorophenoxy) propionic acid.

Its solubility in water is 180ppm at 25°C (Klingman et al., 1975). The acute oral $LD_{50}$ rats is 650mg/kg body weight.

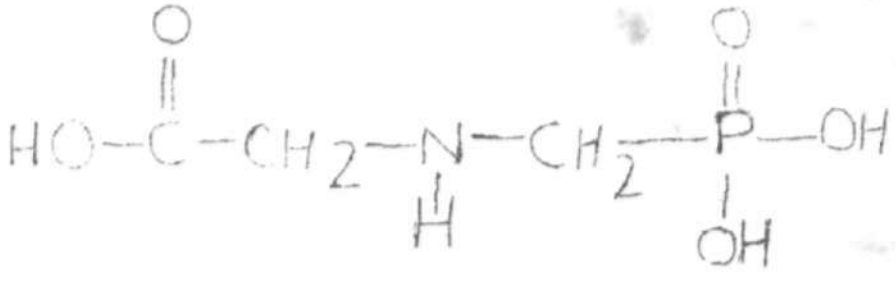
Silvex is absorbed by roots and/or leaves and is distributed throughout the whole plant in the apoplastic and symplastic systems of the plant. Growth symptoms in broad-leaved weeds consist of crinkled strap shaped leaves while the treated plants are stunted and malformed (Anon, 1983b). The leaf veins are caused to be parallel rather than netted. In most cases stems are crooked and brittle with shortened internodes. In grasses, the leaves are rolled near the base of the petiole in an onion-like fashion. The tip of terminal leaf is free and flaglike in appearance. The mode of action of silvex is not the result of any single factor but plant death results from the effect of a number of disturbances in the treated plants. Silvex causes growth responses similar to those of natural growth regulating substances called auxins. It causes cell division and respiration rates to increase while photosynthesis decreases. This mechanism completely exhaust the food supply of the treated plants leading to eventual death. Roots of treated plants lose their ability to take up soil nutrients and tissues of the stem fail to move food effectively through the plant (Anon, 1983b). The selectivity of silvex in rice is physiological. Susceptible plants absorb and accumulate silvex while tolerant plant species degrade it to non-toxic molecules. The degradation is a process of decarboxylation, demethylation of the side chain as well as dechlorination and hydroxylation of the ring (Klingman et al., 1975).

Silvex is used for the control of emergent aquatic weeds, submerged aquatic weeds in still water and 2,4-D tolerant weeds (Anon, 1983b). De Datta and Lacsina (1974) in a field evaluation trial in the Philippines reported that silvex at 1.5 kg a.i./ha applied after weed emergence resulted in complete eradication of Scirpus maritimus in wetland rice. Trials conducted in some of the rice growing regions of U.S.A. showed that silvex is effective in the control of purple ammania, Eleocharis spp., Cyperus spp., Ipomoea spp., Fimbristylis spp., hemp sesbania and Sphenoclea zeylanica.

## 2.9 Non-selective preplant herbicide

### 2.9.1. Glyphosate

Glyphosate belongs to the group of compounds called aliphatics. The chemical structure is as shown below



N-(phosphonomethyl) glycine

The molecular weight is 169.1. It is a white solid which is soluble in water. At 25°C its solubility in water is 1g/100g (Anon, 1983b). Glyphosate is relatively non-toxic to mammals. The acute oral toxicity $LD_{50}$ rats is 4900mg/kg while acute dermal toxicity $LD_{50}$ rats is greater than 7940mg/kg. The compound is a foliar absorbed herbicide which is easily translocated from vegetative

parts to underground roots, rhizomes, stolons and tubers in the photosynthate (Anon, 1983b). Its knock-down effect is slow compared with paraquat but fairly rapid when compared with amitrole. Translocation of glyphosate in treated plants can be affected by various factors, such as drought stress, growth and vegetative stage of weeds to be destroyed, method of application, soil cultivation before and after treatment. Visible symptoms develop progressively for several days. Symptoms are a gradual wilting and yellowing of the plant, seven to 14 days after spraying which advances to complete browning or dessication of above-ground growth and similar deterioration of underground plant parts within 30 days of application (Anon, 1983b). Jarworski (1972) suggested that the mode of action of glyphosate is the suppression of the biosynthesis of the essential amino-acids phenylalanine more specifically with the metabolism of chorismic acid in the aromatic amino-acid biosynthetic pathway. It is essentially non-selective and therefore it is not used in crops except where it can be kept off the crop through directed application. The propensity of glyphosate of binding to soil particles combined with biodegradation in the soil (Sprankle et al., 1975) contributes to a virtual total lack of activity in the soil. Antagonistic effects of glyphosate when mixed with other herbicides like alachlor, atrazine and simazine have been reported by Baird et al., (1971) and Somabhi (1975).

Akobundu (1977) working at Ibadan in south-western Nigeria found that glyphosate at 1.0 kg ae./ha was a

better broadspectrum pre-plant applied herbicide than paraquat at comparable rates. For instance Paspalum orbiculare Forst, Panicum maximum Jacq, Talinium triangulare Jacq Willd and Commelina spp partially controlled by paraquat at 1.0 kg a.i./ha fully recovered in about four weeks after treatment. Glyphosate was found to be generally more effective when applied pre-plant followed by sequential application of either alachlor or atrazine than when each of the two soil residual herbicides was mixed with glyphosate and applied pre-plant. Good control of Pannisetum purpureum Schamach in no tillage maize using glyphosate at 4.8 kg ae./ha and 6.0 ae./ha was obtained by Michieka and Akobundu (1979) in trial conducted in Bendel State, South-western Nigeria.

Lagoke (1978) found glyphosate at 4.0 kg ae./ha to be a better systemic herbicide compared with dalapan at 15 kg a.i./ha in the control of speargrass in trials conducted at Ilaro, south-western Nigeria. He also reported that ploughing before and after application resulted in better performance of glyphosate in the control of speargrass. De Datta and Lacsina (1974) reported significantly better control of Scirpus maritimus L. when glyphosate was applied at 0.75 and 1.0 kg ae./ha compared with the untreated control. Glyphosate at 0.75 kg ae./ha was comparable in performance to bentazon at 3.0 kg a.i./ha both in efficacy of control and subsequent effect on grain yield. At Birnin Kebbi in the northern Guinea Savanna of Nigeria, glyphosate at 2.0 kg ae./ha was

more effective in the reduction of weed dry-weight compared with paraquat at 4.8 kg a.i./ha and dalapon at 10 kg a.i./ha (Anon, 1980). Claus and Behrens (1972) reported greater kill of taller quackgrass (Agropyron repens Linn) plants by glyphosate at 0.28 to 1.12g ae./ha when applied on 55cm, 25cm and 12.5cm tall plants. They further observed over 80% control of quackgrass when 1.68kg ae./ha of glyphosate was sprayed on 20cm tall plants as against 51% control when 12.5cm tall plants were treated. Various other workers such as Brockman et al. (1973) working with quackgrass, Connel and Derting (1973) and Derting et al. (1973) working with Johnsongrass Sorghum halepense Stapf attributed better control of actively growing and older stages of these perennial grasses with glyphosate to (1) greater rhizome commitment (2) more active basipetal translocation of glyphosate with the photosynthate and (3) greater foliage interception of the herbicide.

# Chapter 3 MATERIALS AND METHODS

The field experiments were conducted on the farm of National Cereals Research Institute, Badeggi (longitude 6° 07'E and latitude 9° 45'N, 70.5metres above mean sea level) in the Southern Guinea Savanna ecological zone of Nigeria to evaluate herbicides for weed control in rice cultivars. In 1985 wet season, a preliminary experiment was conducted in the greenhouse to evaluate some herbicides for the control of cutgrass. Details of the methodology of each experiment are contained in the appropriate subsection. The soil at the experimental sites was fine sandy loam. Details of the physico-chemical properties of the soil and common weed species at the experimental site are contained in Tables 3.1 and 3.2 respectively. Records of meteorological data viz temperature, rainfall, relative humidity and sunshine hours which were obtained from the meteorological station at Badeggi in the years of experimentation are contained in the Appendix.

## 3.1 Experiment 1. Chemical control of weeds in three rice cultivars.

The experiments were conducted during the 1983 wet and 1983-84 dry seasons.

### 3.1.1 Cultural practices

For the wet season trial, the land was ploughed and disc-harrowed two weeks later. In the dry season trial, the experimental site was flooded and puddled by a rotavator before levelling which was done manually using the hand hoe. In the two trials, all the plots were given a blanket application of molinate at 4.0 kg a.i./ha three days before seeding.

Table 3.1 Physical and Chemical analysis of soil samples taken at two depths from experimental sites at Badeggi.

| Depth (cm) | Sand % | Silt % | Clay % | pH in water | 0.01M KCl | Organic C % | Total N % | Bray P-1 (ppm) | Exchangeable cations (Meq/100g) | | | | | | CEC Meq/100g |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | $Ca^{2+}$ | $Mg^{2+}$ | $K^{+}$ | $Na^{+}$ | $Al^{3+}$ | $H^{+}$ | |
| 1983 Wet Season | | | | | | | | | | | | | | | |
| 0-15 | 71.51 | 17.49 | 11.00 | 4.75 | 4.21 | 0.84 | 0.16 | 4.14 | 0.96 | 0.96 | 0.04 | 0.04 | 0.68 | 0.05 | 2.18 |
| 15-35 | 77.28 | 11.62 | 11.10 | 4.70 | 4.22 | 0.41 | 0.09 | 2.20 | 0.65 | 0.08 | 0.02 | 0.01 | 0.16 | 1.01 | 0.93 |
| 1983-84 Dry Season | | | | | | | | | | | | | | | |
| 0-15 | 70.00 | 20.00 | 10.00 | 4.80 | 4.50 | 0.88 | 0.13 | 4.00 | 0.98 | 0.14 | 0.03 | 0.06 | 0.74 | 0.06 | 2.01 |
| 15-35 | 82.00 | 12.00 | 6.00 | 4.60 | 4.11 | 0.41 | 0.05 | 0.10 | 0.74 | 0.04 | 0.04 | 0.01 | 0.41 | 0.02 | 1.26 |
| 1985 Wet Season | | | | | | | | | | | | | | | |
| 0-15 | 70.60 | 18.40 | 11.00 | 4.72 | 4.16 | 0.88 | 0.17 | 3.96 | 0.90 | 0.20 | 0.11 | 0.07 | 0.80 | 0.06 | 2.14 |
| 15-35 | 75.11 | 16.00 | 8.99 | 4.72 | 4.00 | 0.42 | 0.04 | 1.80 | 0.84 | 0.06 | 0.06 | 0.04 | 0.35 | 0.00 | 1.35 |
| 1986 Wet Season | | | | | | | | | | | | | | | |
| 0-15 | 74.00 | 9.35 | 11.65 | 4.81 | 4.62 | 0.84 | 0.18 | 4.02 | 1.60 | 0.18 | 0.09 | 0.06 | 0.91 | 0.08 | 2.92 |
| 15-35 | 78.21 | 12.65 | 9.14 | 4.70 | 4.22 | 0.48 | 0.03 | 0.95 | 0.74 | 0.04 | 0.04 | 0.01 | 0.53 | 0.01 | 1.37 |
| 1986-87 Dry Season | | | | | | | | | | | | | | | |
| 0-15 | 78.61 | 10.33 | 11.06 | 4.90 | 4.50 | 0.82 | 0.14 | 4.33 | 0.94 | 0.11 | 0.10 | 0.04 | 0.76 | 0.09 | 2.04 |
| 15-35 | 78.80 | 14.20 | 7.00 | 4.72 | 4.22 | 0.50 | 0.06 | 0.15 | 0.72 | 0.09 | 0.02 | 0.01 | 0.14 | 0.00 | 0.98 |

Textural class, fine sandy loam.

Table 3.2 Weed species at the experimental sites and their levels of infestation

| Classification | Scientific name | Life cycle | Infestation level | | | |
|---|---|---|---|---|---|---|
| | | | 1983 WS | 1983-84 DS | 1986 WS | 1986-87 DS |
| Grasses | Digitaria debilis Willd. | Annual | H | M | L | L |
| | Eragrostis gangetica Steud | Annual | H | H | L | L |
| | Leptochloa coerulescens Steud | Annual | H | H | L | L |
| | Echinochloa pyramidalis Hitchc & Chase | Perennial | L | L | - | - |
| | Leersia hexandra Swartz Prod | Perennial | L | L | H | H |
| | Panicum proliferum var. Longijubatum Stapf | Perennial | L | L | - | - |
| | Sacciolepis africana Hubb et Snowden | Perennial | H | H | - | - |
| Sedges | Cyperus difformis Linn | Annual | H | H | - | - |
| | Cyperus compressus Linn | Annual | L | L | - | - |
| | Fimbristylis dichotoma Linn Vahl | Annual | L | L | - | - |
| | Scirpus cubensis Peoppig & Kunth | Perennial | L | L | - | - |
| | Cyperus sphacelatus Rottb | Annual | L | L | - | - |
| Broad-leaved | Sphenochlea zeylanica Gaertn | Annual | M | M | - | - |
| | Ipomoea aquatica Forsk | Annual | L | L | - | - |
| | Heteranthena callifollia Rohb & Kunth | Annual | L | L | - | - |
| | Celosia trigyna Linn | Annual | L | L | - | - |

H = High infestation (60-90%); M = Moderate infestation (40-50%); L = Low infestation (10-39%)
Nill (absent) WS = Wet season; DS = Dry season.

In the two experiments, rice was planted on June 8, 1983 and December 6, 1983. In the wet season trial, the three cultivars FARO 15, FARO 29 and FARO 27 were drill-seeded at an inter-row spacing of 30cm at a depth of 2cm giving a seeding rate of 80kg/ha. In the dry season trial pre-germinated seeds were drilled on moist surface at the seeding rate and spacing indicated for the wet season.

A basal application of 40kg $P_2O_5$ and 40kg $K_2O$/ha using single super phosphate and muriate of potash was done by broadcasting before seeding in the two trials. Urea at the rate of 80kg N/ha was broadcast in all the plots at four weeks after seeding. The experimental area was bunded and each plot was also seperated by bunds. In the wet-season trial, uniform water depth of 15cm was maintained throughout the crop life-cycle by supplementary irrigation. The water depth was monitored with a metre rule. In the dry season trial, shallow water depth of 3cm was maintained throughout the crop life cycle also by supplementary irrigation.

3.1.2 Experimental design and treatments

The experiment was laid out in a split-plot design with rice cultivars in the main-plot and weed control treatments in the sub-plot. All the treatments were replicated four times. The main plot whose gross size was 40m long by 5.1m wide consisted of eight sub plots, while the sizes of the sub plot were 5m long by 5.1m wide and 4m by 3m wide for the gross and net sub plots.

The main treatments evaluated were three rice cultivars FARO 15, FARO 29 and FARO 27 whose seeds were collected from National Cereals Research Institute seed store. A brief description of the cultivars is given below.

FARO 15 which is derived from the hybridisation of FARO 1 (BG 79) and IR 8 at the National Cereals Research Institute, Badeggi grows under shallow irrigated conditions The plant whose leaves are short, erect and thick is of intermediate height (120 - 130cm) and high tillering ability. It responds to high nitrogenous fertilizer application and has an average yield of 4 to 5t/ha. FARO 1 is a late maturing variety with a maturity time of 140 to 150 days. The grain is bold with a length to width ratio of about 2.0 to 3.0.

FARO 29 whose origin is Ceylon grows under shallow swamp and irrigated conditions. It has a medium plant height of 100 - 106cm, with moderate tillering ability. It responds to high nitrogen fertilizer and has an average yield of 4 to 5t/ha. It is an early maturing variety with a maturity time of 110-120 days. The grain is bold, with a length to width ratio of about 2.0 to 3.0.

FARO 27 which was developed at the International Rice Research Institute(IRRI), Philippines grows under shallow water conditions with medium plant height (90-95cm) and tillers moderately. It responds to high nitrogenous fertilizer application, producing an average yield of 4 to 5t/ha. It is an early-maturing variety

with a maturity time of 100-110 days. The grain is slender, with a length to width ratio of about 3.0.

The sub-plot treatments consisted of variable rates of herbicide mixtures (Table 4.1).

3.13 Herbicide application

Herbicides were applied with a knapsack sprayer using a deflector nozzle at a pressure of about 2.1 kg $cm^2$ and in a spray volume of 200 litres/ha. The plots were drained to expose the weeds before herbicide application and again flooded with water three days after herbicide application.

3.14 Observations

Weed dry matter

Weed samples were taken from an 0.5 x 0.5m quadrat at 30 and 60 days after herbicide application (DAH) and at harvest. The weed samples which were cut at ground level were oven-dried at 70°C for 48 hours for dry weigh.

Weed cover (%)

Percentage coverage of weeds was taken with visual observation of all the plots using a 0 to 100 scale where 0 = no weeds and 100 = complete weed cover.

3.2 Evaluation of herbicides for the control of cutgrass in the greenhouse

The experiment was conducted between July and October, 1985 in the greenhouse of National Cereals Research Institute, Badeggi to identify treatments for field evaluation against cutgrass in rice. During the period of experimentation the daily minimum and maximum

temperature were 23 ± 2 and 31 ± 3°C while the relative humidity was 84 ± 10%.

3.2.1 Greenhouse practice

The soil which was used for the experiment was a fine sandy loam obtained from the top 15cm profile of the north field of the experimental farm of the Institute. Details of the physico-chemical characteristics of the soil are contained in Table 3.1. Fertilizers were mixed thoroughly with the dry soil at the equivalent of 80kg N/ha, 40 kg $K_2O$/ha and 40 kg $P_2O_5$/ha using urea, muriate of potash and single super phosphate respectively. The soil was then used to fill one-half the volume each of the 15-litre plastic pots. The soil in each pot was saturated with water before cutgrass plant whose apical shoot had been removed to stimulate lateral shoot growth was planted. The length of each planting material with four nodes was 12.0cm. The soil in each pot was kept water saturated by regular daily watering to enhance successful establishment of cutgrass plant.

3.2.2 Experimental design and treatments

The pots were arranged in a randomised complete block design in four replicates. There were eleven herbicide treatments and an untreated control. The herbicides tested included glyphosate, oxadiazon and combinations of herbicide treatments applied on repidly

growing tillers, at bud initiation and at 2-3-leaf stage of regrowth of cutgrass respectively. Details are indicated in Table 4.21.

3.2.3. Herbicide application

Herbicides were applied with a knapsack sprayer using a deflector nozzle at a pressure of about 2.1kg/cm$^2$ and in a spray volume of 200 litres/ha. Pre-emergence herbicides were applied at bud initiation while early post-emergence herbicides were applied at 2 to 3 leaf stage of cutgrass. Glyphosate, a foliar translocated herbicide, was applied when the tillers were rapidly growing about three weeks after planting. During application all the pots constituting a treatment were arranged in a marked out area 1m wide by 10m long and sprayed at the same time. After each application, all the pots were returned to the greenhouse and subjected to regular flooding.

3.2.4. Observations

Visual control rating

Control ratings of cutgrass based on observation were made at one, two, four, eight and twelve weeks after herbicide application using a scale of 0 to 100 where 0 = no control and 100 = complete control.

Tiller number of cutgrass

Tiller number of cutgrass was taken per pot at 30 and 60 days after herbicide application and at maturity.

Plant height of cutgrass

Plant height of cutgrass was taken at maturity from the base of the plant to the tip of each tiller. Six tagged tillers were used per pot for height determination.

Dry matter production

The shoots, roots, and rhizomes in each pot were harvested at 12 weeks after planting. The roots and rhizomes were washed free of soi;. All the plant parts were oven-dried at 70°C for about 48 hours to constant weight.

## 3.3 Evaluation of herbicide combinations for the control of cutgrass in rice in the field

### 3.3.1. Description of experimental site

The field trials were conducted on the sites of the farm of National Cereals Research Institute, Badeggi that were highly infested with cutgrass during the 1985-86 and 1986-87 dry and 1986 wet seasons. Details of the physico-chemical properties of the soil are contained in Table 3.1. Records of meteorological data, temperature, rainfall, and relative humidity were obtained from the meteorological station at Badeggi (Appendix 1 - 13).

### 3.3.2 Cultural practices

Land preparation was carried out in the wet and dry season trials as reported for experiment 1. Cutgrass plants were allowed to sprout from basal underground rhizomes, stolons and seeds. The average height attained before herbicide application was 8 to 12cm. The three trials were established at Badeggi on Novermber 6, 1985,

June 21, 1986 and October 20, 1986 by dibbling rice seeds (cv FARO 29) at a spacing of 20cm by 20cm. Fertilizers were applied as described for experiment 1.

3.3.3 Experimental design and treatments

Design and layout

The experiment was laid out in a split-split-plot design with levels of glyphosate as main-plot treatment and pre-emergence oxadiazon as sub-plot treatment and the post-emergence herbicide treatments assigned to sub-sub-plots. The whole experimental unit was replicated four times. The gross and net sub-sub-plot sizes were 4m by 3m and 3m by 2m. The routine samples were taken from the remaining outer rows. The gross main plot size was 32m by 6m while the sub-plot was 32m by 3m.

Treatments

The main plot treatments were three levels of foliar-applied glyphosate at 0.0, 0.5 and 1.0 kg ae./ha while the sub-plot treatments were pre-emergence oxadiazon at 0, 0 and 0.75 kg a.i./ha. The sub-sub-plot treatments were post-emergence herbicide mixtures (Table 4.25)

3.3.4 Herbicide application

Herbicides were applied with a knapsack sprayer using a deflector nozzle at a pressure of about 2.1 kg/cm$^2$ and in spray volume of 2001/ha. Glyphosate was applied on 12cm regrowth of cutgrass and 21 days after application the plots were levelled with hand-hoe in 1986 wet and in the 1985-86 and 1986-87 dry seasons the plots were flooded and puddled manually. Pre-emergence oxadiazon was applied before weed emergence but three days prior to

seeding to eliminate crop toxicity on fine sandy loam soil. The post-emergence herbicide mixtures were applied 14 days after seeding.

3.3.5. Observations

Cutgrass infestation

Plots were scored visually for cutgrass using a scale of 0 to 100 where 0 = no cutgrass and 100 = complete cutgrass cover. Cutgrass plant parts above the ground were cut from 0.5 x 0.5m quadrat area, each from two random spots at opposite ends of each plot. The sampled weeds were oven-dried at 70°C until dry weight was constant which usually took about 48 hours.

Rice crop.

Data were obtained on the following crop parameters: plant height of rice at 28, 56 and 98 DAS, tiller number 30 and 60 DAS, number of panicles per ha, number of spikelets per panicle, percentage of unfilled grains and grain yield in 1986 wet and 1986-87 dry season trials (Tables 4.45-4.63). In the 1985-86 dry season trial (Table 4.60) only the grain yield was determined because it was a preliminary trial. Plant height of rice was measured from the base of the plant to the uppermost growing tip. Tiller number of rice was taken from $0.5m^2$ sampling area and later converted to $m^2$. Number of panicles was taken from plants sampled at harvest from area of $0.5m^2$. Spikelets were counted per panicle from the panicles sampled.

Percentage of unfilled grains was determined by taking a count of both total grains and unfilled grains and the latter expressed as a percentage of the former. Weights of 1000 grain of each plot harvest was also determined. Grain was harvested at 14% moisture content from the net plot and the yields converted to tons/ha.

3.4 Analysis of data

All data were subjected to statistical analysis. Regression analysis was also done on some variables. Treatment means were compared using Duncans Multiple Range Test (DMRT). Only data of observations whose F value differed in significance from the original data when transformed had the treatment mean comparison based on the transformed data. Otherwise the original data were used for treatment comparison. The type of transformation varied with the distribution of the data.

# RESULTS

## 4.1 Chemical control of weeds in three rice cultivars

### 4.1.1 Plant height

Cultivars differed significantly in plant height at 28, 56 and 98 days after sowing (DAS) in the 1983 wet and 1983-84 dry season trials. At 28 DAS in the wet and dry seasons, FARO 27 plants were significantly shorter than those of FARO 29 and FARO 15 which were comparable in height. At 56 DAS in the wet and dry season trials, plants of FARO 15 were significantly taller than those of FARO 29 and FARO 27. FARO 27 was however the shortest variety in the dry season trial. The results obtained at 98 DAS in the two trials were similar to that obtained at 56 days in the dry season trial (Table 4.1).

The effect of weed control treatments on height of rice was also significant at 28 and 56 DAS. At 28 and 56 DAS, plants in the hand-weeded plots were significantly taller than those of the herbicide treated and unweeded control plots in the wet and dry seasons. At 28 DAS in the wet season, among all the herbicide treatments, only butachlor plus propanil at 3.6 + 1.02 kg a.i./ha resulted in significantly taller plants than the unweeded control while all the herbicide treatments resulted in taller plants in the dry season. The mixture of benthiocarb + propanil + silvex at 1.8 + 3.24 + 0.75 kg a.i./ha, however resulted in shorter rice plants than the other herbicide treatments in the dry season. At 56 DAS in the wet and dry season trials, benthiocarb + propanil + silvex at 1.8 + 3.24 + 0.75 kg a.i./ha resulted

in shorter plants than those of the same mixtures at 1.08 + 1.44 + 0.45 kg a.i./ha and 1.44 + 2.5 + 0.6 kg a.i./ha and all the mixtures containing butachlor only in the wet season. In the dry season trial, plots treated with butachlor + propanil at 1.8 + 2.04 kg a.i./ha had the shortest plants among herbicide treatments.

At 98 DAS in the wet season, plots treated with butachlor plus propanil at 2.4 + 1.7 kg a.i./ha and 3.6 + 1.02 kg a.i./ha and benthiocarb + propanil + silvex at 1.44 + 2.5 + 0.6 kg a.i./ha had plants with comparable height to those of the hand-weeded control. Mixtures of bentiocarb with propanil and silvex resulted in the shortest plants in this trial. In the dry season, no significant differences were observed in plant height between the herbicide treatments.

The interaction of cultivar and herbicide treatments on plant height at maturity was significant in the two trials (Tables 4.2 and 4.3). In both trials FARO 15 consistently produced taller plants irrespective of the herbicide mixtures compared with FARO 29 and FARO 27. In the wet season, under FARO 15, benthiocarb + propanil + silvex at 1.08 + 1.44 + 0.45 kg a.i./ha and butachlor + propanil at 1.8 + 2.04 kg a.i./ha resulted in significantly shorter rice plants than the hand-weeded control while all the weed control treatments including hand-weeding resulted in similar plant heights in FARO 27. Except butachlor + propanil at 1.8 + 2.04 kg a.i./ha, all the herbicide treatments resulted in comparable plant

height to hand-weeding under FARO 29 (Table 4.2).

In the dry season under FARO 15 and FARO 27, all the herbicide treatments resulted in comparable plant height to the hand-weeded control (Table 4.2). FARO 27 rice plant height at maturity for all the weed control treatments, including hand-weeding, were similar in the trial. However under FARO 29, benthiocarb + propanil + silvex at 1.08 + 1.44 + 0.45 kg a.i./ha caused significantly shorter plants than hand-weeding.

4.1.2 Tiller number at 30 and 60 DAS

In the wet season, at 30 DAS, FARO 27 produced significantly higher number of tillers than FARO 29 and FARO 15 which had similar values (Table 4.4). In the dry season, FARO 15 produced significantly higher number of tillers than FARO 29 and FARO 27, FARO 29 also produced higher tiller number than FARO 27 in the same trial (Table 4.4) However, cultivar did not differ significantly in tiller production at 60 DAS in both the wet and dry seasons.

The effect of weed control treatments on tiller number at 30 and 60 DAS was significant in the two trials. At 30 DAS in the wet season trial, among the herbicide treatments, only benthiocarb plus propanil plus silvex at 1.08 + 1.94 + 0.45 kg a.i./ha resulted in comparable tiller number to the hand-weeded control. Conversely butachlor plus propanil at 1.8 + 2.04 kg a.i./ha caused the least tiller production which was significantly

Table 4.1 Effects of cultivars and weed control treatments on plant height in direct seeded lowland rice at Badeggi, 1983 wet and 1983-84 dry seasons

| Treatments | Rate (Kg a.i./ha) | Time DAS | Plant height (cm) Days after seeding | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 56 | 98 | | 28 | 56 | 98 |
| | | | Wet Season | | | Dry Season | | |
| Cultivar | | | | | | | | |
| FARO 15 | - | - | 29.6a | 77.7a | 102.6a | 30.5a | 73.0a | 105.5a |
| FARO 27 | - | - | 25.9b | 74.6b | 84.6c | 30.1c | 64.1c | 83.7c |
| FARO 29 | - | - | 28.9a | 74.7 b | 92.6 b | 31.3 a | 67.1 b | 90.8 b |
| SE± Cultivar | - | - | 0.24 | 0.49 | 0.66 | 0.21 | 0.60 | 1.53 |
| Weed Control | | | | | | | | |
| Benthiocarb + propanil + silvex | 1.08+1.44+0.45 | 14 | 27.8bc | 77.4 bc | 103.6 bc | 31.0 b | 71.4 b | 105.5 a |
| Benthiocarb + propanil + silvex | 1.44+2.5+0.6 | 14 | 27.1 bc | 74.5 cd | 106.9 ab | 30.5 b | 71.4 b | 106.7 a |
| Benthiocarb + propanil + silvex | 1.8+3.24+0.75 | 14 | 27.0 bc | 71.6 d | 108.2 c | 29.6 c | 62.5 c | 108.7 a |
| Butachlor + propanil | 1.8 + 2.0 | 14 | 27.2 bc | 76.3 bc | 103.7 bc | 30.3 b | 58.7 d | 105.7 a |
| Butachlor + propanil | 2.4 + 1.7 | 14 | 27.8 bc | 78.1 b | 107.6 a | 30.7 b | 70.4 b | 106.2 a |
| Butachlor + propanil | 3.6 + 1.02 | 14 | 28.9 b | 77.5 bc | 107.6 a | 30.9 b | 71.7 b | 105.7 a |
| Handweeding twice at | - | 20 & 40 | 33.1 a | 84.8 a | 108.5 a | 38.3 a | 80.4 a | 108.9 a |
| Unweeded control | - | - | 26.2 c | 65.2 e | 65.2 d | 24.1 d | 48.0 e | 48.0 b |
| SE± Weed control | - | - | 0.61 | 0.94 | 1.12 | 0.69 | 0.75 | 1.34 |

Means followed by the same letter(s) within a treatment column are not significantly different using DMRT at 5% level of probability.

Table 4.2 Interaction of cultivars and weed control treatments on plant height at 98 DAS in direct-seeded lowland rice at Badeggi, 1983 wet season

| Treatments | Application | | Plant height at 98 DAS (cm) | | |
|---|---|---|---|---|---|
| | 1 Rate (kg a.i./ha) | Time (DAS) | FARO 15 | FARO 27 | FARO 29 |
| Benthiocarb + propanil + silvex | 1.08 + 1.94 + 0.45 | 14 | 110.7 b | 94.9 f | 105.3 bcd |
| Benthiocarb + propanil + silvex | 1.44 + 2.5 + 0.6 | 14 | 118.7 a | 97.3 f | 104.5 cde |
| Benthiocarb + propanil + silvex | 1.8 + 3.24 + 0.75 | 14 | 119.8 a | 98.0 ef | 107.0 bc |
| Butachlor + propanil | 1.8 + 2.04 | 14 | 111.0 b | 93.9 f | 100.0 def |
| Butachlor + propanil | 2.4 + 1.7 | 14 | 118.5 a | 100.0 def | 104.4 cde |
| Butachlor + propanil | 3.6 + 1.02 | 14 | 119.8 a | 96.6 f | 106.5 bcd |
| Handweeding twice at | - | 20 & 40 | 123.0 a | 96.0 f | 106.7 bc |
| Unweeded control | - | - | 0.0 g | 0.0 g | 0.0 g |
| SE± Cultivar x Weed control treatments | | | | 1.93 | |

1 DAS = Days after seeding

Means followed by the same letter(s) within a column are not significantly different using Duncans Multiple Range Test (DMRT) at 5% level of probability.

Table 4.3 Interaction of cultivar and weed control treatments on plant height at maturity in direct-seeded lowland rice at Badeggi, 1983-84 dry season.

| Treatments | Rate (kg a.i./ha) | Time of application DAS | Plant height at 98 DAS (cm) FARO 15 | FARO 27 | FARO 29 |
|---|---|---|---|---|---|
| Benthiocarb + propanil + silvex | 1.08 + 1.94 + 0.45 | 14 | 120.8 a | 97.3 cd | 98.5 cd |
| Benthiocarb + propanil + silvex | 1.44 + 2.5 + 0.6 | 14 | 123.7 a | 92.7 d | 103.7 bc |
| Benthiocarb + propanil + silvex | 1.8 + 3.24 + 0.5 | 14 | 126.0 a | 95.0 cd | 105.2 b |
| Butachlor + propanil | 1.8 + 2.04 | 14 | 118.7 a | 94.5 cd | 104.0 b |
| Butachlor + propanil | 2.4 + 1.7 | 14 | 118.5 a | 97.0 cd | 103.2 bc |
| Butachlor + propanil | 3.6 + 1.02 | 14 | 119.0 a | 94.5 cd | 103.6 bc |
| Handweeding twice at | | 20 & 40 | 120.0 a | 98.5 cd | 108.3 b |
| Unweeded control | | | 0.0 e | 0.0 e | 0.0 e |
| SE± Cultivar x weed control treatments | | | | 2.66 | |

DAS = Days after seeding

Means followed by the same letter(s) within a column are not significantly different using Duncan's Multiple Range Test (DMRT) at 5% level.

Table 4.4 Effects of cultivar and weed control treatments on number of tillers in direct-seeded lowland rice at Badeggi, 1983 and 1983-84 wet and dry seasons.

| Treatments | Rate kg a.i./ha | Time of application | Tiller (number/ha x 10,000) | | | |
|---|---|---|---|---|---|---|
| | | | 30 DAS | | 60 DAS | |
| Cultivar | | | WS | DS | WS | DS |
| FARO 15 | | | 323 b | 418 a | 306 a | 381 a |
| FARO 27 | | | 344 a | 336 c | 325 a | 371 a |
| FARO 29 | | | 318 b | 396 b | 308 a | 366 a |
| SE± Cultivar | | | 6.08 | 5.80 | 6.30 | 3.42 |
| Weed control | | | | | | |
| Benthiocarb+propanil+silvex | 1.08+1.94+0.45 | 14 | 385 a | 422 b | 315 c | 366 d |
| Benthiocarb+propanil+silvex | 1.44+2.5+0.6 | 14 | 350 bc | 403 bc | 328 c | 373 d |
| Benthiocarb+propanil+silvex | 1.8+3.24+0.75 | 14 | 307 d | 337 e | 400 a | 472 b |
| Butachlor + propanil | 1.8 + 2.04 | 14 | 294 e | 347 de | 336 c | 354 d |
| Butachlor + propanil | 2.4 + 1.7 | 14 | 334 c | 374 cd | 361 b | 378 d |
| Butachlor + propanil | 3.6 + 1.02 | 14 | 355 b | 426 b | 374 b | 440 c |
| Hand-weeding twice at | | 20 & 40 | 383 a | 466 a | 383 ab | 511 a |
| Unweeded control | | | 218 f | 292 f | 100 d | 89 e |
| SE± Weed control | | | 6.85 | 7.89 | 6.85 | 10.57 |

Means followed by the same letter(s) within a column are not significantly different using Duncan's Multiple Range Test DMRT at 5% level.

WS = Wet season; DS = Dry season.

lower than those of the other herbicide treatments. In the dry season, none of the plots treated with herbicide produced comparable tiller number to the hand-weeded control. Benthiocarb plus propanil plus silvex at 1.8 + 3.24 + 0.75 kg a.i./ha and butachlor plus propanil at 1.8 + 2.04 kg a.i./ha resulted in lower number than the other herbicide treatments. Butachlor plus propanil at 2.4 + 2.7 kg a.i./ha also caused lower tiller number production than the mixture with the higher rate of butachlor and benthiocarb mixtures at 1.08 + 1.94 + 0.45 and 1.44 + 2.05 + 0.6 kg a.i./ha respectively.

At 60 DAS in the wet season, mixture containing benthiocarb at the highest rate resulted in the highest tiller number which differed significantly from those of the other weed control treatments including hand-weeding. Mixtures with lower rates of the same herbicide and lowest rate of butachlor however, caused lower tiller number compared with hand-weeding.

In the dry season none of the herbicide treatments resulted in comparable tiller number at 60 DAS to the hand-weeded control. Mixtures containing the highest rate of benthiocarb and butachlor however resulted in significantly higher tiller number than the remaining herbicide treatments While the corresponding mixtures containing the lowest and medium rates of the herbicide caused similar tiller number. With butachlor plus propanil, tiller number increased significantly with the rate of butachlor in the mixtures.

4.1.3 Panicle number per hectare

Cultivars differed significantly in the number of

Table 4.5 Effects of cultivar and weed control treatments on the number of panicles and spikelets and % unfilled grains in direct-seeded lowland rice at Badeggi, 1983 wet and 1983-84 dry season.

| | Rate (kg a.i./ha) | Application (DAS) | Panicles (no/hax10000) | | Spikelets 6 (no/ha x 10) | | Unfilled grains (%) | |
|---|---|---|---|---|---|---|---|---|
| Cultivar | | | WS | DS | WS | DS | WS | DS |
| FARO 15 | - | - | 274 a | 353 a | 396 b | 340 c | 21.5 d | 31.8 a |
| FARO 27 | - | - | 208 b | 329 b | 400 b | 410 b | 20.3 a | 12.0 c |
| FARO 29 | - | - | 275 a | 329 b | 453 a | 582 a | 18.0 b | 21.0 b |
| SE± Cultivar | | | 8.02 | 6.16 | 3.41 | 12.54 | 0.57 | 0.61 |
| Weed control | | | | | | | | |
| Benthiocarb+propanil+ silvex | 1.08+1.94+0.45 | 14 | 202 e | 295 d | 332 f | 336 f | 11.6 a | 25.3 a |
| Benthiocarb+propanil+ silvex | 1.44+2.5+0.6 | 1 14 | 281 c | 345 cd | 459 d | 441 d | 8.7 bcd | 22.3 b |
| Benthiocarb+propanil+ silvex | 1.8+3.24+0.75 | 14 | 373 a | 456 a | 618 a | 623 a | 7.0 d | 15.3 d |
| Butachlor + propanil | 1.8 + 2.0 | 14 | 240 d | 319 c | 391 e | 391 e | 10.0 ab | 23.7 ab |
| Butachlor++ propanil | 2.4 + 1.7 | 14 | 254 d | 358 b | 417 e | 452 c | 9.8 ab | 22.5 ab |
| Butachlor + propanil | 3.6 + 1.0 | 14 | 354 a | 398 ab | 591 ab | 519 b | 7.3 cd | 19.0 c |
| Hand-weeding twice | - | 20 & 40 | 311 b | 452 a | 517 c | 614 a | 5.0 e | 15.0 d |
| Unweeded control | - | - | 0 f | 70 e | 0 g | 41 g | 0.0 f | 25 a |
| SE± Weed control treatments | | | 6.69 | 11.11 | 9.37 | 14.42 | 0.64 | 0.71 |

Means followed by the same letter(s), within a column are not significantly different using Duncans Multiple Range Test (DMRT) at 5% level of probability
WS = Wet Season; DS = Dry Season.

Table 4.6. Interaction of cultiver and weed control treatment on the number of panicles in direct-seeded lowland rice at Badeggi, 1983 wet season.

| Treatments | Rate (kg a.i./ha) | Time of Application (DAS) | Panicles (number/hax10,000) | | |
|---|---|---|---|---|---|
| | | | FARO 15 | FARO 27 | FARO 29 |
| Benthiocarb + propanil + silvex | 1.08 + 1.94+0.45 | 14 | 210 fg | 173 gh | 226 f |
| Benthiocarb + propanil+silvex | 1.44+2.5+0.6 | 14 | 312 de | 208 g | 324 de |
| Benthiocarb + propanil + silvex | 1.8+3.24+0.75 | 14 | 423 a | 311 de | 380 b |
| Butachlor + propanil | 1.8 + 2.04 | 14 | 266 f | 142 h | 312 de |
| Butachlor + propanil | 2.4 + 1.7 | 14 | 274 e | 205 f | 284 e |
| Butachlor + propanil | 3.6 + 1.02 | 14 | 370 bc | 328 d | 372 bc |
| Hand-weeding twice at | | 20 & 40 | 332 cd | 300 de | 302 de |
| Unweeded control | | | 0.0 i | 0.0 i | 0.0 i |
| SE± Cultivar x Weed control treatments | | | - | 13.48 | - |

Means followed by the same letter(s), within a column are not significantly different using Duncan's Multiple Range Test (DMRT) at 5% level

DAS = Days after seeding.

panicles produced per hectare in the wet and dry seasons. In the wet season, FARO 15 and FARO 29 produced similar number of panicles per hectare which were significantly higher than that of FARO 27. FARO 15 also produced significantly higher panicle number than the other two cultivars in the dry season.

Herbicide treatments resulted in significantly higher number of panicles than the untreated control in the two seasons. In the wet season, the plots treated with the highest rate of benthiocarb plus propanil plus silvex at 1.8 + 3.24 + 0.75 kg a.i./ha and butachlor plus propanil at 3.6 + 1.02 kg a.i./ha produced significantly higher number of panicles than those of other herbicide treatments and those hand-weeded twice. In the dry season, benthiocarb + propanil + silvex at 1.8 + 3.24 + 0.75 kg a.i./ha and butachlor plus propanil at 3.6 + 1.02 kg a.i./ha resulted in panicle numbers that were comparable to that of hand-weeding (Table 4.5).

The interaction of cultivars and herbicide treatments on panicle number of rice was significant in the two trials. In the wet season under FARO 15, benthiocarb + propanil + silvex at 1.8 + 3.24 + 0.75 kg a.i./ha caused significantly higher number of panicles than the other herbicide treatments and hand-weeding. Under this variety, panicle number increased with the rate of benthiocarb in the mixture. However, butachlor plus propanil at 3.6 + 1.02 kg a.i./ha caused comparable panicle number to hand-weeding while other treatments resulted in

Table 4.7. Interaction of cultivar and weed control treatment on the number of panicles in direct-seeded lowland rice at Badeggi, 1983- 84.dry season

| Treatments | Rate (kg a.i./ha) | Time of application (DAS) | Panicles(number/ha x 10,000) FARO 15 | FARO 27 | FARO 29 |
|---|---|---|---|---|---|
| Benthiocarb + propanil + silvex | 1.08 + 1.94+0.45 | 14 | 300 e | 280 e | 305 e |
| Benthiocarb + propanil+ silvex | 1.44+2.5+0.6 | 14 | 374 cd | 308 e | 354 de |
| Benthiocarb+propanil+silvex | 1.8+3.24+0.75 | 14 | 462 a | 436 ab | 470 a |
| Butachlor + propanil | 1.8 + 2.04 | 14 | 304 e | 314 e | 280 e |
| Butachlor + propanil | 2.4 + 1.7 | 14 | 395 bcd | 366 cde | 314 e |
| Butachlor + propanil | 3.6 + 1.02 | 14 | 413 abc | 400 bcd | 378 cd |
| Hand-weeding twice at | | 20 & 40 | 420 abc | 468 a | 468 a |
| Unweeded control | | | 92 f | 60 f | 60 f |
| SE± Cultivar x Weed control treatments | | | | 19.03 | |

Means followed by the same letter(s) within a column are not significantly different according to Duncan's Multiple Range Test (DMRT) at 5% level.

DAS = Days after seeding.

significantly lower values. With FARO 27, benthiocarb + propanil + silvex at 1.8 + 3.24 + 0.75 kg a.i./ha and butachlor + propanil at 3.6 + 1.02 kg a.i./ha resulted in significantly higher number of panicles than all the other herbicide treatments and was comparable to the hand-weeded control. Under this variety, the least number of panicles was produced with the mixture containing the least amount of butachlor. Under FARO 29, the mixtures of propanil with the highest rates of benthiocarb plus silvex and butachlor resulted in similar panicle number that were significantly higher than that of the hand-weeded control. The plots treated with the mixture of propanil with the lowest rate of benthiocarb plus silvex at 1.94 + 1.08 + 0.45 kg a.i./ha under this variety produced the least number of panicles (Table 4.6).

In the dry season, under FARO 15 plots treated with benthiocarb + propanil + silvex at 1.8 + 3.24 + 0.75 kg a.i./ha and butachlor + propanil at 3.6 + 1.02 kg a.i./ha, produced comparable number of panicles to the hand-weeded control while with FARO 27 and FARO 29 only those plots treated with mixture of propanil with the highest rate of benthiocarb plus silvex produced similar number of panicles to hand-weeding (Table 4.7).

4.1.4 Number of Spikelets per hectare

The effect of cultivar on the number of spikelets per hectare, was significant in the wet and dry seasons. FARO 29 produced significantly higher number of spikelets per hectare than the other two cultivars in both trials. In the dry season, FARO 27 resulted in significantly

Table 4.8. Interaction of cultivar and weed control treatments on the number of spikelets/ha in direct-seeded lowland rice at Badeggi, 1983 wet season.

| Treatments | Rate (kg a.i./ha) | Time of application (DAS) | Spikelets (number/ha x $10^6$) FARO 15 | FARO 27 | FARO 29 |
|---|---|---|---|---|---|
| Benthiocarb+propanil+ silvex | 1.08 + 1.44 + 0.45 | 14 | 302 i | 375 h | 370 h |
| Benthiocarb+propanil+ silvex | 1.44 + 2.5 + 0.6 | 14 | 449 g | 399 h | 531 e |
| Benthiocarb+propanil+ silvex | 1.8 + 3.24 + 0.75 | 14 | 616 abc | 595 bcd | 642 a |
| Butachlor + propanil | 1.8 + 2.04 | 14 | 383 h | 230 i | 511 ef |
| Butachlor + propanil | 2.4 + 1.7 | 14 | 394 h | 393 h | 465 fg |
| Butachlor + propanil | 3.6 + 1.02 | 14 | 532 e | 629 ab | 610 abc |
| Hand-weeding twice at | | 20 & 40 | 482 fg | 576 cde | 495 efg |
| Unweeded control | | | 0.0 j | 0.0 j | 0.0 j |
| SE± Cultivar x weed control treatments | | | | 15.57 | |

Means followed by the same letter(s) within column are not significantly different using Duncan's Multiple Range Test (DMRT) at 5% level.

DAS = Days after seeding.

higher number of spikelets than FARO 15 while both were comparable in the wet season (Table 4.5).

All the herbicide treatments resulted in significantly higher number of spikelets than the untreated control in the two trials. In the wet season, the mixture of propanil plus benthiocarb plus silvex at 3.24 + 1.8 + 0.75 kg a.i./ha resulted in significantly higher number of spikelets than the hand-weeded control and all the other herbicide treatments except butachlor + propanil at 3.6 + 1.02 kg a.i./ha. However, in the dry season, the former was comparable to the hand-weeded control. In the two trials, the number of spikelets increased as the rate of benthiocarb and butachlor increased in their respective mixtures. In all cases, among the herbicide treatments, the least number of spikelets occurred with the mixture containing the least rate of benthiocarb at 1.08 + 1.94 + 0.45 kg a.i./ha (Table 4.5).

Significant interaction between cultivar and herbicide treatments was observed on spikelet number in the two trials (Tables 4.8 & 4.9). In both trials, under FARO 15, the mixture containing the highest rate of benthiocarb caused significantly higher number of spikelets than all the other weed control treatments including hand-weeding. In the wet season, under the same variety, the other herbicide treatments resulted in significantly lower number of spikelets than the hand-weeded control. In the same season under FARO, 27, plots treated with butachlor in mixture with propanil produced the highest number of spikelets which was significantly higher than that of the hand-weeded control but comparable to that of benthiocarb + propanil + silvex at 1.8+3.24+ 0.75 kg a.i./ha. In the dry season, only benthiocarb + propanil +

Table 4.9. Interaction of cultivar and weed control treatments on the number of spikelets/ha in direct-seeded lowland rice at Badeggi, 1983-84 dry season.

| Treatments | Rate (kg a.i./ha) | Time of application DAS | Spikelets (number/ha x $10^6$) FARO 15 | FARO 27 | FARO 29 |
|---|---|---|---|---|---|
| Benthiocarb+propanil+silvex | 1.08 + 1.94 + 0.45 | 14 | 288 f | 230 f | 489 cd |
| Benthiocarb+propanil+silvex | 1.44 + 2.5 + 0.6 | 14 | 359 e | 400 e | 566 c |
| Benthiocarb+propanil+silvex | 1.8 + 3.24 + 0.75 | 14 | 491 cd | 588 b | 790 a |
| Butachlor + propanil | 1.8 + 2.04 | 14 | 349 e | 376 e | 448 d |
| Butachlor + propanil | 2.4 + 1.7 | 14 | 380 e | 475 d | 502 cd |
| Butachlor + propanil | 3.6 + 1.02 | 14 | 401 e | 520 cd | 638 b |
| Hand-weeding twice at | | 20 & 40 | 412 de | 655 b | 775 a |
| Unweeded control | | | 40 g | 36 g | 48 g |
| $SE_{\pm}$ Cultivar x Weed Control treatments | | | | 26.52 | |

Means followed by the same letter(s) within a column are not significantly different using Duncan's Multiple Range Test (DMRT) at 5% level.

DAS = Days after seeding.

silvex at 1.8 + 3.24 + 0.75 kg a.i./ha was comparable to the hand-weeded control. However, under FARO 29 in both the dry and wet seasons, only benthiocarb + propanil + silvex at 1.8 + 3.24 + 0.75 kg a.i./ha resulted in comparable number of spikelets to the hand-weeded control. Under FARO 15 and FARO 29 in the wet season and FARO 15 and FARO 27 in the dry season, spikelet number increased with the rate of benthiocarb in the mixture. Under FARO 27 in the wet season, the least was obtained with butachlor + propanil at 1.8 + 2.04 kg a.i./ha (Table 4.9).

4.1.5 % Unfilled grains

Cultivars differed significantly in the production of % unfilled grains in the two seasons (Table 4.5). In the wet season, FARO 29 had significantly lower % unfilled grains than the other two cultivars which had comparable values. In the dry season, % unfilled grains decreased with cultivar in the order of FARO 15, FARO 29 and FARO 27, respectively.

In the wet and dry seasons, weed control treatments had significant effect on the % unfilled grains. All the herbicide treatments resulted in higher % unfilled grains than the hand-weeded control in the wet season trial. In the dry season, benthiocarb plus propanil plus silvex at 1.8 +

3.24 + 0.75 kg a.i./ha resulted in lower % unfilled grains than the other herbicide treatments and was comparable to the hand-weeded check. Butachlor plus propanil at 3.6 + 1.02 kg a.i./ha also resulted in lower % unfilled grains than the remaining herbicide treatments.

4.1.6 1000 grain weight

Rice cultivars differed significantly in grain size in the dry season trial when FARO 15 produced higher 1000 grain weight than FARO 29 and FARO 27 which were similar.

Weed control treatments did not however, differ significantly in their effect on grain size in the two trials (Table 4.10.).

4.1.7 Grain yield

Cultivars differed significantly in rice grain yield in the two trials. In the wet season trial, FARO 27 produced significantly lower grain yield than FARO 29 and FARO 15 which had similar values (Table 4.10.). In the dry season trial, FARO 29 produced significantly higher grain yield than FARO 15 and FARO 27 which were also similar in grain yield (Table 4.10.).

All the weed control treatments resulted in significantly higher grain yield than the untreated control in the two seasons (Fig. 2). In the wet season, none of the herbicide treatments resulted in comparable grain yield to the hand-weeded control. Benthiocarb + propanil + silvex at 1.8 + 3.24 + 0.75 kg a.i./ha and butachlor + propanil at 3.6 + 1.02 kg a.i./ha, resulted in similar grain yields that were significantly higher

Table 4.10. Effects of cultivar and weed control treatments on grain yield and size of direct-seeded lowland rice at Badeggi.

| Treatments | Rate (kg a.i./ha) | Time of application DAS | Grain yield (t/ha) 1983 WS | Grain yield (t/ha) 1983-84 DS | Weight of 1000 grains 1983 WS | Weight of 1000 grains 1983-84 DS |
|---|---|---|---|---|---|---|
| Cultivar | | | | | | |
| FARO 15 | | | 3.4 a | 2.8 b | 25.4 a | 28.4 a |
| FARO 27 | | | 2.6 b | 2.6 b | 25.2 a | 27.9 b |
| FARO 29 | | | 3.2 a | 3.3 a | 25.6 a | 27.9 b |
| SE± Cultivar | | | 0.09 | 0.06 | 0.25 | 0.06 |
| Weed Control | | | | | | |
| Benthiocarb+propanil+ silvex | 1.08+1.94+0.45 | 14 | 2.1 e | 1.8 e | 29.5 a | 28.1 a |
| Benthiocarb+propanil+ silvex | 1.44+2.5+0.6 | 14 | 3.0 c | 2.9 c | 29.4 a | 28.0 a |
| Benthiocarb+propanil+ silvex | 1.8+3.24+0.75 | 14 | 4.9 b | 4.6 a | 29.6 a | 28.1 a |
| Butachlor + propanil | 1.8 + 2.04 | 14 | 2.1 e | 2.3 d | 29.0 a | 28.0 a |
| Butachlor + propanil | 2.4 + 1.7 | 14 | 2.5 d | 2.9 c | 28.4 a | 28.0 a |
| Butachlor + propanil | 3.6 + 1.02 | 14 | 4.7 b | 3.9 b | 28.5 a | 28.1 a |
| Hand-weeding twice at | | 20 & 40 | 5.4 a | 4.7 a | 28.8 a | 28.0 a |
| Unweeded control | | | 0.0 f | 0.4 f | 0.6 b | 27.9 a |
| SE± Weed control | | | 0.10 | 0.09 | 0.87 | 0.10 |

DS = Dry Season; WS = Wet season

Means followed by the same letter(s) within a treatment column are not significantly different using DMRT at 5%.

than those of the other herbicide treatments. In the wet season, grain yield increased significantly as the rate of benthiocarb and butachlor increased in their respective mixtures. Uncontrolled weed growth throughout the crop life-cycle resulted in complete crop loss in the wet season (Table 4.10) In the dry season, benthiocarb + propanil + silvex at 1.8+3.24+ 0.75 kg a.i./ha, resulted in comparable grain yield to the hand-weeded control. Butachlor + propanil at 3.6 + 1.02 kg a.i./ha also caused significantly higher grain production than the other herbicide treatments. As observed in the wet season, grain yield increased as the rate of butachlor and benthiocarb increased in the mixtures (Table 4.10).

The interaction between cultivars and herbicide treatments was significant on grain yield in the two seasons (Tables 4.11 and 4.12). Both in the wet and dry seasons under FARO 15 and FARO 29, benthiocarb + propanil + silvex at 1.8 + 3.24 + 0.75 kg a.i./ha resulted in comparable grain yield to the hand-weeded control. In the dry season, the same herbicide treatment also resulted in comparable grain yield to the hand-weeded control under FARO 27 (Table 4.12). Similarly under FARO 27 and FARO 29 in the wet season, grain yields obtained with butachlor plus propanil at 3.6 + 1.02 kg a.i./ha did not differ significantly from that of the hand-weeded control (Table 4.11). In the dry season, under the three cultivars, the same herbicide treatment resulted in lower grain yield than hand-weeding.

Table 4.11. Interaction of cultivar and weed control treatments on grain yield in direct-seeded lowland rice at Badeggi, 1983 wet season

| Treatments | Rate (kg a.i./ha) | Time of application (DAS) | Grain yield (t/ha) | | |
|---|---|---|---|---|---|
| | | | FARO 15 | FARO 27 | FARO 29 |
| Benthiocarb+propanil+ silvex | 1.08 + 1.94 + 0.45 | 14 | 2.2 ef | 1.6 gh | 2.6 def |
| Benthiocarb+propanil+ silvex | 1.44 + 2.50 + 0.6 | 14 | 3.5 cd | 2.4 ef | 3.1 d |
| Benthiocarb+propanil+ silvex | 1.8 + 3.24 + 0.75 | 14 | 5.4 ab | 4.0 c | 5.4 ab |
| Butachlor + propanil | 1.8 + 2.04 | 14 | 2.8 de | 1.2 h | 1.8 gh |
| Butachlor + propanil | 2.4 + 1.7 | 14 | 3.1 d | 2.1 f | 2.3 ef |
| Butachlor + propanil | 3.6 + 1.02 | 14 | 4.8 b | 4.7 b | 4.7 b |
| Hand-weeding twice at | | 20 & 40 | 5.7 a | 5.1 ab | 5.4 ab |
| Unweeded control | | | 0.0 i | 0.0 i | 0.0 i |
| SE± Cultivar x Weed control treatments | | | | 0.20 | |

Means followed by the same letter(s) within a column are not significantly different using Duncan's Multiple Range Test (DMRT) at 5% level.

DAS = Days after seeding.

Table 4.12 Interaction of cultivar and weed control treatments on grain yield in direct-seeded lowland rice at Badeggi 1983-84 dry season.

| Treatments | Rate (kg a.i./ha) | Time of application (DAS) | Grain Yield (t/ha) FARO 15 | FARO 27 | FARO 29 |
|---|---|---|---|---|---|
| Benthiocarb+propanil+ silvex | 1.08 + 1.94 + 0.45 | 14 | 2.1 f | 1.4 g | 2.0 f |
| Benthiocarb+propanil+ silvex | 1.44 + 2.5 + 0.6 | 14 | 2.2 f | 2.8 e | 3.6 d |
| Benthiocarb+propanil+ silvex | 1.8 + 3.24 + 0.75 | 14 | 4.2 c | 4.8 ab | 5.0 a |
| Butachlor + propanil | 1.2 + 2.04 | 14 | 2.0 f | 1.8 fg | 2.9 e |
| Butachlor + propanil | 2.4 + 1.7 | 14 | 3.0 e | 2.2 f | 3.4 d |
| Butachlor + propanil | 3.6 + 1.02 | 14 | 3.7 d | 3.6 d | 4.4 bc |
| Handweeding twice at | | 20 & 40 | 4.5 bc | 4.5 bc | 5.1 a |
| Unweeded control | | | 0.7 h | 0.1 i | 0.3 i |
| SE± Cultivar x weed control treatments | | | | 0.16 | |

Means followed by the same letter(s) within a column are not significantly different using Duncan's Multiple Range Test (DMRT) at 5% level.

1. DAS = Days after seeding

In the wet season, under FARO 15 and FARO 27, and in the dry season under FARO 27 and FARO 29, grain yield increased with increasing rate of butachlor and benthiocarb in their respective mixtures. In the wet season under FARO 29, and in the dry season (Table 4.12) under FARO 15, grain yield increased specifically only with increases in the rate of butachlor in the mixture. In both trials, the mixture containing benthiocarb at the two low rates had comparable grain yields. In the wet season (Fig. 1), uncontrolled weed growth resulted in complete crop loss in the three cultivars. In the dry season, FARO 27 was apparently most affected by weed competition among the varieties (Fig. 1). Uncontrolled weed growth throughout the crop life cycle caused 84.4% grain yield reduction in FARO 15, 97.7% in FARO 27 and 94% in FARO 29 in the dry season trial (Table 4.12.).

4.1.8 % weed cover

Cultivar only had significant effect on % weed cover in the wet season trial at 8 WAH and at crop harvest, and in the dry season trial at 4 and 8 WAH. In the wet season trial, FARO 27 had significantly higher weed coverage than the other two cultivars which had similar coverage. Results of % weed coverage at 4 WAH in the dry season was also similar while at 8 WAH all the varieties differed significantly from each other. The least coverage was obtained with FARO 29 and the highest occurred on plots sown with FARO 27.

In the two trials, the weed control treatments,

Table 4.13 Effects of cultivar and weed control treatments on % weed coverage in direct-seeded lowland rice at Badeggi, 1983 wet and 1983-84 dry seasons.

| Treatments | Rate (kg a.i./ha) | Time of application (DAS) | % Weed coverage (WAH) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 4 | | 8 | | Harvest | |
| Cultivar | | | WS[2] | DS[3] | WS | DS | WS | DS |
| FARO 15 | | | 24.8a | 17.9b | 21.2b | 29.9a | 18.0b | 30.4a |
| FARO 27 | | | 25.5a | 23.0a | 23.4a | 28.3b | 19.4a | 30.3a |
| FARO 29 | | | 23.5a | 18.0b | 20.8b | 25.5c | 17.5b | 30.1a |
| SE± Cultivar | | | 0.23 | 0.08 | 0.17 | 0.17 | 0.22 | 0.43 |
| Weed control | | | | | | | | |
| Benthiocarb+propanil+ silvex | 1.08+1.94+0.45 | 14 | 24.0b | 15.0b | 20.7b | 31.0b | 13.3b | 35.3b |
| Benthiocarb+propanil+ silvex | 1.44+2.5+0.6 | 14 | 15.0d | 10.0d | 11.0d | 15.0d | 7.3d | 26.5c |
| Benthiocarb+propanil+ silvex | 1.8+3.24+0.75 | 14 | 8.0 g | 5.0 g | 3.0 f | 7.7 h | 2.0 g | 10.0d |
| Butachlor + propanil | 1.8 + 2.04 | 14 | 21.7c | 12.0c | 17.5c | 27.3c | 14.0b | 32.0b |
| Butachlor+propanil | 2.4 + 1.7 | 14 | 13.7e | 6.0f | 12.0d | 14.0e | 7.0d | 19.7c |
| Butachlor + propanil | 3.6 + 1.02 | 14 | 9.3f | 7.0e | 7.0e | 12.0f | 4.0e | 12.7d |
| Hand-weeding twice at | | 20 & 40 | 5.0h | 2.0h | 3.0f | 6.0g | 2.0g | 6.3e |
| Unweeded control | - | - | 100.0a | 100.0a | 100.0a | 100.0a | 100.0a | 100.0a |
| SE± Weed control | | | 0.31 | 0.24 | 0.32 | 0.43 | 0.34 | 1.04 |

1 WAH = Weeks after herbicide application; 2 WS = Wet season; 3 DS = Dry season; Means followed by the same letter(s) within a treatment column are not significantly different using DMRT at 5% level of probability.

including hand-weeding resulted in significantly lower % weed cover than the untreated control throughout the crop life-cycle (Table 4.13.). Among the herbicide treatments, benthiocarb plus propanil plus silvex at 1.8 + 3.24 + 0.75 kg a.i./ha resulted in similar % weed coverage at 8 WAH and at crop harvest to the hand-weeded control in the wet season trial. No herbicide treatment caused comparable % weed cover to hand-weeding in the dry season.

Although % weed coverage with herbicide treatments was higher in the wet season than in the dry season, at 4 WAH, higher coverage occurred generally in the dry season and at the later stage of crop growth. In the wet season trial, % weed coverage with the herbicide treatments were 8 to 24 at 4 WAH, 3 to 20 at 8 WAH and 2 to 14 at harvest, while the corresponding values in the dry season trials were 5 to 15, 8 to 31 and 12 to 36 respectively. The least % weed coverage was obtained with benthiocarb + propanil + silvex at 1.8 + 3.24 + 0.75 kg a.i./ha in the two trials throughout the crop life cycle except at harvest in the dry season trial where % weed coverage with butachlor + propanil at 3.6 + 1.02 kg a.i./h were similar in value. Generally, % weed coverage decreased significantly with increase in the rate of butachlor and benthiocarb in each mixture throughout the crop life cycle in the two trials, except at 4 WAH in the dry season trial.

4.1.9 Weed dry matter production

Weed samples collected at crop harvest in the two trials were separated into three main categories, viz: grasses, sedges and broad-leaved weeds.

Grasses

Higher grass weed weight was obtained in the dry season than in the wet season. In the two seasons, higher grass weed weights were obtained under FARO 27 than FARO 15. Although FARO 29 had lower weed weight in the wet season, it was comparable to FARO 15 (Tables 4.14 and 4.15).

Treatments of herbicide mixtures significantly reduced the infestation of grasses in the wet and the dry seasons compared with the untreated control (Fig.3). In the wet season trial, benthiocarb + propanil + silvex at 1.8 + 3.24 + 0.75 kg a.i./ha had significantly lower infestation of grasses than all the other weed control treatments including the hand-weeded control. In the same wet season, grass weed weight decreased with increasing rate of benthiocarb in the mixture while only the highest rate at 1.8 kg a.i./ha was significantly lower than the other two rates in the butachlor mixture. In the dry season trial, all the herbicide treatments resulted in higher grass weed weight than the the hand-weeded control. In the season, grass weed weight decreased with increasing rates of benthiocarb and butachlor in their respective mixtures. Also benthiocarb + propanil + silvex at 1.08 + 1.94 + 0.45 kg a.i./ha resulted in comparable grass weed weight to butachlor+ propanil at 1.8+2.04 kg a.i./ha.

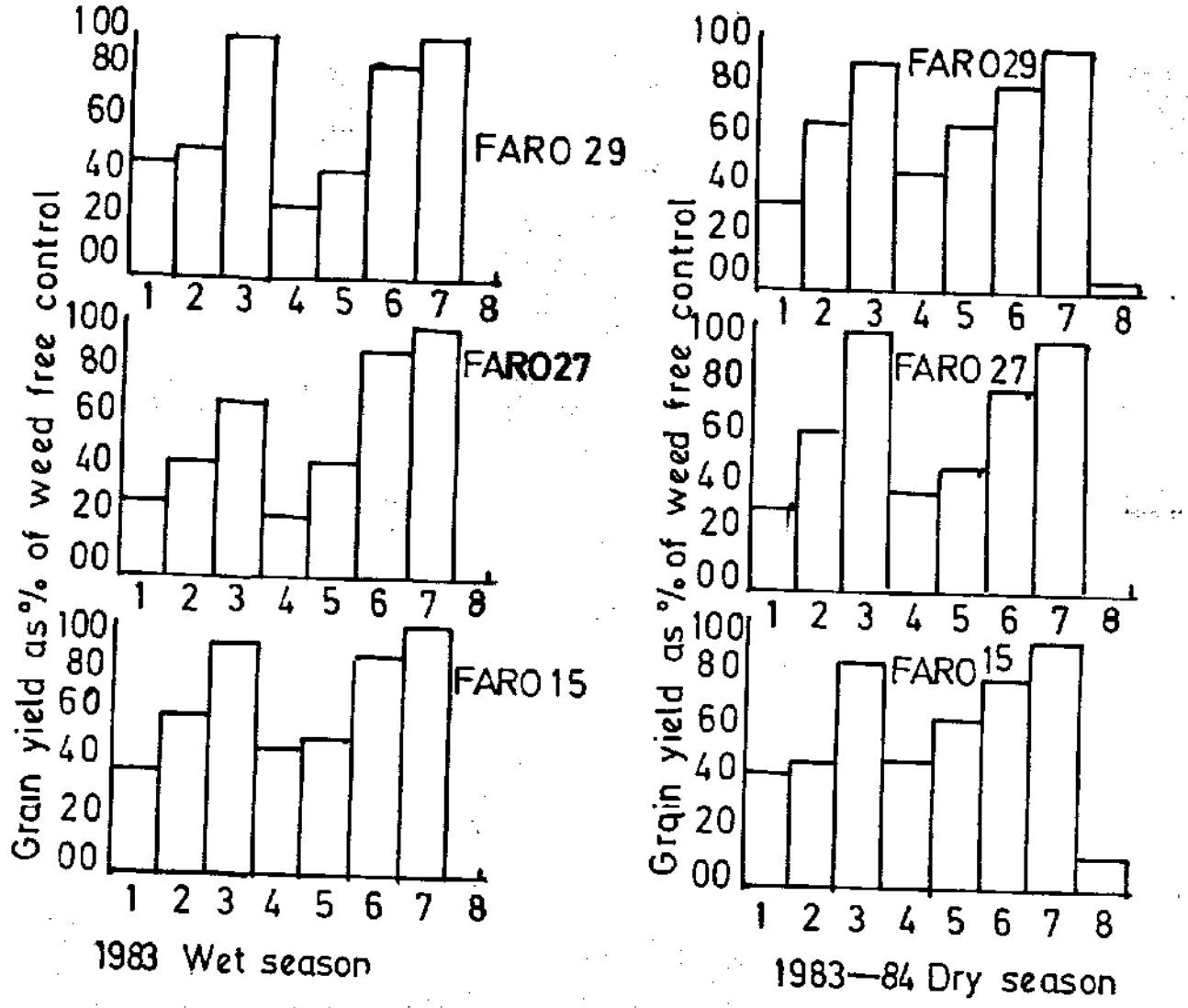



Fig.1 Grain yield as % of weed free control as affected by different weed control treatments

Broad-leaved weeds

Broad-leaved weed weight was higher in the wet season than in the dry season. Cultivars only had significant effect on broad-leaved weed weight in the dry season trial. FARO 29 had no broadleaved weed infestation and was significantly lower than FARO 15 and FARO 27 which had similar weights.

Weed control treatments had significant effect on broad-leaved weeds at harvest in both trials (Tables 4.14 and 4.15). While the highest broad-leaved weed weight was obtained with the untreated control in the wet season, no broad-leaved weed was observed with the treatment in the dry season. Among the herbicide treatments, benthiocarb plus propanil plus silvex at 1.0 + 1.94 + 0.45 and 1.44 + 2.50+ 0.6 kg a.i./ha resulted in significantly higher broad-leaved weed weight than the hand-weeded and untreated controls in the dry season trial. In the dry season, the highest broad-leaved weed weight was obtained with the mixture containing benthiocarb at 1.08 + 1.94 + 0.45 kg a.i./ha. With this mixture, broad-leaved weed weight decreased significantly as the rate of benthiocarb increased. In the wet season, broad-leaved weed weight significantly decreased as the rate of butachlor and benthiocarb increased in their respective mixtures. Mixtures containing the highest rates of these herbicides were however comparable in broad-leaved weed weight in this season.

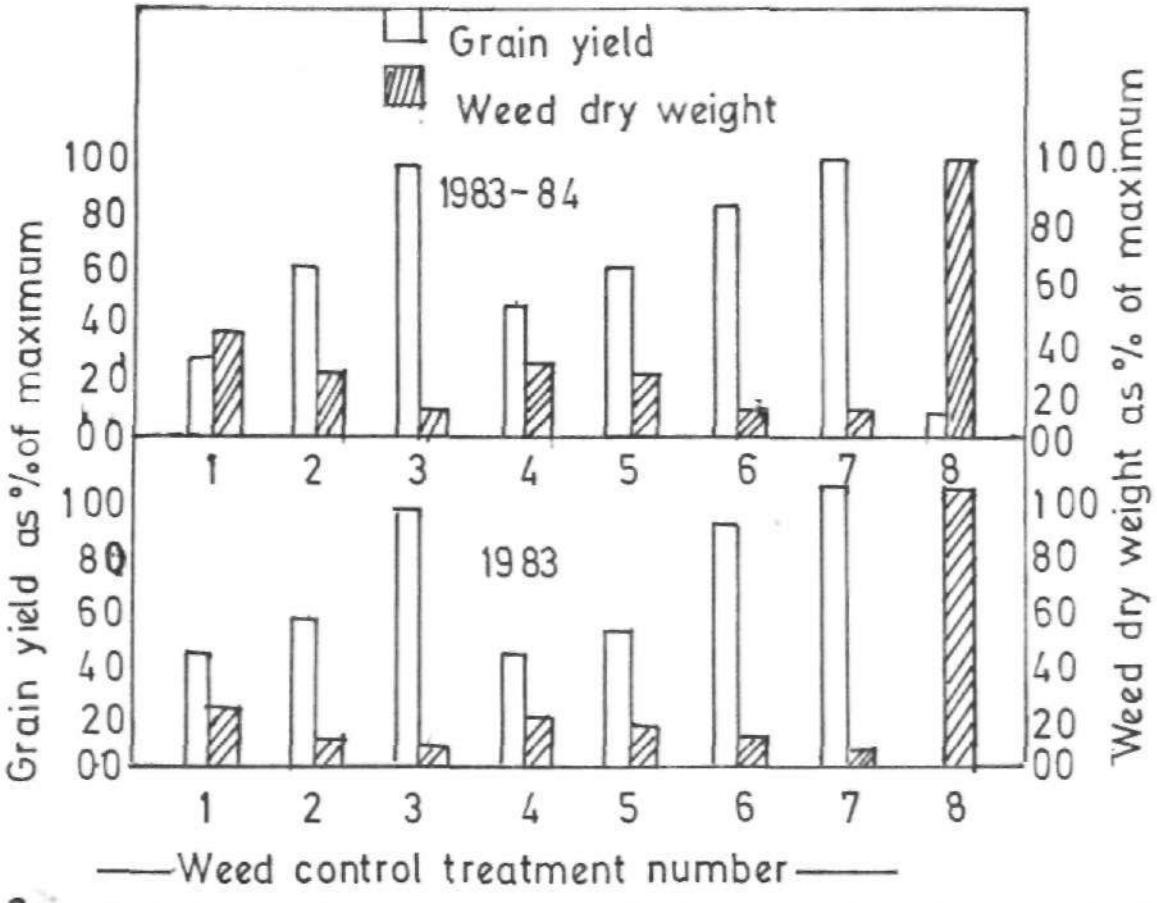



Fig. 2. Relationsphip between weed dry weight and grain yield of lowland rice in the 1983 wet and 1983–84 dry season trials at Badeggi as affected by different weed control treatments

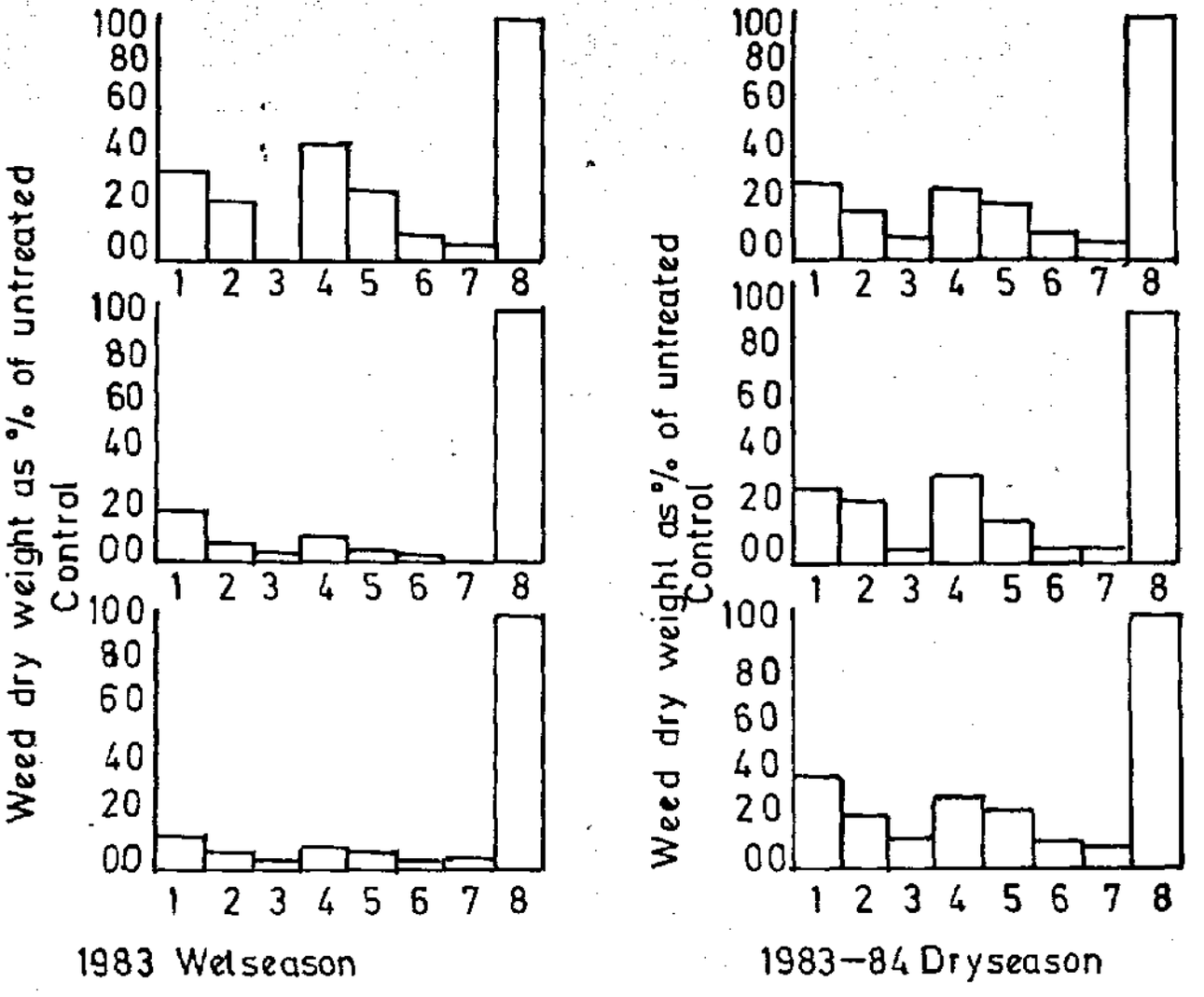



Fig. 3. Effect of weed control treatments on different categories of weeds in rice in 1983 wet and 1983–84 dry seasons.

Table 4.14. Effects of cultivar and weed control treatments on weed dry matter production in direct-seeded lowland rice at Badeggi 1983 wet season.

| Treatments | Rate (kg a.i./ha) | Time of application DAS | Dry weed weight at harvest (kg/ha) | | |
|---|---|---|---|---|---|
| | | | Grasses | Sedges | Broad-leaved |
| Cultivar | | | | | |
| FARO 15 | | | 304.7 b | 218.2 b | 301.0 a |
| FARO 27 | | | 473.4 a | 391.0 a | 284.0 a |
| FARO 29 | | | 360.4 b | 241.0 b | 321.5 a |
| SE± | | | 12.71 | 30.90 | 19.73 |
| Weed Control | | | | | |
| Benthiocarb+propanil+silvex | 1.08+1.94+0.45 | 14 | 310.5 b | 297.0b | 342.0 c |
| Benthiocarb+propanil+silvex | 1.44+2.50+0.6 | 14 | 91.6 d | 137.0 c | 229.6 e |
| Benthiocarb+propanil+silvex | 1.80+3.24+0.75 | 14 | 26.7 e | 70.0 cd | 81.4 f |
| Butachlor + propanil | 1.8 + 2.04 | 14 | 307.3 bc | 163.0 c | 418.3 b |
| Butachlor + propanil | 2.4 + 1.70 | 14 | 249.3 c | 68.0 cd | 285.3 d |
| Butachlor + propanil | 3.6 + 1.02 | 14 | 92.0 d | 20.0 d | 120.3 f |
| Hand-weeding twice at | | 20 & 40 | 76.5 d | 0.0 d | 65.3 g |
| Unweeded control | | | 2196.6 a | 1486.0 a | 874.3 a |
| SE± Weed control | | | 15.61 | 60.60 | 15.52 |

Means followed by the same letter(s) within a treatment column are not significantly different using DMRT at 5% level.

Table 4.15. Effects of cultivar and weed control treatments on weed weight in direct-seeded lowland rice at Badeggi, 1983-84 dry season.

| Treatments | Rate (kg a.i./ha) | Time of application (DAS) | Dry weed weight at harvest kg/ha | | |
|---|---|---|---|---|---|
| | | | Grasses | sedges | Broad-leaved |
| Cultivar | | | | | |
| FARO 15 | | | 1021.0 c | 158.5 b | 56.6 a |
| FARO 27 | | | 1344.0 a | 253.8 a | 55.2 a |
| FARO 29 | | | 1200.0 b | 178.4 b | 0.0 b |
| SE± Cultivar | | | 32.10 | 6.20 | 9.40 |
| Weed Control | | | | | |
| Benthiocarb+propanil+silvex | 1.08+1.94+0.45 | 14 | 1430.0 b | 223.3 b | 116.1 a |
| Benthiocarb+propanil+silvex | 1.44+2.5+0.6 | 14 | 790.0 c | 175.8cd | 91.0 b |
| Benthiocarb+propanil+silvex | 1.8+3.24+0.75 | 14 | 500.0 d | 7.5 e | 33.0 c |
| Butachlor + propanil | 1.8 + 2.04 | 14 | 1340.0 b | 251.3 b | 0.0 d |
| Butachlor + propanil | 2.4 + 1.7 | 14 | 860.0 c | 124.2 d | 33.0 c |
| Butachlor + propanil | 3.6 + 1.02 | 14 | 440.0 d | 41.9 e | 30.7 c |
| Hand-weeding twice at | | 20 & 40 | 250.0 e | 40.3 e | 21.0 cd |
| Unweeded control | | | 3850.0 a | 664.0 a | 0.0 d |
| SE± Weed control | | | 66.60 | 11.11 | 9.69 |

Means followed by the same letter(s) within a treatment column are not significantly different from each other using DMRT at 5% level.

completely.

Sedges

Although the differences were less dramatic than was observed with the broad-leaved weeds, sedge weed weight was higher in the wet season than in the dry season. Significantly higher sedge weed weight was observed under FARO 27 compared with FARO 15 and FARO 29 which had similar sedge weight in the wet and dry season trials (Tables 4.14 and 4.15).

All the herbicide treatments significantly reduced the infestation of sedge weeds compared with the untreated control in both trials (Fig. 3). In both trials, benthiocarb+ propanil+silvex at 1.8 + 3.24 + 0.75 kg a.i./ha and butachlor + propanil at 3.6 + 1.02 kg a.i./ha resulted in sedge weights that were comparable to that of the hand-weeded control. Sedge weights with the mixtures containing the lowest rates of butachlor and benthiocarb were significantly higher. In the wet season, butachlor + propanil at 3.6 + 1.02 kg a.i./ha also resulted in dry weight of sedges that were comparable to the hand-weeded control (Table 4.16). In the dry season, sedge dry weight decreased as the rate of butachlor and benthiocarb increased in their respective mixtures.

The interaction between cultivar and herbicide

Table 4.16. Interaction of cultivar and weed control treatments on sedges at harvest in direct-seeded lowland rice at Badeggi, 1983 wet season.

| Treatments | Rate kg a.i./ha | Time of application (DAS) | Dry weight of sedges at harvest (kg/ha) FARO 15 | FARO 27 | FARO 29 |
|---|---|---|---|---|---|
| Benthiocarb+propanil+ silvex | 1.08+1.94+0.45 | 14 | 168.0 cd | 500.0 c | 228.0 cd |
| Benthiocarb+propanil+ silvex | 1.44+2.5+0.6 | 14 | 20.0d | 300.0 cd | 90.0 d |
| Benthiocarb+propanil+ silvex | 1.8+3.24+0.75 | 14 | 0.0d | 100.0d | 110.0 d |
| Butachlor + propanil | 1.8 + 2.04 | 14 | 190.0 cd | 120.0 d | 183.0 cd |
| Butachlor + propanil | 2.4 + 1.70 | 14 | 20.0 d | 160.0 d | 25.0 d |
| Butachlor + propanil | 3.6 + 1.02 | 14 | 0.0d | 60.0d | 0.0d |
| Hand-weeding twice at | | 20 & 40 | 0.0d | 0.0d | 0.0d |
| Unweeded control | | | 1268.0 b | 1890.0 a | 1300.0 b |
| SE± Cultivar x Weed control treatments | | | | 103.10 | |

Means followed by the same letter(s) within a column are not significantly different using Duncan's multiple Range Test (DMRT).

Table 4.17. Interaction of cultivar and weed control treatments on sedges at harvest in direct-seeded lowland rice at Badeggi 1983-84 dry season.

| Treatments | Rate kg a.i./ha | Time of application (DAS) | Dry weight of sedges at harvest (kg/ha) FARO 15 | FARO 27 | FARO 29 |
|---|---|---|---|---|---|
| Benthiocarb+propanil+ silvex | 1.08+1.94+0.45 | 14 | 0.0g | 190.0 de | 480.0e |
| Benthiocarb+propanil+ silvex | 1.44+2.5+0.6 | 14 | 321.5 cd | 206.0 de | 0.0g |
| Benthiocarb + propanil+ silvex | 1.8+3.24+0.75 | 14 | 0.0g | 0.0g | 22.5 fg |
| Butachlor + propanil | 1.8 + 2.04 | 14 | 170.0 d-g | 316.0 cd | 26.0 fg |
| Butachlor + propanil | 2.4 + 1.7 | 14 | 100.0 fg | 132.5 efg | 14.0 fg |
| Butachlor + propanil | 3.6 + 1.02 | 14 | 2.5fg | 59.6fg | 63.5 fg |
| Hand-weeding twice | at | 20 & 40 | 57.0fg | 30.0fg | 34.0 fg |
| Unweeded control | | | 605.0 b | 960.0 a | 427.0c |
| SE± Cultivar x Weed control treatments | | | | 59.66 | |

Means followed by the same letter(s) within a column are not significantly different using Duncan's Multiple Range Test (DMRT) at 5%.

treatments on dry weight of sedges was significant in the two trials (Tables 4.16) and 4.17). In wet season although all the herbicide treatments resulted in dry weight of sedges that were comparable to that of the hand-weeded check under FARO 15 and FARO 29, benthiocarb plus propanil plus silvex at 1.08+1.94+0.45 kg a.i./ha resulted in higher weight of sedges under FARO 27. In the dry season trial, plots of FARO 27 had higher infestation of sedges than the other two cultivars irrespective of the rate of butachlor in the trial. However, benthiocarb+propanil+silvex at 1.8+3.24+0.75 kg a.i./ha and butachlor+propanil at 3.6 + 1.02 kg a.i./ha resulted in dry weight of sedges comparable to hand-weeded control. Under FARO 15, benthiocarb + propanil +silvex at 1.08 + 1.94 + 0.45 kg a.i./ha also had no sedge infestation while similar situation was observed with benthiocarb at 1.44kg a.i./ha under FARO 29(Table 4.17).

Total weed dry weight

Higher weed dry weight was obtained in the dry season trial than in the wet season trial. Rice cultivars had significant effect on weed dry matter production at harvest in the two trials. In both trials, the highest weed dry matter production occurred under FARO 27. While similar weed weights were obtained with the other two cultivars in the wet season, higher weight was produced under FARO 29 compared with FARO 15 in the dry season.

The weed control treatments had significant effect on the total weed dry matter production (Table 4.18). Weed dry weight was significantly reduced by all weed

control treatments at 30 and 90 DAH and at harvest compared with the untreated control in the two trials. In the wet season trial at 30 DAH, benthiocarb plus propanil plus silvex at 1.44 + 2.50 + 0.60 and 1.80 + 3.24 + 0.75 kg a.i./ha and butachlor plus propanil at 3.6 + 1.02 kg a.i./ha resulted in comparable weed dry weight to the hand-weeded check and lower than the mixtures containing the lowest rates of benthiocarb and butachlor. In the dry season trial, none of the herbicide treatments resulted in comparable dry weed weight to the hand-weeded control throughout the crop life cycle. Mixtures containing the highest rates of butachlor and benthiocarb however caused lower weed dry matter production than the other herbicide treatments. Similarly, in the two trials, dry weed weights with the mixtures of the lowest rates of butachlor and benthiocarb were significantly higher than those of 1.8 + 2.04 and 1.08 + 1.94 + 0.45 kg a.i./ha, respectively.

At 60 DAH, in addition to the mixtures with the highest rates of butachlor and benthiocarb, corresponding respective rates at 2.4 + 1.7 and 1.44 + 2.50 + 0.60 kg a.i./ha also had similar weed dry weight to the hand-weeded control in the wet season trial. Weed dry weight with benthiocarb plus propanil plus silvex at 1.08+1.94+0.45 kg a.i./ha was significantly higher than those of other herbicide treatments in the trial. In the dry season trial, the mixtures containing the highest rates of butachlor and benthiocarb resulted in lower dry matter production compared with the other

Table 4. 10. Effects of cultivar and weed control treatments on weed dry matter production in direct-seeded lowland rice at Badeggi, 1983 wet and 1983-84 dry seasons.

| Treatments | Rate (kg a.i./ha) | Time DAS[4] | Dry weed weight (kg/ha) at 30 DAH[1] WS | 30 DAH DS | 60 DAH WS[2] | 60 DAH DS[3] | Harvest WS | Harvest DS |
|---|---|---|---|---|---|---|---|---|
| **Cultivar** | | | | | | | | |
| FARO 15 | | | 1488.0a | 798.0a | 1000.9a | 1349.0a | 907.0b | 1236.1c |
| FARO 27 | | | 1499.0a | 792.0a | 1248.0a | 1437.0a | 1114.0a | 1653.0a |
| FARO 29 | | | 1469.0a | 737.0a | 1190.0a | 1299.0a | 910.0b | 1378.0b |
| SE± Cultivar | | | 30.10 | 44.50 | 122.70 | 32.53 | 42.50 | 35.80 |
| **Weed control** | | | | | | | | |
| Benthiocarb+propanil+ silvex | 1.08+1.94+0.45 | 14 | 1423.0b | 896.0b | 1176.0b | 1606.0b | 949.5b | 1769.4b |
| Benthiocarb+propanil+ silvex | 1.44+2.50+0.60 | 14 | 569.0cd | 568.0cd | 286.0d | 920.0d | 458.2de | 1056.8c |
| Benthiocarb+propanil+ silvex | 1.80+3.24+0.75 | 14 | 268.0d | 223.0e | 200.0d | 426.0e | 178.1ef | 540.5d |
| Butachlor + propanil | 1.8 + 2.04 | 14 | 1419.0b | 740.0bc | 1054.0bc | 1500.1c | 888.66c | 1591.3b |
| Butachlor + propanil | 2.4 + 1.7 | 14 | 777.0c | 548.0d | 502.0cd | 951.3bc | 602.6cd | 1017.0c |
| Butachlor + propanil | 3.6 + 1.02 | 14 | 390.0d | 259.0e | 218.0d | 444.0e | 232.0ef | 512.6d |
| Hand-weeding twice at | | 20 & 40 | 195.0d | 49.0f | 161.0d | 240.0f | 141.8f | 311.3e |
| Unweeded control | | | 6839.0a | 2923.3a | 2527.0a | 4810.0a | 4556.9a | 4514.0a |
| SE± Weed control | | | 78.64 | 72.40 | 174.80 | 115.10 | 95.61 | 71.30 |

1. DAH = Days after herbicide; 2. WS = Wet Season; 3. DS = Dry season; 4. DAS = Days after seeding. Means followed by the same letters within a treatment column are not significantly different using DMRT at 5% level.

herbicide treatments. Weed dry weight significantly decreased as the rate of butachlor or benthiocarb increased in the mixture at 60 DAH in the same trial.

At harvest in the wet season trial, benthiocarb + propanil + silvex at 1.8 + 3.24 + 0.75 kg a.i./ha and butachlor + propanil at 3.6 + 1.02 kg a.i./ha, reduced weed infestation similarly and were comparable to the hand-weeded control. The herbicidetreatments indicated also resulted in significantly lower weed dry weight than the mixtures with the lowest rates of butachlor and benthiocarb. The same trend occurred in the dry season trial except that hand-weeding resulted in the least dry weed weight among weed control treatments.

4.2 Correlation studies 1983 and 1983-84

In the 1983 wet and 1983-84 dry season trials, number of tillers per ha at 30 DAS and at crop harvest, plant height at maturity, number of panicles and spikelets per ha and grain yield were significantly negatively correlated with dry weight of grasses, sedges, broad-leaved weeds and total weed dry weight per ha at harvest (Tables 4.19 and 4.20). Percentage of unfilled grains was significantly positively correlated with total weed dry weight per ha at harvest ($r = 0.97$) in the 1983 wet and ($r = 0.86$) in the 1983-84 dry season.

However, grain yield was significantly positively correlated with the number of tillers at 30 DAS ($r = 0.49$; 0.43) number of panicles per ha ($r = 0.86$; 0.85) and number of spikelets per ha ($r = 0.84$; 0.86) in the 1983 and 1983-84 wet and dry season trials respectively.

Table 4.19. Relationship between yield, crop growth and weed weight as affected by chemical weed control in direct-seeded lowland rice at Badeggi, 1983 wet season

| | | Crop growth | | | | | | Weeds at harvest | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Grain Yield | Grain yield | Spikelet (number /ha). | % unfilled grains | Panicle (number/ ha). | Tiller (number at 30DAS/ ha). | Tiller (number at maturity/ ha | Plant height at maturity | Grasses | Sedges | Broad-leaved weeds | Total weed weight |
| Grain Yield | 1.00 | 0.85* | -0.68* | 0.86* | 0.82* | 0.82* | 0.45* | -0.80* | -0.72* | -0.65* | -0.74* |
| Spikelet(number/ha) | | 1.00 | -0.85* | 0.93* | 0.55* | 0.87* | 0.40* | -0.87* | -0.82* | -0.78* | -0.86* |
| % Unfilled grains | | | 1.00 | 0.54 | 0.47 | 0.34 | -0.31 | 0.97* | 0.80* | 0.86* | 0.93* |
| Panicle(number/ha) | | | | 1.00 | 0.50* | 0.83* | 0.44* | -0.85* | -0.85 | -0.79 | -0.85* |
| Tiller(number at 30 DAS/ha) | | | | | 1.00 | 0.85* | 0.21 | -0.68* | -0.60* | -0.60* | -0.67* |
| Tiller (number at at maturity/ha). | | | | | | 1.00 | 0.53* | 0.93* | -0.80* | -0.84 | -0.91* |
| Plant height at maturity | | | | | | | 1.00 | -0.95* | -0.86* | -0.70* | -0.90* |
| Grasses at harvest | | | | | | | | 1.00 | -0.25 | -0.20 | 0.79 |
| Sedges at harvest | | | | | | | | | 1.00 | -0.30 | 0.48* |
| Broadleaved weeds at harvest | | | | | | | | | | 1.00 | 0.67* |
| Total weed weight at harvest | | | | | | | | | | | 1.00 |

Table 4.20. Relationship between yield, crop growth and weed dry weight as affected by chemical weed control in direct-seeded lowland rice 1983-84 dry season at Badeggi.

| | Grain yield | Crop growth | | | | | | Weeds at harvest | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Spikelet (number/ha). | % unfilled grains | Panicle (number/ha.) | Tiller (number 30 DAS/ ha.) | Tiller number at maturity/ha | Plant height at maturity | Grasses | Sedges | Broad-leaved weeds | Total weed weight |
| Grain yield 1.00 | | 0.86* | -0.35 | 0.88* | 0.43* | 0.83* | 0.36 | -0.74 | -0.77 | -0.73* | -0.79 |
| Spikelet(number/ha.) | | 1.00 | -0.81 | 0.83* | 0.35 | 0.80* | 0.41 | -0.74* | -0.68 | -0.17 | -0.78 |
| % Unfilled grains | | | 1.00 | 0.51* | 0.58* | 0.60* | 0.33 | 0.86* | 0.86* | 0.74* | 0.86* |
| Panicle(number/ha) | | | | 1.00 | 0.45* | 0.91* | 0.40 | -0.79* | -0.78* | -0.09* | -0.82* |
| Tiller(number/ha at 30 DAS) | | | | | 1.00 | 0.91* | 0.16 | -0.40* | -0.53 | -0.16 | -0.44* |
| Tiller(number/ha at maturity) | | | | | | 1.00 | 0.50* | -0.78* | -0.74* | -0.10 | -0.80* |
| Plant height at maturity | | | | | | | 1.00 | -0.79* | -0.76* | -0.27 | -0.82* |
| Grasses at harvest. | | | | | | | | 1.00 | -0.41* | -0.46* | 0.71* |
| Sedges at harvest | | | | | | | | | 1.00 | -0.51* | 0.70* |
| Broad-leaved weeds at harvest | | | | | | | | | | 1.00 | 0.74* |
| Weed weight at 60 DAH at harvest | | | | | | | | | | | 1.00 |

*Significant at the 0.05 probability level.

## 4.3 Effect of herbicide treatments on cutgrass control in the greenhouse

### 1.3.1 % Control

All the herbicide treatments resulted in significantly lower cutgrass growth parameters than the untreated control throughout the period of experimentation (Table 4.21). Glyphosate at 1.6 kg ae/ha applied on rapidly growing cutgrass, gave complete control of both the shoot, rhizome and root of cutgrass throughout the period of the experiment which lasted 12 weeks in the greenhouse. From 4 to 12 weeks after treatment (WAT), oxadiazon at 1.25kg a.i./ha resulted in comparable control of cutgrass to glyphosate at 1.6kg ae/ha. At 1 and 2 WAT there was no significant difference between oxadiazon at 1.0 and 1.25 kg a.i./ha in the control rating. Benthiocarb plus propanil at 1.8 + 3.24 kg a.i./ha resulted in comparable cutgrass control to oxadiazon at 1.0 kg a.i./ha in the first week of observation. At 2 WAT, among the herbicide treatments, the mixture of propanil with butachlor at 2.04 + 1.8 and 1.02 + 3.6 kg a.i./ha was less effective on cutgrass than oxadiazon at 1.25 kg a.i./ha. At 4 WAT, molinate at 4.0kg a.i./ha followed by benthiocarb plus propanil at 1.08 + 1.94 and 1.8 + 3.24 kg a.i./ha resulted in comparable cutgrass control to glyphosate at 1.6 kg ae./ha. At 8 WAT, in addition to those indicated for 4 WAT, molinate at 4.0 kg a.i./ha followed by butachlor plus propanil also caused comparable cutgrass control to the maximum. Application of mixtures of benthiocarb or butachlor with propanil were significantly less effective

Table 4.21. Effect of herbicides on cutgrass in the greenhouse at Badeggi, 1985 wet season.

| Treatments (Herbicides) | Rate kg a.i./ha | Time DAP[4] | % Control[1] at 1WAT[2] | 2WAT | 4WAT | 8WAT | 12WAT |
|---|---|---|---|---|---|---|---|
| Glyphosate | 1.6 | 21 | 100a[3] | 100a | 100a | 100a | 100a |
| Oxadiazon | 1.0 | 7 | 75 bc | 62 b | 68bc | 74bcd | 70bcde |
| Oxadiazon | 1.25 | 7 | 83b | 65b | 77abc | 82abd | 74abcd |
| Butachlor + propanil | 1.8 + 2.04 | 14 | 60c | 28c | 20e | 50d | 37f |
| Butachlor + propanil | 3.6 + 1.02 | 14 | 60c | 30c | 22e | 50d | 43ef |
| Benthiocarb + propanil | 1.08 + 1.94 | 14 | 63c | 50b | 57cd | 60d | 46def |
| Benthiocarb + propanil | 1.0 + 3.24 | 14 | 72bc | 58b | 63bc | 63cd | 53def |
| Molinate fb butachlor + propanil | 4.0fb 1.8+2.04 | 7fb 14 | 45d | 50d | 73bc | 91ab | 57def |
| Molinate fb butachlor + propanil | 4.0fb 3.6+1.02 | 7fb 14 | 60c | 50b | 77bc | 96a | 85abc |
| Molinate fb benthiocarb + propanil | 4.0fb 1.08+1.94 | 7fb 14 | 42d | 50b | 75abc | 96a | 40f |
| Molinate fb benthiocarb + propanil | 4.0fb 1.8+3.24 | 7fb 14 | 43d | 50b | 85ab | 99a | 90ab |
| Untreated control | - | - | 0e | 0d | 0e | 0e | 0g |
| SE± Weed control | | - | 4.54 | 4.71 | 7.45 | 7.21 | 8.59 |

1. Based on 0-100 where less than 60% = poor, 60 to 80% = fair; 80 to 90 = good; 90 to 100 = excellent
2. Weeks after treatment (post emergence herbicide application).
3. Different letters within column show significant differences according to DMRT at 5%
4. Days after planting.

in the control of cutgrass without a prior application of molinate at 4.0 kg a.i./ha. At 12 WAT, among the treatments containing molinate at 4.0 kg a.i./ha, only those with a follow-up of the two mixtures of benthiocarb plus propanil and butachlor plus propanil at 3.6 + 1.02kg a.i./ha caused comparable % control to the maximum.

4.3.2 Tiller number/pot.

Glyphosate at 1.6 kg ae./ha completely inhibited tiller development of cutgrass throughout the period of the experiment (Table 4.22.). At 30 days after treatment (DAT) all the other herbicide treatments resulted in significantly lower tiller number of cutgrass than the untreated control (Fig. 4). Molinate at 4.0 kg a.i./ha followed by mixtures of propanil with butachlor and benthiocarb each at both rates (Table 4.22) completely inhibited tillering at this stage. At 60 DAT (Fig. 4), these herbicide treatments and oxadiazon at 1.0 and 1.25 kg a.i./ha resulted in tiller number that were comparable to those obtained with glyphosate at 1.6 kg ae./ha and significantly lower than that of the untreated control. Tiller numbers for the other treatments were however similar to that of the untreated control (Table 4.23.). At 12 WAT, only molinate at 4.0 kg a.i./ha followed by the mixture of propanil with butachlor at 3.6 + 1.02 kg a.i./ha and benthiocarb at 1.8 + 3.24 kg a.i./ha and oxadiazon at 1.25 kg a.i./ha were comparable to glyphosate at 1.6 kg ae/ha in tiller number. Treatments of mixtures of propanil with benthiocarb or butachlor at the low rate without prior application of molinate at 4.0 kg a.i./ha

Table 4.22. Effect of herbicide treatments on tiller number of cutgrass in the greenhouse at Badeggi, 1985 wet season.

| Treatments (Herbicides) | Application | | Tiller number per pot | | |
|---|---|---|---|---|---|
| | Rate kg a.i./ha | Time DAP[1] | 30 DAT[2] | 60 DAT | at maturity |
| Glyphosate | 1.6 | 21 | 0 c[3] | 0 c | 0 d |
| Oxadiazon | 1.0 | 7 | 62 b | 102 bc | 204 abc |
| Oxadiazon | 1.25 | 7 | 55b | 54 c | 142 bcd |
| Butachlor + propanil | 1.8 + 2.04 | 14 | 85 b | 333 a | 397 ab |
| Butachlor + propanil | 3.6 + 1.02 | 14 | 75 b | 326 a | 331 abc |
| Benthiocarb + propanil | 1.08 + 1.84 | 14 | 61 b | 279 ab | 369 ab |
| Benthiocarb + propanil | 1.8 + 3.24 | 14 | 54 b | 338 a | 287 abc |
| Molinate fb butachlor+propanil | 4.0 fb 1.8+2.04 | 7 fb 14 | 0 c | 127 bc | 163 bc |
| Molinate fb butachlor+propanil | 4.0 fb 3.6+1.02 | 7 fb 14 | 0 c | 62 c | 84 cd |
| Molinate fb benthiocarb+propanil | 4.0 fb 1.08+1.94 | 7 fb 14 | 0 c | 71 c | 201 bc |
| Molinate fb benthiocarb+propanil | 4.0 fb 1.8+3.24 | 7 bf 14 | 0 c | 42 c | 56 cd |
| Untreated control | | | 224 a | 445 a | 495 a |
| SE± Weed Control | | | 26 | 53 | 83 |

1. Days after planting; 2. Days after treatment; 3. Different letters within column show significant differences according to DMRT at 5%

fb = followed by

as well as oxadiazon at 1.0 kg a.i./ha, resulted in significantly lower tiller number than the untreated control (Table 4.22).

4.3.3 Plant height

As observed with many other vegetative parameters, no emergence occurred at 30 DAT in pots treated with glyphosate at 1.6 kg a.i./ha throughout the period of the experiment (Table 4.23). Similarly no plants had emerged in the pots treated with molinate. In addition to the herbicide treatments indicated, oxadiazon at both rates and benthiocarb plus propanil at 1.8 + 3.24 kg a.i./ha significantly reduced cutgrass plant height compared with the untreated control. At 60 DAT, oxadiazon at both rates and treatments containing molinate, except when followed by butachlor plus propanil at 1.8 + 2.04 kg a.i./ha resulted in shorter plants of cutgrass than the tallest with butachlor plus propanil at 1.8 + 2.04 kg a.i./ha alone. At the end of the experiment which lasted 12 weeks only glyphosate at 1.6 kg a.e./ha and molinate followed by the two mixtures of benthiocarb and propanil produced significantly shorter plants compared with the untreated control, which produced 224.5 cm cutgrass plants.

4.3.4 Rhizome dry weight

Glyphosate at 1.6 kg a.e./ha resulted in no rhizome development. The value obtained with this treatment was significantly lower than those of all the other herbicide treatments (Table 4.24). The other herbicide treatments resulted in 8.7 g to 20.0g rhizome dry weight compared with 23.5g obtained with the untreated control. Oxadiazon at

Table 4.23. Effect of herbicide treatments on plant height (cm) in the greenhouse at Badeggi, 1985 wet season.

| Treatments (Herbicides) | Application | | Plant height (cm) | | |
|---|---|---|---|---|---|
| | Rate kg a.i./ha | Time DAP[1] | 30 DAT | 60 DAT[2] | 84DAT. |
| Glyphosate | 1.6 | 21 | 0.0e[3] | 0.0d | 0.0d |
| Oxadiazon | 1.0 | 7 | 71.5 cd | 101.5bcd | 150.8 ab |
| Oxadiazon | 1.25 | 7 | 47.0 d | 84.5 cd | 127.8 abc |
| Butachlor + propanil | 1.8 + 2.04 | 14 | 114.0 ab | 187.3 a | 191.5 a |
| Butachlor + propanil | 3.6 + 1.02 | 14 | 89.0 abc | 176.5 ab | 189.7 a |
| Benthiocarb + propanil | 1.08 + 1.94 | 14 | 95.2 abc | 156.3 ab | 178.5 a |
| Benthiocarb + propanil | 1.8 + 3.24 | 14 | 86.9 bc | 145.0abc | 161.3 ab |
| Molinate fb butachlor+propanil | 4.0 fb 1.8+2.04 | 7 fb 14 | 0.0e | 128.3abc | 136.8abc |
| Molinate fb[4] butachlor+propanil | 4.0 fb 3.6+1.02 | 7 fb 14 | 0.0e | 56.0 d | 128.8 abc |
| Molinate fb benthiocarb+propanil | 4.0 fb 1.08+1.94 | 7 fb 14 | 0.0e | 75.0 cd | 111.5 bc |
| Molinate fb benthiocarb+propanil | 4.0 fb 1.8+3.24 | 7 fb 14 | 0.0e | 57.0 cd | 77.3 c |
| Untreated control | | | 116.6 a | 169.0ab | 224.5 a |
| SE± Weed control | | | 8.20 | 22.52 | 19.26 |

1. Days after planting; 2. Days after treatment; 3. Different letters within column show significant differences according to DMRT at 5% 4. Followed by

1.25. kg a.i./ha, benthiocarb plus propanil at 1.8 + 3.24kg a.i./ha, molinate at 4.0 kg a.i./ha followed by the mixture of propanil with butachlor at both rates and that with benthiocarb at 1.8 + 3.24 kg a.i./ha caused lower rhizome dry weights than the untreated control. Oxadiazon at 1.0 kg a.i./ha and the mixture of benthiocarb with propanil at 1.08 + 1.94 kg a.i./ha alone and when it followed molinate, all had comparable rhizome dry weights to oxadiazon at 1.25 kg a.i./ha but were not significantly different from the untreated control (Fig. 4).

4.3.5 Root dry weight.

All the herbicide treatments resulted in significantly lower root dry weight than the untreated control (Table 4.24.). Oxadiazon at 1.25 kg a.i./ha, molinate at 4.0 kg a.i./ha followed by butachlor + propanil at 3.6 + 1.02 kg a.i./ha and benthiocarb plus propanil at 1.8 + 3.24 kg a.i./ha resulted in comparable root dry weight to glyphosate at 1.6 kg ae./ha which completely prevented root production. The above mentioned herbicide treatments resulted in 43.5g to 80.0g root dry weight/pot compared with the value of 349g/pot for the untreated control. Oxadiazon at 1.25 kg a.i./ha however, resulted in lower root dry weight than the low rate at 1.0 kg a.i./ha, while the mixtures of butachlor and benthiocarb with propanil when applied alone caused higher root dry weight production compared with their corresponding mixtures preceded by molinate at 4.0 kg a.i./ha (Fig. 4).

Table 4.24. Effect of herbicide treatments on cutgrass in the greenhouse at Badeggi, 1985 wet season.

| Treatments (Herbicides) | Application Rate kg a.i./ha | Application Time DAP[1] | Rhizome | Root g/pot | Shoot |
|---|---|---|---|---|---|
| Glyphosate | 1.6 | 21 | 0.0 d[2] | 0.0 e | 0.0 e |
| Oxadiazon | 1.0 | 7 | 17.5 abc | 186.0 bc | 89.0 bcd |
| Oxadiazon | 1.25 | 7 | 15.0 bc | 52.5 e | 85.0 bcd |
| Butachlor + propanil | 1.8 + 2.04 | 14 | 20.0 ab | 245.0 b | 152.4 ab |
| Butachlor + propanil | 3.6 + 1.02 | 14 | 19.5 ab | 185.0 bc | 124.5 bc |
| Benthiocarb + propanil | 1.08 + 1.94 | 14 | 18.8 abc | 253.8 b | 136.5 bc |
| Benthiocarb + propanil | 1.8 + 3.24 | 14 | 14.9 bc | 191.0 bc | 102.8 bcd |
| Molinate fb butachlor+propanil | 4.0 fb 1.8+2.04 | 7 fb 14 | 15.8 bc | 80.0 de | 60.0 cde |
| Molinate fb butachlor+propanil | 4.0 fb 3.6+1.02 | 7 fb 14 | 12.5 c | 50.0 e | 38.5 de |
| Molinate fb benthiocarb+propanil | 4.0 fb 1.08+1.94 | 7 fb 14 | 17.7 abc | 140.6 cd | 55.0 cde |
| Molinate fb benthiocarb+propanil | 4.0 fb 1.8+3.24 | 7 fb 14 | 8.7 c | 43.5 e | 23.0 de |
| Untreated control | | | 23.5 a | 349.0 a | 230.0 a |
| SE± Weed control | | | 1.88 | 26.00 | 24.50 |

1. Days after planting
2. Different letters within column show significant differences according to DMRT at 5%

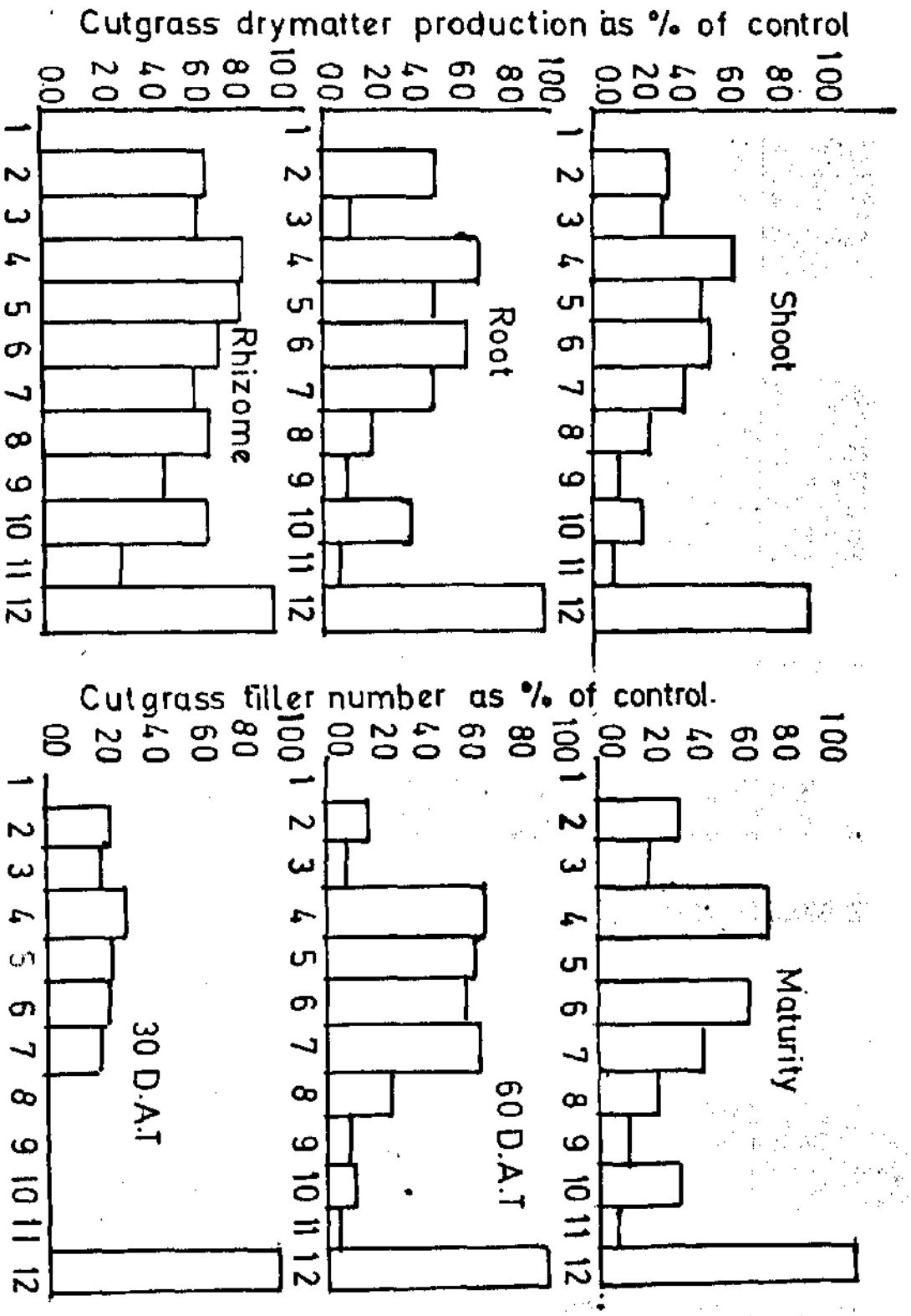



**Fig 4.** Dry matter production of cutgrass as % of the untreated control as affected by herbicide treatments in the greenhouse at Badeggi 1985.

4.3.6 Shoot dry weight

All the herbicide treatments, except butachlor plus propanil at 1.8 + 2.04 kg a.i./ha, significantly reduced cutgrass shoot dry weight compared with the untreated control (Table 4.24). Among the herbicide treatments, only those containing molinate at 4.0 kg a.i./ha had comparable shoot dry weight to glyphosate at 1.6 kg ae/ha which completely prevented shoot dry matter production. The shoot weight with these herbicide treatments were 23.0g to 60.0g/pot compared with 230g/pot obtained with the untreated control. Preceeding mixtures of butachlor and propanil with molinate application resulted in lower shoot dry weight than when the mixtures were applied alone (Fig. 4).

Experiment 4.4 Field control of cutgrass in lowland rice

4.4.1 Effect of herbicide treatments on cutgrass dry weight

Cutgrass plants were only sampled at 60 days after herbicide application (DAH) during 1985-86 and 1986-87 dry seasons. However, in the 1986 wet season, cutgrass dry weight at 30 DAH decreased significantly with the rate of glyphosate application, while both rates of glyphosate resulted in similar but lower cutgrass dry weight compared with no glyphosate treatment at 60 DAH (Table 4.25). At 60 DAH in the 1985-86 dry season, cutgrass dry weight also decreased with the rate of glyphosate applied, while in the 1986-87 dry season both rates similarly significantly reduced cutgrass dry weight compared with the untreated control.

Table 4.25. Effects of levels of glyphosate, oxadiazon and weed control treatments on cutgrass dry matter production in direct-seeded lowland rice at Badeggi.

| Treatments | | Cutgrass dry weight (kg/ha) | | | |
|---|---|---|---|---|---|
| Preplant glyphosate rate (kg ae /ha) | | 30 DAH[1] | | 60 DAH | |
| | | 1986 WS[2] | 1985-86 DS[3] | 1986 WS | 1986-87 DS |
| 0.0 | | 703.3 a | 863.6 a | 939.7 a | 920.5 a |
| 0.5 | | 639.8 b | 651.9 b | 473.8 b | 345.2 b |
| 1.0 | | 437.3 c | 608.8 c | 440.4 b | 299.1 c |
| SE± | | 21.20 | 10.32 | 30.30 | 27.92 |
| Pre-emergence Oxadiazon rate (kg a.i./ha) | | | | | |
| 0.0 | | 736.8 a | 719.7 a | 772.0 a | 580.9 a |
| 0.75 | | 474.5 b | 696.5 b | 463.9 b | 462.3 b |
| SE± | | 27.28 | 18.18 | 25.52 | 12.36 |
| Post-emergence | Rate (kg a.i./ha) | | | | |
| Butachlor + propanil | 1.8 + 2.0 | 605.4 b | 455.7 c | 387.0 b | 371.5 c |
| Bentazon + propanil | 0.96 + 2.0 | 608.0 b | 504.6 bc | 551.7 b | 486.5 bc |
| Benthiocarb+propanil | 1.08 + 2.0 | 517.0 bc | 508.6 bc | 511.7 b | 406.9 c |
| Oxadiazon+propanil | 0.75 + 2.0 | 561.3 bc | 458.4 c | 431.0 b | 308.1 c |
| Dimethametryn+propanil | 0.75 + 2.0 | 516.7 bc | 455.6 bc | 397.7 b | 404.1 c |
| Propanil | 2.0 | 616.6 b | 571.6 b | 494.0 b | 501.0 bc |
| Hand-weeding twice at | 20 & 40 | 363.3 c | 252.0 d | 51.1 c | 100.3 d |
| Control (untreated) | | 1056.0 a | 2459.6 a | 2118.9 a | 1593.8 a |
| SE± Weed control | | 58.84 | 34.90 | 55.16 | 34.90 |

1. DAH = Days after herbicide application; 2. WS = Wet Season; 3. DS = Dry season
Means followed by the same letter(s) within a treatment column are not significantly different at 5% level of probability using DMRT

The effect of pre-emergence oxadiazon on cutgrass dry weight was significant at 30 and 60 DAH in the 1986 wet season and at 60 DAH in the 1986-87 dry season. In both cases, application of pre-emergence oxadiazon at 0.75 kg a.i./ha reduced cutgrass dry weight (Table 4.25).

Post-emergence herbicides had significant effect on cutgrass dry weight at 30 DAH in the 1986 wet season (Table 4.26) and at 60 DAH in all the trials. In all cases, all the weed control treatments including the hand-weeded control caused significant reduction in cutgrass dry weight compared with the untreated control. In the 1986 wet season, while the mixtures of propanil with dimethametryn at 2.0 + 1.08 kg a.i./ha and benthiocarb at 2.0 + 1.08 kg a.i./ha and oxadiazon at 2.0 + 0.75 kg a.i./ha resulted in comparable cutgrass dry weight to the hand-weeded control at 30 DAH, none of the post-emergence herbicide treatments was comparable at 60 DAH. Mixtures of propanil with benthiocarb and dimethametryn also resulted in higher cutgrass dry weights than propanil mixtures with butachlor and oxadiazon which produced 371.5 kg/ha and 308.1 kg/ha respectively compared with 1593.8 kg/ha of the untreated

Table 4.26. Interaction of glyphosate and post emergence weed control treatments on cutgrass dry weight in dry-seeded lowland rice at Badeggi, 1986 wet season.

| Treatments | Application | | Cutgrass dry weight at 30 DAH[1] (kg/ha) | | |
|---|---|---|---|---|---|
| Post-emergence | Rate kg a.i./ha | Time DAS[2] | Glyphosate rate (kg ae /ha) 0.0 | 0.5 | 1.0 |
| Butachlor + propanil | 1.8 + 2.0 | 14 | 784.2 bc | 666.0 bcd | 366.1 ef |
| Bentazon + propanil | 0.96 + 2.0 | 14 | 866.0 ab | 684.0 bcd | 466.0 def |
| Benthiocarb + propanil | 1.08 + 2.0 | 14 | 668.0 bcd | 566.0 cde | 317.1 ef |
| Oxadiazon + propanil | 0.75 + 2.0 | 14 | 716.0 bc | 634.0 bcd | 334.0 ef |
| Dimethametryn + propanil | 0.75 + 2.0 | 14 | 700.0 bc | 533.9 cde | 316.3 ef |
| Propanil | 2.0 | 14 | 749.5 bc | 583.6 bcde | 516.8 cde |
| Hand-weeding twice at | | 20 & 40 | 470.1 def | 399.5 def | 200.1 f |
| Control | | | 1134.0 a | 1050.0 a | 984.0 a |
| SE± Glyphosate x weed control treatments | | | | 97.40 | |

1. DAH = Days after herbicide application; 2. DAS = Days after seeding.

Means followed by the same letter(s) within a column are not significantly different at 5% level of probability using DMRT.

Table 4.27. Interaction of glyphosate and post-emergence weed control treatments on cutgrass dry weight in the wet seeded lowland rice at Badeggi, 1985-86 dry season.

| Treatments (Post-emergence) | Application Rate (kg a.i./ha) | Application Time DAS[1] | Cutgrass dry weight at 60 DAH[2] (kg/ha) Glyphosate rate (kg ae /ha) 0.0 | 0.5 | 1.0 |
|---|---|---|---|---|---|
| Butachlor + propanil | 1.8 + 2.0 | 14 | 675.4 bc | 401.2 e | 290.6 f |
| Bentazon + propanil | 0.96 + 2.0 | 14 | 687.6 bc | 455.0 de | 371.0 ef |
| Benthiocarb + propanil | 1.08 + 2.0 | 14 | 725.6 bc | 450.0 de | 350.0 ef |
| Oxadiazon + propanil | 0.75 + 2.0 | 14 | 571.6 cd | 357.0 ef | 446.6 de |
| Dimethametryn + propanil | 0.75 + 2.0 | 14 | 649.4 bc | 433.4 de | 284.4 f |
| Propanil | 2.0 | 14 | 784.6 b | 456.4 de | 469.0 de |
| Hand weeding twice at | | 20 & 40 | 273.6 f | 237.0 f | 245.4 f |
| Control | | | 2540.8 a | 2425.2 a | 2413.2 a |
| SE± Glyphosate x post-emergence weed control | | | | 52.28 | |

1. DAS = Days after seeding; 2. DAH = Days after herbicide application

Means followed by the same letter(s) within a column are not significantly different at 5% level of probability using DMRT.

Table 4.28. Interaction of glyphosate and post-emergence weed control treatments on cutgrass dry weight in the wet-seeded lowland rice at Badeggi, 1986-87 dry season.

| Treatments (Post-emergence) | Application Rate (kg a.i./ha) | Application Time DAS[1] | Cutgrass dry weight (kg/ha) at 60 DAH[2] Glyphosate rate (kg ae /ha) 0.0 | 0.5 | 1.0 |
|---|---|---|---|---|---|
| Butachlor + propanil | 1.8 + 2.0 | 14 | 750.4 cd | 218.4 fg | 145.6 fg |
| Bentazon + propanil | 0.96 + 2.0 | 14 | 860.8 c | 324.0 f | 274.6 fg |
| Benthiocarb + propanil | 1.08 + 2.0 | 14 | 737.2 cd | 260.2 fg | 223.4 fg |
| Oxadiazon + propanil | 0.75 + 2.0 | 14 | 620.0 d | 202.4 fg | 101.8 g |
| Dimethametryn + propanil | 0.75 + 2.0 | 14 | 575.2 e | 271.4 f | 185.6 fg |
| Propanil | 2.0 | 14 | 877.4 c | 338.6 f | 287.0 fg |
| Hand-weeding twice at | | 20 & 40 | 133.6 g | 67.4 g | 100.0 g |
| Control | | | 2628.0a | 1079.2 b | 1074.4 b |
| SE± Glyphosate x Post emergence weed control | | | | 53.48 | |

1. DAS = Days after seeding; 2. DAH = Days after herbicide application
Means followed by the same letter(s) within a column are not significantly different at 5% level of probability using DMRT.

Table 4.29. Interaction of pre-emergence oxadiazon and glyphosate on cutgrass dry weight in the wet season direct-seeded lowland rice at Badeggi, 1986.

| Treatments | | | Cutgrass dry weight at 60DAH[2] (kg/ha) Pre-emergence oxadiazon rate kg a.i./ha | |
|---|---|---|---|---|
| (Pre-plant) | Application Rate (kg ae./ha) | Time DBS[1] | 0.0 | 0.75 |
| Glyphosate | 0.0 | 21 | 880.0 a | 648.0 b |
| Glyphosate | 0.5 | 21 | 880.0 a | 400.0 cd |
| Glyphosate | 1.0 | 21 | 500.0 c | 376.0 d |
| SE± Glyphosate x oxadiazon | | | 39.80 | |

1. DBS = Days before seeding

2. DAH = Days after herbicide application

Means followed by the same letter(s), within a column are not significantly different at 5% level of probability using DMRT.

control in this trial. In the 1985-86 and 1986-87 dry seasons (Tables 4.27 and 4.28) none of the herbicide treatments resulted in comparable cutgrass dry weight to the hand-weeded control. Propanil at 2.0 kg a.i./ha resulted in significantly higher cutgrass dry weight than the mixtures with butachlor and oxadiazon. In 1986-87 dry season these mixtures also resulted in lower cutgrass dry weight than bentazon plus propanil.

The interactions between pre-plant glyphosate and post-emergence weed control treatments and that of pre-emergence oxadiazon with post-emergence weed control treatments were significant on cutgrass dry weight at 30 DAH in the 1986 wet season (Table 4.26) and at 60 DAH in the 1985-86 and 1986-87 dry seasons (Tables 4.27 and 4.28). The interaction between glyphosate and pre-emergence oxadiazon (Table 4.29) was only significant on cutgrass dry weight at 60 DAH in the 1986 wet season.

While both rates of glyphosate caused significant reduction of cutgrass dry weight when pre-emergence oxadiazon was applied later at 0.75 kg a.i./ha, only glyphosate at 1.0 kg ae/ha significantly reduced the weight without pre-emergence oxadiazon. Even without glyphosate, significant difference was obtained between pre-emergence oxadiazon at 0.0 and 0.75 kg a.i./ha,(Table 4.29) while with glyphosate at 0.5 and 1.0 kg ae/ha, plots treated with oxadiazon also caused significant reduction of cutgrass dry weight compared with no oxadiazon treatment.

Table 4.30. Interaction of pre-emergence oxadiazon and post-emergence weed control treatments on cutgrass dry weight in the dry-seeded lowland rice at Badeggi, 1986 wet season.

| Treatments (Post-emergence) | Application Rate (kg a.i./ha) | Time DAS[1] | Cutgrass dry weight (kg/ha) at 30DAH[2] Oxadiazon rate (kg a.i./ha) | |
|---|---|---|---|---|
| | | | 0.0 | 0.75 |
| Butachlor + propanil | 1.8 + 2.0 | 14 | 700.0bcd | 510.6cd |
| Bentazon + propanil | 0.96 + 2.0 | 14 | 672.0bcd | 544.0cd |
| Benthiocarb + propanil | 1.08 + 2.0 | 14 | 634.0cd | 400.0cde |
| Oxadiazon + propanil | 0.75 + 2.0 | 114 | 800.6bc | 322.0de |
| Dimethametryn + propanil | 0.75 + 2.0 | 14 | 622.0cd | 411.2cde |
| Propanil | 2.0 | 14 | 755.2bcd | 478.0c |
| Hand weeding twice at | | 20 & 40 | 510.0d | 216.5e |
| Control | | | 1200.0a | 912.0bc |

SE± Oxadiazon x Post emergence weed control 82.51

1. DAS = Days after seeding.

2. DAH = Days after herbicide application

Means followed by the same letter(s) within a column are not significantly different from each other at 5% level of probability using DMRT.

In this trial with the application of glyphosate, all the weed control treatments resulted in significantly lower cutgrass dry weight at 30 DAH and 60 DAH in the 1985-86 and 1986-87 dry seasons than the untreated control. At 30 DAH, without glyphosate cutgrass dry weight with bentazon plus propanil at 0.96 + 2.0 kg a.i./ha did not differ significantly from that of the untreated control. In addition to bentazon + propanil at 0.96 + 2.0 kg a.i./ha, propanil alone and its mixture with butachlor, oxadiazon and dimethametryn caused higher cutgrass dry matter production at 30 DAH than the hand-weeded control. However, with glyphosate at 0.5 kg ae/ha all the post-emergence treatments including hand-weeding were comparable. With glyphosate at 1.0 kg ae/ha, propanil alone at 2.0 kg a.i./ha caused higher cutgrass matter production than the hand-weeded control. At 60 DAH in the dry season trials, the post-emergence herbicides resulted in higher cutgrass dry weight than the hand-weeded control on plots not treated with glyphosate (Tables 4.27 and 4.28).

The interaction between pre-emergence oxadiazon and post-emergence weed control treatments was significant on cutgrass dry weight at 30 DAH in the 1986 wet season (Table 4.30) and at 60 DAH in the 1986-87 dry season trials (Table 4.31). In the two trials, cutgrass dry weights were significantly lower on all the plots which received post-emergence weed control treatments irrespective of pre-emergence oxadiazon treatment. At 30 DAH, in the 1986 wet season, without pre-emergence oxadiazon, post-emergence oxadiazon plus propanil

at 0.75 + 2.0 kg a.i./ha caused significantly higher cutgrass dry weight than hand-weeding. With the application of pre-emergence oxadiazon at 0.75 kg a.i./ha, propanil alone at 20 kg a.i./ha and its mixtures with butachlor at 2.0 + 1.8 kg a.i./ha, bentazon at 2.0 + 0.96 kg a.i./ha resulted in significantly higher cutgrass dry weight than the hand-weeded control (Table 4.30). At 60 DAH in the 1986-87 dry season trial, cutgrass dry weights on plots which received post-emergence herbicide treatments were significantly lower than that on plots without post-emergence treatments, irrespective of pre-emergence oxadiazon treatment. Without pre-emergence oxadiazon, post-emergence oxadiazon plus propanil at 0.75 + 2.0 kg a.i./ha caused the least cutgrass dry weight among herbicide treatments. Benthiocarb plus propanil at 1.08 + 2.0 kg a.i./ha resulted in comparable cutgrass dry weight to the least among herbicide treatments under the same oxadiazon treatment. All the other herbicide treatments resulted in similar cutgrass weight but higher than that of oxadiazon mixture. With the application of pre-emergence oxadiazon, butachlor plus propanil at 1.8 + 2.0 kg a.i./ha and oxadiazon plus propanil at 0.75 + 2.0 kg a.i./ha resulted in the least cutgrass dry weight among herbicide treatments. Propanil at 2.0 kg a.i./ha caused the highest cutgrass dry weight under the same pre-emergence oxadiazon treatment. Dimethoametryn plus propanil at 0.96 + 2.0 kg a.i./ha, however resulted in similar cutgrass weight to that of oxadiazon mixture while the value obtained with propanil was

Table 4.31. Interaction of pre-emergence oxadiazon and post-emergence weed control treatments on cutgrass dry weight in the dry season, wet-seeded lowland rice at Badeggi, 1986-87.

| Treatments (Post-emergence) | Application Rate (kg a.i./ha) | Application Time DAS[1] | Cutgrass dry weight (kg/ha) at 60 DAH[2] | |
|---|---|---|---|---|
| | | | Oxadiazon rate (kg a.i./ha) | |
| | | | 0.0 | 0.75 |
| Butachlor+propanil | 1.8 + 2.0 | 14 | 463.8c | 279.24e |
| Bentazon+propanil | 0.96 + 2.0 | 14 | 542.0c | 431.0cd |
| Benthiocarb + propanil | 1.08 + 2.0 | 14 | 439.2cd | 364.0de |
| Oxadiazon+propanil | 0.75 + 2.0 | 14 | 364.8de | 262.0e |
| Dimethametryn + propanil | 0.75 + 2.0 | 14 | 484.4c | 325.2de |
| Propanil | 2.0 | 14 | 535.2c | 466.8c |
| Hand-weeding twice at | | 20 & 40 | 140.2f | 60.4f |
| Control | | | 2677.6a | 1510.0b |
| SE± Oxadiazon x Post-emergence weed control | | | 39.30 | |

1. DAS = Days after seeding

2. DAH = Days after herbicide application

Means followed by the same letter(s) within a column are not significantly different at 5% level of probability using DMRT.

significantly higher. Irrespective of pre-emergence application of oxadiazon at 0.0 and 0.75 kg a.i./ha, all the herbicide treatments caused significantly higher cutgrass dry weight than hand-weeding done twice (Table 4.31).

4.4.2 % Cutgrass coverage.

Cutgrass coverage was higher in the wet season than in the dry season. Glyphosate at both rates significantly reduced cutgrass % coverage at 30 and 60 DAH in all the trials when compared with zero glyphosate treatment. Cutgrass coverage at 30 DAH in the 1985-86 dry season trial ranged from 1.0 + 9.1% while in the 1986 wet season the value ranged from 21.5 to 46.8% and in the 1986-87 dry season the value was between 1.3 and 11.0%. At 60 DAH cutgrass coverage varied from 12.3 to 31.2% in 1985-86 dry season, while in 1986 wet and 1986-87 dry seasons the corresponding values ranged from 12.6 to 40.3% and 5.1 to 27.9% respectively. The difference between 0.5 and 1.0 kg ae/ha of glyphosate was however only significant at 60 DAH in the 1985-86 dry season when 1.0 kg ae./ha resulted in lower cutgrass coverage than 0.5 kg ae/ha.

In all the trials except at 60 DAH in 1986-87 dry season, pre-emergence oxadiazon significantly reduced % coverage of cutgrass at 30 and 60 DAH compared with no oxadiazon treatment (Tables 4.31 and 4.32).

All the post-emergence weed control treatments significantly reduced % coverage of cutgrass at

Table 4.32. Effects of levels of glyphosate, oxadiazon and weed control treatments on % cutgrass coverage in direct-seeded lowland rice.

| Treatments | | Cutgrass coverage at 30 DAH[1] (%) | | |
|---|---|---|---|---|
| | | 1985-86 DS[3] | 1986 WS[2] | 1986-87 DS |
| Pre-plant glyphosate rate (kg ae./ha) | | | | |
| 0.0 | | 9.1 a | 46.8 a | 11.0 a |
| 0.5 | | 1.5 b | 22.5 b | 1.3 b |
| 1.0 | | 1.0 b | 21.5 b | 1.3 b |
| SE± | | 0.60 | 6.70 | 0.75 |
| Pre-emergence Oxadiazon rate (kg a.i./ha) | | | | |
| 0.0 | | 5.3 a | 36.5 a | 7.3 a |
| 0.75 | | 2.5 b | 23.8 b | 2.8 b |
| SE± | | 0.41 | 3.55 | 0.40 |
| Pre-emergence | | | | |
| Butachlor+propanil | 1.8 + 2.0 | 2.0 bc | 27.0 bc | 2.0 cd |
| Bentazon+propanil | 0.96 + 2.0 | 3.0 b | 37.3 b | 5.0 b |
| Benthiocarb + propanil | 1.08 + 2.0 | 3.0 b | 26.6 bc | 4.0 bc |
| Oxadiazon+propanil | 0.75 + 2.0 | 3.0 b | 25.3 bc | 4.0 bc |
| Dimethametryn + propanil | 0.75 + 2.0 | 3.0 b | 21.3 c | 4.0 bc |
| Propanil | 2.0 | 4.0 b | 22.7 c | 4.0 bc |
| Hand-weeding twice | 20.& 40 | 1.0 c | 14.4 c | 1.0 d |
| Control | - | 12.0 a | 67.3 a | 12.0 a |
| SE± Weed control | | 0.8 | 4.50 | 0.82 |

1. DAH = Days after herbicide application

2. WS = Wet Season; 3. DS = Dry Season

Means followed by the same letter(s) within a treatment column are not significantly different at 5% level of probability using DMRT.

Table 4.33. Effects of levels of glyphosate, oxadiazon and weed control treatments on % cutgrass coverage in the direct-seeded lowland rice at Badeggi.

| Treatments | | Cutgrass coverage at 60 DAH[1] (%) | | |
|---|---|---|---|---|
| Pre-plant glyphosate rate (kg ae./ha) | | 1985-86 DS[3] | 1986 WS[2] | 1985-87 DS |
| 0.0 | | 31.2 a | 40.3 a | 27.9 a |
| 0.5 | | 20.0 b | 17.4 b | 6.9 b |
| 1.0 | | 12.2 c | 10.6 b | 5.1 b |
| SE± | | 2.00 | 9.41 | 44.01 |
| Pre-emergence Oxadiazon rate (kg a.i./ha) | | | | |
| 0.0 | | 22.6 a | 30.2 a | 14.4 a |
| 0.75 | | 19.7 b | 15.3 b | 12.3 a |
| SE± | | 0.90 | 2.43 | 2.29 |
| Post-emergence | | | | |
| Butachlor+propanil | 1.8 + 2.0 | 13.2 b | 19.3 bc | 11.0bc |
| Bentazon+propanil | 0.96 + 2.0 | 17.1 ȧ | 26.8 b | 16.2 b |
| Benthiocarb-propanil | 1.08+2.0 | 17.7 ȧ | 23.3bc | 7.1 cd |
| Oxadiazon+propanil | 0.75+2.0 | 13.0b | 17.7bc | 7.6 c |
| Dimethametryn + propanil | 0.75+2.0 | 14.8 b | 15.1 c | 7.2 cd |
| Propanil | 2.0 | 13.6 b | 24.3 bc | 14.4 bc |
| Hand-weeding twice at | 20 & 40 | 2.0 c | 3.3 d | 2.0 d |
| Control | - | 17.7 a | 52.2 a | 41.5 a |
| SE± Weed control | | 2.30 | 2.92 | 1.70 |

1. DAH = Days after herbicide application

2. WS = Wet season; 30. DS = Dry season

Means followed by the same letter(s) within a treatment column are not significantly different from each other at 5% level of probability using DMRT.

Table 4.34. Interaction of glyphosate and post-emergence weed control treatments on % cutgrass coverage in the wet-seeded lowland rice at Badeggi, 1985-86 dry season.

| Treatments | Application Rate (kg a.i./ha) | Time DAS[1] | Cutgrass coverage at 30 DAH[2] (%) Glyphosate rate (kg ae/ha) | | |
|---|---|---|---|---|---|
| | | | 0.0 | 0.5 | 1.0 |
| Butachlor + propanil | 1.8 + 2.0 | 14 | 6 bc | 0 c | 0 c |
| Bentazon + propanil | 0.96 + 2.0 | 14 | 9 b | 0 c | 0 c |
| Benthiocarb + propanil | 1.08 + 2.0 | 14 | 9 b | 0 c | 0 c |
| Oxadiazon + propanil | 0.75 + 2.0 | 14 | 9 b | 0 c | 0 c |
| Dimethametryn + propanil | 0.75 + 2.0 | 14 | 9 b | 0 c | 0 c |
| Propanil | 2.0 | 14 | 12 ab | 0 c | 0 c |
| Hand-weeding twice at | | 20 & 40 | 3 bc | 0 c | 0 c |
| Control | | | 16 a | 12ab | 8 b |
| SE± Glyphosate x Post-emergence weed control | | | | 2.10 | |

1. DAS = Days after seeding

2. DAH = Days after herbicide application

Means followed by the same letters within a column are not significantly different from each other at 5% level of probability using DMRT.

Table 4.35. Interaction of glyphosate and post-emergence weed control treatments on % coverage of cutgrass in the dry-seeded lowland rice at Badeggi, 1986 wet season.

| Treatments | Application | | % cutgrass coverage at 30 DAH[2] | | |
|---|---|---|---|---|---|
| Post-emergence | Rate (kg a.i./ha) | Time DAS[1] | Glyphosate rate (kg ae /ha) 0.0 | 0.5 | 1.0 |
| Butachlor + propanil | 1.8 + 2.0 | 14 | 49b-e | 9 g | 23d-g |
| Bentazon + propanil | 0.96 + 2.0 | 14 | 62 ab | 32c-g | 18e-g |
| Benthiocarb + propanil | 1.08 + 2.0 | 14 | 51b-d | 23d-g | 6 g |
| Oxadiazon + propanil | 0.75 + 2.0 | 14 | 38b-f | 17d-g | 21e-g |
| Dimethametryn + propanil | 0.75 + 2.0 | 14 | 3 g | 12fg | 16 fg |
| Propanil | 2.0 | 14 | 35b-f | 11 fg | 22d-g |
| Hand-weeding twice at | | 20 & 40 | 15 fg | 20e-g | 8 g |
| Control | | | 88 a | 56 bc | 58 bc |
| SE± Glyphosate x Post-emergence weed control | | | | 9.9 | |

1. DAS = Days after seeding

2. DAH = Days after herbicide application

Means followed by the same letter(s) within a column are not significantly different from each other at 5% level of probability using DMRT.

Table 4.36. Interaction of glyphosate and post-emergence weed control treatments on % cutgrass coverage in the wet-seeded lowland rice at Badeggi, 1986-87 dry season.

| Treatments<br>Post-emergence | Application Rate (kg a.i./ha) | Time DAS[1] | % cutgrass coverage at 30 DAH[2] Glyphosate rate (kg ae /ha) | | |
|---|---|---|---|---|---|
| | | | 0.0 | 0.5 | 1.0 |
| Butachlor + propanil | 1.8 + 2.0 | 14 | 6 abc | 0 c | 0 c |
| Bentazon + propanil | 0.96 + 2.0 | 14 | 15 a | 0 c | 0 c |
| Benthiocarb + propanil | 1.08 + 2.0 | 14 | 12 ab | 0c | 0 c |
| Oxadiazon + propanil | 0.75 + 2.0 | 14 | 12 ab | 0 c | 0 c |
| Dimethametry + propanil | 0.75 + 2.0 | 14 | 12 ab | 0 c | 0 c |
| Propanil | 2.0 | 14 | 12 ab | 0 c | 0 c |
| Hand-weeding twice at | | 20 & 40 | 3 bc | 0 c | 0 c |
| Control | | | 16 a | 10abc | 10abc |
| SE± Glyphosate x Post-emergence weed control | | | | 3.6 | |

1. DAS = Days after seeding

2. DAH = Days after herbicide application

Means followed by the same letter(s) within a column are not significantly different from each other at 5% level of probability using DMRT.

Table 4.37. Interaction of glyphosate and post-emergence weed control treatments on % cutgrass coverage in the direct-seeded lowland rice at Badeggi, 1985-86 dry season.

| Treatments | Application Rate (kg a.i./ha) | Time DAS[1] | % cutgrass coverage at 60 DAH[2] Glyphosate rate (kg ae/ha) | | |
|---|---|---|---|---|---|
| | | | 0.0 | 0.5 | 1.0 |
| Butachlor + propanil | 1.8 + 2.0 | 14 | 25.0cd | 12.1ef | 2.3 f |
| Bentazon + propanil | 0.96 + 2.0 | 14 | 33.0 c | 10.3ef | 7.8ef |
| Benthiocarb + propanil | 1.08 + 2.0 | 14 | 26.0cd | 18.cde | 8.1ef |
| Oxadiazon + propanil | 0.75 + 2.0 | 14 | 31.0 c | 6.0ef | 2.0 f |
| Dimethametryn + propanil | 0.75 + 2.0 | 14 | 32.0 c | 7.6ef | 4.6ef |
| Propanil | 2.0 | 14 | 31.5 c | 7.1ef | 2.0 f |
| Hand-weeding twice at | 20 & 40 | 20 & 40 | 2.0 f | 2.0ef | 2.0 f |
| Control | | | 69.1 b | 95.6 a | 68.3b |
| SE± Glyphosate x Post-emergence weed control | | | | 3.99 | |

1. DAS = Days after seeding

2. DAH = Days after herbicide application

Means followed by the same letter(s) within a column are not significantly different at 5% level of probability using DMRT.

Table 4. 38. Interaction of glyphosate and post-emergence weed control treatments on % cutgrass coverage in the dry-seeded lowland rice at Badeggi, 1986 wet season.

| Treatments | Application Rate (kg a.i./ha) | Time DAS[1] | % cutgrass coverage at 60 DAH[2] Glyphosate rate (kg ae/ha) | | |
|---|---|---|---|---|---|
| | | | 0.0 | 0.5 | 1.0 |
| Butachlor + propanil | 1.8 + 2.0 | 14 | 37.5bc | 11.7c | 8.7c |
| Bentazon + propanil | 0.96 + 2.0 | 14 | 48.3 b | 21.7bc | 10.3c |
| Benthiocarb + propanil | 1.08 + 2.0 | 14 | 45.0 b | 16.3bc | 8.7 c |
| Oxadiazon + propanil | 0.75 + 2.0 | 14 | 35.8bc | 9.2c | 8.2c |
| Dimethametryn + propanil | 0.75 + 2.0 | 14 | 30.0bc | 10.0c | 5.2c |
| Propanil | 2.0 | 14 | 44.0b | 19.2bc | 9.8c |
| Hand-weeding twice at | | 20 & 40 | 2.5c | 3.3c | 4.2c |
| Control | | | 79.2a | 47.5b | 30.0bc |
| SE± Glyphosate x Post-emergence weed control | | | | 10.53 | |

1. DAS = Days after seeding

2. DAH = Days after herbicide application.

Means followed by the same letter(s) within a column are not significantly different from each other at 5% level of probability using DMRT.

Table 4.39. Interaction of glyphosate and post-emergence weed control treatments on % cutgrass coverage in the wet-seeded lowland rice at Badeggi, 1986-87 dry season.

| Treatments | Application | | Cutgrass coverage at 60 DAH[1] (%) | | |
|---|---|---|---|---|---|
| | Rate (kg a.i./ha) | Time DAS[1] | Glyphosate.rate (kg ae/ha). | | |
| Post-emergence | | | 0.0 | 0.5 | 1.0 |
| Butachlor + propanil | 1.8 + 2.0 | 24 | 24.0bc | 5.3 c | 4.6c |
| Bentazon + propanil | 0.96 + 2.0 | 14 | 35.6b | 7.5c | 5.3c |
| Benthiocarb + propanil | 1.08 + 2.0 | 14 | 16.8c | 2.1c | 2.1c |
| Oxadiazon + propanil | 0.75 + 2.0 | 14 | 17.0c | 2.0c | 1.6c |
| Dimethametryn + propanil | 0.75 + 2.0 | 14 | 16.1c | 3.3c | 2.0c |
| Propanil | 2.0 | 14 | 32.5b | 7.0c | 3.8c |
| Hand-weeding twice at | | 20 & 40 | 2.0 c | 2.0c | 2.0c |
| Control | | | 78.6a | 25.8bc | 20.0bc |
| SE± Glyphosate x Post-emergence weed control | | | | 4.87 | |

1. DAS = Days after weeding

2. DAH = Days after herbicide application

Means followed by the same letter(s) within a column are not significantly different at 5% level of probability using DMRT.

30 DAH only in all the trials. In 1985-86 and 1986-87 dry seasons at 30 DAH, among the herbicide treatments only butachlor plus propanil at 1.8 + 2.0 kg a.i./ha resulted in comparable % coverage of cutgrass to hand-weeding. However, at 60 DAH, none of the herbicide treatments was comparable to the hand-weeded control in the 1985-86 dry season while benthiocarb plus propanil at 1.08 + 2.0 and dimethametryn plus propanil at 0.75 + 2.0 kg a.i./ha resulted in similar cutgrass coverage to the hand-weeded check in 1986-87 dry season. In the 1986-87 dry season, bentazon plus propanil also resulted in higher % cutgrass coverage than post-emergence oxadiazon plus propanil. In the 1986 wet season trial, while only bentazon plus propanil caused higher % coverage at 30 DAH than the hand-weeded control, all the herbicide treatments resulted in higher value at 60 DAH. Bentazon plus propanil still resulted in higher coverage than the lowest with herbicide mixtures caused by dimethametryn plus propanil.

In all the trials, the interaction of the post-emergence herbicide treatments with glyphosate was significant on % coverage of cutgrass at 30 and 60 DAH (Tables 34 - 39). All the post-emergence weed control treatments including hand-weeding did not differ significantly in % coverage of cutgrass at 30 and 60 DAH when they followed both rates of glyphosate in all the trials.

Without glyphosate, the mixture of propanil with butachlor at 2.0 + 1.8 kg a.i./ha, bentazon at 2.0 + 1.08 kg a.i./ha at 30 DAH in the 1986 wet season and all the post-emergence herbicide treatments at 60 DAH in all the trials resulted in higher % coverage of cutgrass than the hand-weeded control. With the application of glyphosate at 0.5 and 1.0 kg a.i./ha at 30 and 60 DAH in all the trials, all the post-emergence herbicide treatments resulted in comparable % cutgrass coverage to the hand-weeded control.

The interaction between pre-emergence oxadiazon and post-emergence herbicide treatments was significant on % coverage of cutgrass at 30 DAH in the 1986 wet and at 60 DAH in the 1986-87 dry seasons. In both trials dimethametryne plus propanil at 0.75 + 2.0 kg a.i./ha consistently produced comparable cutgrass coverage to hand-weeding irrespective of the rate of oxadiazon treatment. Post-emergence oxadiazon plus propanil at 0.75 + 2.0 kg a.i./ha under both rates of pre-emergence oxadiazon treatment in 1986 wet season at 30 DAH resulted in comparable cutgrass coverage to hand-weeding. Butachlor plus propanil at 1.8 + 2.0 kg a.i./ha and benthiocarb plus propanil at 1.08 + 2.0 kg a.i./ha at 30 DAH caused comparable cutgrass coverage to hand-weeding under zero oxadiazon treatment in the two trials (Tables 4.40 and 4.41).

Table 4.40. Interaction of pre-emergence oxadiazon and post-emergence weed control treatments on % coverage of cutgrass in the dry-seeded lowland rice at Badeggi, 1986 wet season.

| Treatments | Application Rate (kg a.i./ha) | Application Time DAS[1] | Cutgrass coverage at 30 DAH[1] (%) Oxadiazon rate (kg a.i../ha) 0.0 | 0.75 |
|---|---|---|---|---|
| Butachlor + propanil | 1.8 + 2.0 | 14 | 23 bc | 31 b |
| Bentazon + propanil | 0.96 + 2.0 | 14 | 43 b | 31 b |
| Benthiocarb + propanil | 1.08 + 2.0 | 14 | 26 bc | 27 bc |
| Oxadiazon + propanil | 0.75 + 2.0 | 14 | 32 bc | 18 c |
| Dimethametryn + propanil | 0.75 + 2.0 | 14 | 27 bc | 16 c |
| Propanil | 2.0 | 14 | 30 b | 15 c |
| Hand-weeding twice at | | 20 & 40 | 20 c | 9 c |
| Control | | | 91 a | 43 b |
| SE± Oxadiazon x Post-emergence weed control 6.9 | | | | |

1. DAS = Days after seeding

2. DAH = Days after herbicide application.

Means followed by the same letter(s) within a column probability using DMRT.

Table 4.41. Interaction of pre-emergence oxadiazon and post-emergence weed control treatments on % coverage of cutgrass in the wet-seeded lowland rice at Badeggi, 1986-87 dry season.

| Treatments | Application Rate (kg a.i./ha) | Time DAS[1] | % cutgrass coverage at 60 DAH[2] Oxadiazon rate (kg a.i./ha) 0.0 | 0.75 |
|---|---|---|---|---|
| Pre-emergence | | | | |
| Butachlor + propanil | 1 1.8 + 2.0 | 14 | 12.2bcd | 9.7 cd |
| Bentazon + propanil | 0.96 + 2.0 | 14 | 18.6 b | 10.7 cd |
| Benthiocarb + propanil | 1.08 + 2.0 | 14 | 7.9 cd | 6.1 d |
| Oxadiazon + propanil | 0.75 + 2.0 | 14 | 8.1 cd | 8.1 cd |
| Dimethametryn + propanil | 0.75 + 2.0 | 14 | 7.8 cd | 6.4 d |
| Propanil | 2.0 | 14 | 16.6 b | 12.2bcd |
| Hand-weeding twice at | | 20 & 40 | 2.0 d | 2.0 d |
| Control | | | 41.6 a | 41.3 a |
| SE± Oxadiazon x Post-emergence weed control | | | 2.29 | |

1. DAS = Days after seeding

2. DAH = Days after herbicide application.

Means followed by the same letter(s) within a column are not significantly different at 5% level of probability using DMRT.

4.4.3 Plant height of rice

At 28 days in the 1986-87 dry season (Table 4.44), and 56 days in the wet season and 98 days in both the dry and wet seasons (Table 4.42), glyphosate application at both rates resulted in significantly taller plants than no glyphosate treatment. At 56 days in the dry season trial, plants of the plots treated with glyphosate at 0.5 kg ae/ha were taller than those of 1.0 kg ae/ha.

Pre-emergence application of oxadiazon only had significant effect on rice plant height in the dry season trial at 28 DAS when the treated plots had shorter plants than the untreated ones.

In the 1986 wet season and 1986-87 dry seasons, post-emergence herbicide treatments had significant effect on plant height at 28, 56 and 98 DAS (Tables 4.42 and 4.44). In the two trials, none of the herbicide treatments resulted in comparable rice plant height at 28 DAS to the hand-weeded control. At this stage of crop growth heights of plants of the plots treated with oxadiazon plus propanil at 0.75 + 2.0 kg a.i./ha did not differ

Significantly from those of the untreated plots in the two trials. Similarly butachlor plus propanil at 1.8 + 2.0 kg a.i./ha resulted in plants of similar heights to those of the untreated plots in the 1986 wet season.

At 56 DAS, although none of the post-emergence herbicide treatments resulted in comparable plant height to the hand-weeded control, all the weed control treatments caused significantly taller plants than the untreated control in the 1986 wet season and 1986-87 dry season. While rice plant height was similar for all the herbicide treatments in the 1986 wet season, bentazon plus propanil at 0.96 + 2.0 kg a.i./ha resulted in taller rice plants than all the post-emergence herbicide treatments in the 1986-87 dry season. At 98 DAS, all the weed control treatments including the hand-weeded control caused similar rice plant height in the wet season trial while those of the post-emergence herbicide treatments were lower than that of the hand-weeded control in 1986-87 dry season.

The interaction between glyphosate and pre-emergence oxadiazon was significant on plant height at 56 DAS in the 1986-87 dry season (Table 4.43). Without pre-emergence oxadiazon, the tallest plants occurred on plots treated with glyphosate at 1.0 kg ae/ha while with pre-emergence application of oxadiazon the tallest plants were obtained with glyphosate at 0.5kg ae/ha.

4.4 Tiller number of rice at 30 DAS

Tiller number of rice was significantly affected by levels of glyphosate at 30 and 60 DAS in the 1986 - 87 dry

Table 4.42. Effects of levels of glyphosate, oxadiazon and weed control treatments on plant height in the direct-seeded lowland rice at Badeggi.

| Treatments | | Plant height (cm) | | | |
|---|---|---|---|---|---|
| | | 56 DAS[1] | | 98 DAS | |
| Pre-plant glyphosate rate (kg ae./ha) | | 1986 WS[2] | 1986-87 DS[3] | 1986 WS | 1986-87 DS |
| 0.0 | | 56.5 b | 61.6 c | 82.6 b | 77.0 b |
| 0.5 | | 74.2 a | 80.9 a | 91.8 a | 98.0 a |
| 1.0 | | 72.5 a | 73.7 b | 95.9 a | 99.0 a |
| SE± | | 3.69 | 2.10 | 3.41 | 6.29 |
| Pre-emergence | | | | | |
| Oxadiazon rate (kg a.i./ha) | | | | | |
| 0.0 | | 68.2 a | 72.7 a | 90.8 a | 92.7 a |
| 0.75 | | 67.2 a | 71.5 a | 90.0 a | 90.5 a |
| SE± | | 2.56 | 1.75 | 1.89 | 1.40 |
| Post-emergence | Rate (kg a.i./ha) | | | | |
| Butachlor + propanil | 1.8 + 2.0 | 68.5 b | 71.1 c | 90.0 a | 94.3 b |
| Bentazon + propanil | 0.96 + 2.0 | 67.6 b | 80.1 b | 87.7 a | 93.5 b |
| Benthiocarb + propanil | 1.08 + 2.0 | 67.4 b | 69.2 c | 93.0 a | 98.5 b |
| Oxadiazon + propanil | 0.75 + 2.0 | 66.5 b | 68.7 c | 94.1 a | 85.6 b |
| Dimethametryn + propanil | 0.75 + 2.0 | 65.8 b | 70.3 c | 88.5 a | 93.4 b |
| Propanil | 2.0 | 65.1 b | 69.7 c | 90.2 a | 94.4 b |
| Hand-weeding twice at | 20 & 40 | 87.7 a | 98.8 a | 102.9 a | 104.5 a |
| Control (untreated) | | 52.1 c | 56.7 d | 77.0 b | 68.5 c |
| SE± Weed control | | 3.38 | 2.66 | 3.56 | 3.24 |

1. DAS = Days after seeding; 2. WS = Wet Season; DS = Dry Season
Means followed by the same letter(s) within a treatment column are not significantly different at 5% level of probability using DMRT.

Table 4.43. Interaction of pre-emergence oxadiazon and pre-plant glyphosate on plant height in the wet-seeded lowland rice at Badeggi, 1986-87 dry season.

| Treatments | | | Plant height at 56 DAS[1] (cm) | |
|---|---|---|---|---|
| Pre-plant herbicide | Rate (kg ae./ha) | Time DBS[1] | Oxadiazon rate (kg a.i./ha) | |
| | | | 0.0 | 0.75 |
| Glyphosate | 0.0 | 21 | 60.1 c | 63.0 c |
| Glyphosate | 0.5 | 21 | 75.5 b | 86.5 a |
| Glyphosate | 1.0 | 21 | 82.5 ab | 64.9 c |
| SE± Glyphosate x Oxadiazon | | | 2.97 | |

1. DBS = Days before seeding.

2. DAS = Days after seeding.

Means followed by the same letter(s) within a column are not significantly different at 5% level of probability using DMRT.

season where it increased significantly with the rate of glyphosate compared with no glyphosate treatment. In the 1986 wet season, glyphosate at 1.0 kg ae./ha significantly increased tiller number at 60 DAS compared with no glyphosate treatment, while at 30 DAS it caused higher tiller number than no glyphosate treatment but the difference was not significant. In the 1986-87 dry season, application of glyphosate at 1.0 kg ae./ha significantly increased tiller number of rice by 48 and 78% at 30 and 60 DAS respectively while in the 1986 wet season, glyphosate at 1.0 kg ae./ha caused about 35.5% significant increase in tiller number at 60 DAS compared with the control (Tables 4.44. and 4.45.).

Although the effect of pre-emergence oxadiazon on tiller number of rice at 30 and 60 DAS in the two trials was not significant, oxadiazon at 0.75 kg a.i./ha seemed to result in higher tiller number than no oxadiazon treatment.

In the 1986 wet and 1986-87 dry seasons all the post-emergence herbicide treatments resulted in higher tiller number than the untreated control. At 60 DAS, all the post-emergence herbicide treatments caused lower tiller production than hand-weeded control in the two trials. Only butachlor plus propanil resulted in comparable tiller number at 30 DAS to the hand-weeded check in the 1986 wet season, while in the 1986-87 dry season trial, the herbicide treatment was the only one that caused significantly lower tiller number than the hand-weeded check.

Table 4.44. Effects of levels of glyphosate, oxadiazon and weed control treatments on plant height and tiller number in the direct-seeded lowland rice at Badeggi.

| Treatments | | Plant height (cm) 28 DAS[1] | | Tiller (no/ha x 10,000) 30 DAS | |
|---|---|---|---|---|---|
| Pre-plant glyphosate rate (kg ae/ha) | | 1986 WS[2] | 1986-87 DS[3] | 1986 WS | 1986-87 DS |
| 0.0 | | 27.0 a | 26.3 b | 166 a | 131 c |
| 0.5 | | 28.5 a | 27.4 a | 168 a | 168 b |
| 1.0 | | 30.0 a | 27.7 a | 177 a | 194 a |
| SE± | | 0.86 | 0.21 | 8.67 | 3.00 |
| Pre-emergence | | | | | |
| Oxadiazon rate (kg a.i./ha) | | | | | |
| 0.0 | | 28.6 a | 26.8 b | 167 a | 161 a |
| 0.75 | | 28.3 a | 27.4 a | 175 a | 168 a |
| SE± | | 0.79 | 0.21 | 7.2 | 4.3 b |
| Post-emergence | Rate (kg a.i./ha) | | | | |
| Butachlor + propanil | 1.8 + 2.0 | 27.4 bc | 27.1 b | 184 ab | 162 b |
| Bentazon + propanil | 0.96 + 2.0 | 28.3 b | 27.6 b | 170 b | 166 ab |
| Benthiocarb + propanil | 1.08 + 2.0 | 28.1 b | 27.2 b | 176 b | 173 ab |
| Oxadiazon + propanil | 0.75 + 2.0 | 27.4 bc | 25.1 c | 177 b | 171 ab |
| Dimethametryn + propanil | 0.75 + 2.0 | 29.0 b | 27.8 b | 166 b | 175 ab |
| Propanil | 2.0 | 29.3 b | 27.2 b | 156 b | 173 ab |
| Hand-weeding x 2 | 20 & 40 | 31.5 a | 29.7 a | 211 a | 183 a |
| Control (untreated) | | 26.6 c | 25.2 c | 124 c | 111 c |
| SE± Weed control | 0. | 0.63 | 0.33 | 9.20 | 6.6 b |

1. DAS = Days after seeding; 2. WS = Wet Season; DS = Dry Season.
Means followed by the same letter(s) within a treatment column are not significantly different from each other at 5% level of probability using DMRT.

In the two trials, the interaction between glyphosate and post-emergence herbicide treatments on tiller number at 30 and 60 DAS was significant. In the 1986 wet season trial at 30 DAS without glyphosate, maximum tiller number was obtained with post-emergence oxadiazon plus propanil while with glyphosate at 0.5 and 1.0 kg ae/ha, the hand-weeded control caused maximum tiller production. Under zero glyphosate, all the weed control treatments including hand-weeding resulted in higher tiller number than the untreated check. Mixtures of propanil with oxadiazon and benthiocarb also resulted in higher tiller number than the hand-weeded control. With the application of glyphosate at 0.5 kg ae/ha, all the herbicide treatments resulted in lower number than the hand-weeded check. Only benthiocarb plus propanil at 1.08 + 2.0 kg a.i./ha and butachlor plus propanil at 1.8 + 2.0 kg a.i./ha caused higher tiller number than the untreated control. With the application of glyphosate at 1.0 kg ae./ha, among the post-emergence herbicide treatments, only benthiocarb plus propanil resulted in tiller number that was comparable to that of the untreated control. Mixtures of propanil with oxadiazon at 0.75 + 2.0 kg a.i./ha, benthiocarb at 2.0 + 1.08 kg a.i./ha and dimethametryne at 2.0 + 0.75 kg a.i./ha had significantly lower tiller number than the hand-weeded check under this glyphosate treatment (Table 4.45).

Table 4.45. Interaction of glyphosate and post-emergence weed control treatments on the number of tillers in the dry-seeded lowland rice at Badeggi, 1986 wet season.

| Treatments | Application Rate (kg a.i./ha) | Time DAS[1] | Tiller (number/ha x 10,000) at 30 DAS | | |
|---|---|---|---|---|---|
| | | | Glyphosate rate (kg ae/ha) | | |
| Post-emergence | | | 0.0 | 0.5 | 1.0 |
| Butachlor + propanil | 1.8 + 2.0 | 14 | 191 bcd | 178 cd | 182 bcd |
| Bentazon + propanil | 0.96 + 2.0 | 14 | 171 cd | 153 cde | 186 bcd |
| Benthiocarb + propanil | 1.0 + 2.0 | 14 | 193 bc | 185 bc | 151 cde |
| Oxadiazon + propanil | 0.75 + 2.0 | 14 | 206 bc | 150 cde | 174 cd |
| Dimethametryn + propanil | 0.75 + 2.0 | 14 | 174 cd | 157 cde | 167 cd |
| Propanil | 2.0 | 14 | 149 cd | 135 de | 184 bcd |
| Hand-weeding twice at | | 20 & 40 | 141 d | 262 a | 230 ab |
| Control | | | 119 e | 123 e | 131 e |
| SE± Glyphosate x Post-emergence weed control | | | | 17.25 | |

1. DAS = Days after seeding

Means followed by the same letter(s) within a column are not significant different from each other at the 5% level of probability using DMRT.

At 60 DAS in the 1986 wet season (Table 4.46), without glyphosate, all the weed control treatments including hand-weeding, resulted in similar tiller numbers which were significantly higher than that of the untreated control. However with the application of glyphosate at 0.5 kg ae/ha, all the herbicide treatments resulted in similar tiller number to the untreated control but benthiocarb plus propanil at 1.08 + 2.0 kg a.i./ha resulted in comparable rice tiller number to the hand-weeded check. With glyphosate at 1.0 kg ae/ha, while all the post-emergence treatments resulted in higher tiller number than the untreated control, only propanil at 2.0 kg a.i./ha, its mixtures with benthiocarb at 2.0 + 1.08 kg a.i./ha, butachlor at 2.0 + 1.8 kg a.i./ha caused comparable tiller number to that of the hand-weeded check.

At 60 DAS in the 1986-87 dry season, without glyphosate, all the post-emergence herbicide treatments caused significantly lower tiller number than hand-weeding. With glyphosate at 0.5 kg ae./ha, benthiocarb plus propanil at 1.08 + 2.0, oxadiazon and propanil at 0.75+2.0 and propanil alone at 2.0 kg a.i./ha

**Table 4.46.** Interaction of glyphosate and post-emergence weed control treatments on the number of tillers in the wet season, dry-seeded lowland rice at Badeggi, 1986.

| Treatments | Application | | Tiller (number/ha x 10,000) at 60 DAS | | |
|---|---|---|---|---|---|
| | Rate | Time | Glyphosate rate (kg ae /ha) | | |
| Post-emergence | (kg a.i./ha) | DAS[1] | 0.0 | 0.5 | 1.0 |
| Butachlor + propanil | 1.8 + 2.0 | 14 | 234 d-f | 223 d-f | 319 bcd |
| Bentazon + propanil | 0.96 + 2.0 | 14 | 193 e-f | 230 d-f | 302 bcd |
| Benthiocarb + propanil | 1.08 + 2.0 | 14 | 238 c-f | 275 b-e | 345 ab |
| Oxadiazon + propanil | 0.75 + 2.0 | 14 | 254 b-e | 238 c-f | 303 bcd |
| Dimethametryn + propanil | 0.75 + 2.0 | 14 | 242 c-f | 238 c-f | 308 bcd |
| Propanil | 2.0 | 14 | 249 c-e | 243 c-f | 328 abc |
| Hand-weeding twice at | | 20 & 40 | 285 b-e | 332 ab | 403 a |
| Control | | | 103 g | 201 e-f | 129 g |
| SE± Glyphosate x Post-emergence weed control | | | | 30.19 | |

1. DAS = Days after seeding

Means followed by the same letter(s) within a column are not significantly different at 5% level of probability using DMRT.

Table 4.47. Interaction of glyphosate and post-emergence weed control treatments on number of tillers in the direct-seeded lowland rice at Badeggi, 1986-87 dry season.

| Treatments | Application Rate (kg a.i./ha) | Application Time DAS[1] | Tiller (number/ha x 10,000) at 60 DAS — Glyphosate rate (kg ae /ha) 0.0 | 0.5 | 1.0 |
|---|---|---|---|---|---|
| Post-emergence | | | | | |
| Butachlor + propanil | 1.8 + 2.0 | 14 | 172 e | 262 cd | 326 ab |
| Bentazon + propanil | 0.96 + 2.0 | 14 | 180 e | 267 cd | 306 ab |
| Benthiocarb + propanil | 1.08 + 2.0 | 14 | 174 e | 305 ab | 302 ab |
| Oxadiazon + propanil | 0.75 + 2.0 | 14 | 160 e | 320 ab | 322 ab |
| Dimethametryn + propanil | 0.75 + 2.0 | 14 | 171 e | 270 c | 334 a |
| Propanil | 2.0 | 14 | 156 e | 299 bc | 316 ab |
| Hand-weeding twice at | | 20 & 40 | 314 ab | 306 ab | 319 ab |
| Control | | | 60 f | 238 d | 236 d |
| SE± Glyphosate x Post-emergence weed control | | | | 11.18 | |

1. DAS = Days after seeding.

Means followed by the same letter(s) within a column are not significantly different at 5% level of probability using DMRT.

caused comparable tiller number to hand-weeding. Under glyphosate at 1.0 kg ae./ha all the weed control treatments resulted in comparable tiller numbers that were higher than that of the untreated control (Table 4.47).

4.4.5 Rice yield attributes

Panicle (number per hectare)

The effect of glyphosate on the number of panicles per hectare was significant in the 1986 wet and 1986-87 dry seasons. In the trials both rates of glyphosate resulted in significantly higher number of panicles per hectare than the no glyphosate treatment (Table 4.48).

Application of pre-emergence oxadiazon at 0.75 kg a.i./ha significantly increased the number of panicles per hectare compared with no oxadiazon treatment in the two trials.

All the post-emergence weed control treatments including the hand-weeded check resulted in higher number of panicles per hectare than the untreated control. The post-emergence herbicide treatments caused lower number of panicles per hectare than the hand-weeded check in 1986 wet and 1986-87 dry seasons.

The interaction between glyphosate and post-emergence weed control treatments was significant on the number of panicles per hectare in the 1986-87 dry season.

Table 4.48. Effects of levels of glyphosate, oxadiazon and weed control treatments tiller number and panicle number in the direct-seeded lowland rice at Badeggi.

| Treatments | | Tillers (no/ha x 10,000) | | Panicle (no/ha x 10,000) | |
|---|---|---|---|---|---|
| | | 60 DAS[1] | | at Harvest | |
| Pre-plant glyphosate rate (kg ae/ha) | | 1986 WS[2] | 1986-7DS[3] | 1986 WS | 1986-87DS |
| 0.0 | | 225 b | 173 c | 172 b | 155 b |
| 0.5 | | 248 ab | 183 b | 242 a | 261 a |
| 1.0 | | 305 a | 308 a | 247 a | 266 a |
| SE± | | 15.00 | 11.00 | 2.43 | 2.00 |
| Pre-emergence Oxadiazon rate (kg a.i./ha) | | | | | |
| 0.0 | | 245 a | 253 a | 214 b | 219 b |
| 0.75 | | 271 a | 256 a | 242 a | 236 a |
| SE± | | 13.22 | 4.0 | 4.20 | 3.17 |
| Post-emergence | Rate (kg a.i./ha) | | | | |
| Butachlor + propanil | 1.8 + 2.0 | 259 b | 254 b | 241 b | 221 b |
| Bentazon + propanil | 0.96 + 2.0 | 242 b | 251 b | 212 b | 223 b |
| Benthiocarb + propanil | 1.08 + 2.0 | 286 b | 260 b | 244 b | 229 b |
| Oxadiazon + propanil | 0.75 + 2.0 | 265 b | 268 b | 222 b | 239 b |
| Dimethametryn + propanil | 0.75 + 2.0 | 263 b | 258 b | 258 b | 234 b |
| Propanil | 2.0 | 273 b | 257 b | 241 b | 235 b |
| Hand-weeding twice | 20 & 40 | 340 a | 313 a | 305 a | 215 a |
| Control (untreated) | | 144 c | 178 c | 71 c | 141 c |
| SE± Weed control | | 16.00 | 17.00 | 6.70 | 6.00 |

1. DAS = Days after seeding; 2. WS = Wet season; 3. DS = Dry Season

Means followed by the same letter(s) within a treatment column are not significantly different at 5% level of probability using DMRT.

Table 4.49. Interaction of glyphosate and post-emergence weed control treatments on number of panicles in the wet-seeded lowland rice at Badeggi, 1986-87 dry season.

| Treatments | Application Rate (kg a.i./ha) | Application Time DAS[1] | Panicle (number/ha x 10,000) Glyphosate rate (kg ae/ha) 0.0 | 0.5 | 1.0 |
|---|---|---|---|---|---|
| Post-emergence | | | | | |
| Butachlor + propanil | 1.8 + 2.0 | 14 | 146 cd | 275 ab | 243 b |
| Bentazon + propanil | 0.96 + 2.0 | 14 | 125 d | 271 ab | 273 ab |
| Benthiocarb + propanil | 1.08 + 2.0 | 14 | 152 cd | 248 b | 286 a |
| Oxadiazon + propanil | 0.75 + 2.0 | 14 | 154 c | 275 ab | 288 a |
| Dimethametryn + propanil | 0.75 + 2.0 | 14 | 139 cd | 276 ab | 289 a |
| Propanil | 2.0 | 14 | 149 cd | 276 ab | 280 a |
| Hand-weeding twice at | | 20 & 40 | 287 a | 297 ab | 302 a |
| Control | | | 87 e | 166 c | 169 c |
| SE± Glyphosate x Post-emergence weed control | | | | 9.41 | |

1. DAS = Days after seeding

Means followed by the same letter(s) within a column are not significantly different at 5% level of probability using DMRT.

Under all rates of glyphosate in the 1986-87 dry season, post-emergence weed control treatments including hand-weeding resulted in significantly higher number of panicles than the untreated control. With glyphosate at 0.5 kg ae/ha all the herbicide treatments were comparable in number to the hand-weeded control, while at 1.0 kg ae of glyphosate, butachlor plus propanil at 1.8 + 2.0 kg a.i./ha resulted in lower number than hand-weeding. Without glyphosate, all the herbicide treatments caused lower panicle production than the hand-weeded control (Table 4.49).

Spikelets per panicle

The effect of glyphosate on the number of spikelets per panicle in the 1986 wet season and 1986-87 dry season was significant. In the 1986 wet season, glyphosate at 0.5 and 1.0 kg ae/ha similarly resulted in higher number of spikelets per panicle than no glyphosate treatment. In the 1986-87 dry season, number of spikelets per panicle increased significantly with the rate of glyphosate treatment in the trial. The number of spikelets were 113, 147 and 154 for glyphosate at 0.0, 0.5 and 1.0 kg ae/ha respectively in the 1986 wet season trial. Corresponding values for the 1986-87 dry season trial were 93, 147 and 174, respectively (Table 4.50).

Table 4.50. Effects of levels of glyphosate, oxadiazon on weed control treatments on spikelets per panicle and % unfilled grains in the direct-seeded lowland rice at Badeggi.

| Treatments | Application (kg ae./ha) | Spikelets(no/panicle) | | Unfilled grains(%) | |
|---|---|---|---|---|---|
| Pre-plant glyphoszte rate | | 1986 WS[1] | 1986-87 DS[2] | 1986 WS | 1986-87 DS |
| 0.0 | | 133 b | 93 c | 17.3 b | 31.6 a |
| 0.5 | | 151 b | 147 b | 31.3 a | 16.8 b |
| 1.0 | | 159 a | 174 a | 25.9 b | 14.0 c |
| SE± | | 3.29 | 2.00 | 0.36 | 0.69 |
| Pre-emergence Oxadiazon rate (kg a.i./ha) | | | | | |
| 0.0 | | 126 b | 136 b | 29.7 a | 21.7 a |
| 0.75 | | 158 a | 140 a | 26.5 b | 19.9 b |
| SE± | | 1.28 | 2.00 | 0.50 | 0.40 |
| Post-emergence | Rate (kg a.i./ha) | | | | |
| Butachlcr + propanil | 1.8 + 2.0 | 132 b | 148.b | 21.8 c | 17.9 c |
| Bentazon + propanil | 0.96 + 2.0 | 129 b | 134 c | 21.3 c | 21.1 b |
| Benthiocarb + propanil | 1.08 + 2.0 | 154 b | 148 b | 23.6 bc | 18.8 bc |
| Oxadiazon + propanil | 0.75 + 2.0 | 167 b | 145 bc | 20.9 c | 16.1 c |
| Dimethametryn+propanil | 0.75 + 2.0 | 165 b | 143 bc | 12.2 d | 17.6 c |
| Propanil | 2.0 | 135 b | 141 bc | 20.6 b | 18.9 bc |
| Hand-weeding twice at | 20 & 40 | 179 a | 171 a | 10.4 d | 7.9 d |
| Control (untreated) | | 46 c | 75 d | 84.9 a | 48.5 a |
| SE± Weed control | | 3.71 | 4.00 | 3.00 | 1.25 |

1. WS = Wet Season; 2. DS = Dry Season

Means followed by the same letter(s) within a treatment column are not significantly different from each other at 5% level of probability using DMRT.

Pre-emergence oxadiazon at 0.75 kg a.i./ha significantly increased the number of spikelets per panicle compared with no oxadiazon treatment in the two seasons.

All the herbicide treatments resulted in higher number of spikelets per panicle than the 1986-87 dry seasons, bentazon plus propanil at 0.96 + 2.0 kg a.i./ha resulted in lower number of spikelets than the mixtures of propanil with butachlor and benthiocarb.

The interaction between glyphosate and post-emergence herbicide treatments was significant on the number spikelets per panicle in the 1986 wet and 1986-87 dry season trials (Tables 4.51 and 4.52). In the 1986 wet season, without glyphosate all the post-emergence herbicide treatments resulted in lower number of spikelets per panicle than the hand-weeded control. With the application of glyphosate at both 0.5 and 1.0 kg ae/ha, among the herbicide treatments, only bentazon plus propanil resulted in significantly lower number of spikelets per panicle than the hand-weeded control.

Table 4.51. Interaction of glyphosate and post-emergence weed control treatments on number of spikelets per panicle in the dry seeded lowland rice at Badeggi, 1986 wet season.

| Treatments | Application Rate (kg a.i./ha) | Time DAS[1] | Spikelets per panicle | | |
|---|---|---|---|---|---|
| | | | Glyphosate rate (kg ae./ha) | | |
| Post-emergence | | | 0.0 | 0.5 | 1.0 |
| Butachlor + propanil | 1.8 + 2.0 | 14 | 114 c | 170 b | 187 ab |
| Bentazon + propanil | 0.96 + 2.0 | 14 | 117 c | 135 c | 135 c |
| Benthiocarb + propanil | 1.08 + 2.0 | 14 | 119 c | 174 ab | 167 b |
| Oxadiazon + propanil | 0.75 + 2.0 | 14 | 134 c | 180 ab | 188 a |
| Dimethametryn + propanil | 0.75 + 2.0 | 14 | 121 c | 182 ab | 191 a |
| Propanil | 2.0 | 14 | 108 c | 182 ab | 182 ab |
| Hand-weeding twice at | | 20 & 40 | 173 ab | 182 ab | 182 ab |
| Control | | | 21 e | 50 d | 66 d |
| SE ± Glyphosate x Post-emergence weed control | | | | **6.85** | |

1. DAS = Days after seeding

Means followed by the same letter(s) within a column are not significantly different from one another at the 5% level of probability using DMRT.

Table 4.52. Interaction of glyphosate and post-emergence weed control treatments on the number of spikelets per panicle in the wet-seeded lowland rice at Badeggi, 1986-87 dry season.

| Treatments | Application Rate (kg a.i./ha) | Time DAS[1] | Spikelets per panicle Glyphosate rate (kg ae /ha) 0.0 | 0.5 | 1.0 |
|---|---|---|---|---|---|
| Post-emergence | | | | | |
| Butachlor + propanil | 1.8 + 2.0 | 14 | 99 e | 165 bcd | 181 ab |
| Bentazon + propanil | 0.96 + 2.0 | 14 | 89 e | 149 d | 174 bc |
| Benthiocarb + propanil | 1.08 + 2.0 | 14 | 99 e | 158 cd | 187 ab |
| Oxadiazon + propanil | 0.75 + 2.0 | 14 | 95 e | 152 cd | 188 ab |
| Dimethametryn + propanil | 0.75 + 2.0 | 14 | 92 e | 156 cd | 180 ab |
| Propanil | 2.0 | 14 | 93 e | 157 cd | 172 bc |
| Hand-weeding twice at | | 20 & 40 | 152 cd | 162 bcd | 199 a |
| Control | | | 36 g | 79 f | 100 f |
| $SE_{\pm}$ Glyphosate x Post-emergence | | | | 7.0 | |

1. DAS = Days after seeding

Means followed by the same letter(s) within a column are not significantly different at 5% level of probability using DMRT.

Table 4.53. Interaction of pre-emergence oxadiazon and post-emergence weed control treatments on the number of spikelets per panicle in the dry-seeded lowland rice at Badeggi, 1986 wet season.

| Treatments | Application Rate (kg a.i./ha) | Time DAS[1] | Spikelets per panicle Oxadiazon rate (kg a.i./ha) 0.0 | 0.75 |
|---|---|---|---|---|
| Post-emergence | | | | |
| Butachlor + propanil | 1.8 + 2.0 | 14 | 135 cd | 179 a |
| Bentazon + propanil | 0.96 + 2.0 | 14 | 121 d | 137 cd |
| Benthiocarb + propanil | 1.08 + 2.0 | 14 | 144 c | 164 bc |
| Oxadiazon + propanil | 0.75 + 2.0 | 14 | 157 c | 178 ab |
| Dimethametryn+propanil | 0.75 + 2.0 | 14 | 147 c | 183 a |
| Propanil | 2.0 | 14 | 126 d | 143 c |
| Hand-weeding twice at | | 20 & 40 | 175 ab | 183 a |
| Control | | | 3 f | 88 e |
| SE± Oxadiazon x Post-emergence weed control | | | 5.07 | |

1. DAS = Days after seeding

Means followed by the same letter(s) are not significantly different at 5% level of probability using DMRT.

In the 1986-87 dry season, without glyphosate no post-emergence herbicide treatment was comparable to the hand-weeded check. While with glyphosate at 0.5 kg a.e/ha, all the post-emergence herbicide treatments were comparable. On plots treated with glyphosate 1.0 kg ae/ha, propanil and its mixture with bentazon resulted in lower number of spikelets per panicle than the hand-weeded control.

The interaction between pre-emergence oxadiazon and post-emergence herbicide treatments was significant on the number of spikelets per panicle in the 1986 wet season. In this trial, no post-emergence herbicide treatment was comparable to the hand-weeded control in the number of spikelets per panicle when no pre-emergence oxadiazon was applied. Propanil alone at 2.0 kg a.i./ha and the mixture of propanil with bentazon at 2.0 + 0.96 kg a.i./ha caused lower number of spikelets per panicle than the mixtures of propanil with oxadiazon and dimethametryn each at 2.0 + 0.75 kg a.i./ha and benthiocarb at 2.0 + 1.08 kg a.i./ha (Table 4.53).

With the pre-emergence application of oxadiazon at 0.75 kg a.i./ha, post-emergence oxadiazon plus propanil and dimethametryn plus propanil each at 0.75 + 2.0 kg a.i./ha and butachlor plus propanil at 1.8 + 2.0 kg a.i./ha resulted in comparable number of spikelets to the hand-weeded check.

Propanil alone and its mixture with bentazon also produced significantly lower number of spikelets per panicle than the post-emergence herbicide treatments indicated above when they followed pre-emergence application of oxadiazon.

% Unfilled grains

The effect of glyphosate on % unfilled grains although significant did not show a consistent trend in the 1986 wet season and 1986-87 dry season. While the maximum % unfilled grains occurred with glyphosate at 0.5 kg ae/ha in 1986 wet season, % unfilled grains decreased with the rate of applied glyphosate in 1986-87 dry season (Table 4.50).

Pre-emergence oxadiazon at 0.75 kg a.i./ha significantly reduced % unfilled grains compared with no oxadiazon treatment in the 1986 wet season and 1986-87 dry season. Application of pre-emergence oxadiazon at 0.75 kg a.i./ha reduced % unfilled grains from 30% and 22% without oxadiazon to 26% and 20% in 1986 wet season and 1986-87 dry season (Table 4.50).

The number of unfilled grains was also significantly reduced by all the post-emergence weed control treatments including the hand-weeded check compared with the untreated control. The herbicide treatments resulted in higher value than the hand-weeded check in 1986-87 dry season while dimethametryn plus propanil was comparable to the hand-weeded check in value in the 1986 wet season.

The interaction between glyphosate and post-emergence herbicide treatments was significant on % unfilled grains in the 1986 wet season and 1986-87 dry season. In 1986 wet season, irrespective of glyphosate treatment, propanil resulted in higher % unfilled grains than the hand-weeded check. With glyphosate at 0.5 kg a.e./ha, propanil also resulted in higher % unfilled grains than its mixture with dimethametryne. When the post-emergence herbicide treatments followed glyphosate at 1.0 kg ae/ha only mixtures of propanil with dimethametryn and oxadiazon resulted in lower % unfilled grains than the hand-weeded check (Table 4.54).

In the 1986-87 dry season, none of the post-emergence herbicide treatments was comparable to the hand-weeded check in the % unfilled grains under no glyphosate treatment. With glyphosate at 0.5 kg ae/ha propanil alone at 2.0 kg a.i./ha and the mixture with bentazon and dimethametryne caused higher % unfilled grains compared with the hand-weeded check (Table 4.55). However, all the post-emergence herbicide treatments were comparable to the hand-weeded check when they followed glyphosate at 1.0 kg ae/ha.

Table 4.54. Interaction of glyphosate and post-emergence weed control treatments on % unfilled grains in the dry-seeded lowland rice at Badeggi, 1986 wet season.

| Treatments | Application | | Unfilled grains (%) | | |
|---|---|---|---|---|---|
| | Rate (kg a.i./ha) | Time DAS[1] | Glyphosate rate (kg ae./ha) | | |
| | | | 0.0 | 0.5 | 1.0 |
| Post-emergence | | | | | |
| Butachlor + propanil | 1.8 + 2.0 | 14 | 17.1 cde | 21.5 bcd | 26.6 bc |
| Bentazon + propanil | 0.96 + 2.0 | 14 | 20.6 bcd | 24.6 bcd | 18.5 bcd |
| Benthiocarb + propanil | 1.08 + 2.0 | 14 | 17.3 cde | 29.8 bc | 23.5 bcd |
| Oxadiazon + propanil | 0.75 + 2.0 | 14 | 24.5 bcd | 21.5 bcd | 16.8 cde |
| Dimethametryn + propanil | 0.75 + 2.0 | 14 | 14.0 cde | 14.0 cde | 8.6 de |
| propanil | 2.0 | 14 | 34.8 b | 35.6 b | 21.8 bcd |
| Hand-weeding twice at | | 20 & 40 | 16.0 cde | 13.5 cde | 1.6 e |
| Control | | | 74.8 a | 90.0 a | 90.0 a |
| SE± Glyphosate x Post-emergence weed control | | | | 5.41 | |

1. DAS = Days after seeding

Means followed by the same letter(s) within a column are not significantly different from one another at the 5% level of probability using DMRT.

Table 4.55. Interaction of glyphosate and post-emergence weed control treatments on % unfilled grains in the wet-seeded lowland rice at Badeggi, 1986-87 dry season.

| Treatments | Application | | Unfilled grains (%) | | |
|---|---|---|---|---|---|
| | Rate (kg a.i./ha) | Time DAS[1] | Glyphosate rate (kg ae./ha) | | |
| Post-emergence | | | 0.0 | 0.5 | 1.0 |
| Butachlor + propanil | 1.8 + 2.0 | 14 | 31.3 c | 12.8defg | 9.5 f |
| Bentazon + propanil | 0.96 + 2.0 | 14 | 31.6 c | 18.1 d | 13.3 def |
| Benthiocarb + propanil | 1.08 + 2.0 | 14 | 31.5 c | 12.0defg | 12.8defg |
| Oxadiazon + propanil | 0.75 + 2.0 | 14 | 27.6 c | 12.5defg | 8.1 fg |
| Dimethametryn + propanil | 0.75 + 2.0 | 14 | 29.3 c | 13.6 def | 9.6 fg |
| Propanil | 2.0 | 14 | 30.0c | 15.8 de | 10.3 efg |
| Hand-weeding twice at | | 20 & 40 | 9.0 fg | 7.0 g | 7.8 fg |
| Control | | | 62.1 a | 42.6 b | 40.6 b |
| SE± Glyphosate x Post-emergence weed control | | | | 2.14 | |

1. DAS = Days after seeding

Means followed by the same letter(s) within a column are not significantly different from one another at the 5% level of probability using DMRT.

Table 4.56. Interaction of pre-emergence oxadiazon and some post-emergence weed control treatments on % unfilled grains in the dry-seeded lowland rice at Badeggi 1986 wet season.

| Treatments | Application | | Unfilled grains(%) | |
|---|---|---|---|---|
| | Rate (kg a.i./ha) | Time DAS[1] | Oxadiazon rate (kg a.i./ha) | |
| Post-emergence | | | 0.0 | 0.75 |
| Butachlor + propanil | 1.8 + 2.0 | 14 | 21.8bc | 21.6bc |
| Bentazon + propanil | 0.96 + 2.0 | 14 | 17.7bc | 22.7bc |
| Benthiocarb + propanil | 1.08 + 2.0 | 14 | 25.6b | 21.4bc |
| Oxadiazon + propanil | 0.75 + 2.0 | 14 | 21.1bc | 20.7bc |
| Dimethametryn + propanil | 0.75 + 2.0 | 14 | 14.6bc | 9.7 c |
| Propanil | 2.0 | 14 | 39.9b | 21.6 c |
| Hand-weeding twice at | | 20 & 40 | 10.2 c | 10.5 c |
| Control | | | 86.6 a | 83.2a |
| SE± Oxadiazon x Post-emergence weed control | | | 4.40 | |

1. DAS = Days after seeding

Means followed by the same letter(s) within a column are not significantly different at the 5% level of probability using DMRT.

The interaction between pre-emergence oxadiazon at 0.75 kg a.i./ha and post-emergence herbicide treatments was significant on % unfilled grains in the 1986 wet season. When no pre-emergence oxadiazon was applied propanil alone and the mixture with benthiocarb resulted in higher % unfilled grains than the hand-weeded check (Table 4.56). With the application of pre-emergence oxadiazon at 0.75 kg a.i./ha in the 1986 wet season all the post-emergence herbicide treatments were comparable to the hand-weeded check (Table 4.56).

Rice grain yield

In all the trials, rice grain yields with glyphosate at 0.5 and 1.0 kg ae/ha were similar but significantly higher than that of no glyphosate treatment. Rice grain yields were 1.8 t/ha, 3.9 t/ha and 4.1 t/ha for glyphosate at 0.0, 0.5 and 1.0 kg ae/ha respectively in the 1985-86 dry season trial. Corresponding values were 1.8 t/ha, 4.1 t/ha and 4.2 t/ha for the 1986-87 dry season trial and 3.0 t/ha, 4.3 t/ha and 4.6 t/ha for the 1986 wet season trial (Table 4.57).

Pre-emergence oxadiazon at 0.75 kg a.i./ha resulted in significantly higher rice grain yield than no oxadiazon treatment. Application of pre-emergence oxadiazon at 0.75 kg a.i./ha increased grain yield in 1985 - 86 dry,

1986 wet and 1986-87 dry seasons respectively, from 3.1, 3.4 and 3.2 t/ha without oxadiazon to 3.4, 4.7 and 3.6 t/ha.

Weed control treatments resulted in significantly higher rice grain yields than the untreated control in all the trials (Table 4.57). In 1985-86 and 1986-87 dry seasons all the post-emergence herbicide treatments caused lower rice grain yield than the hand-weeded check. Grain yields on the plots which received treatments of propanil mixtures with dimethametryne and oxadiazon each at 2.0 + 0.75 kg a.i./ha, were comparable to the hand-weeded check in the 1986 wet season. Bentazon plus propanil resulted in lower grain yield than all the other post-emergence herbicide treatments in 1986-87 dry season and with the exception of propanil at 2.0 kg a.i./ha in the 1986 wet season (Table 4.57).

The interaction between glyphosate and post-emergence herbicide treatments was significant on grain yield in all the trials. Without glyphosate, none of the post-emergence herbicide treatments resulted in comparable grain yield to the hand-weeded check in the dry season trials, while mixtures of propanil with butachlor, oxadiazon and dimethametryne were comparable in grain yield during the wet season. In the 1985-86 dry season, under glyphosate at 0.5 kg ae./ha only bentazon plus propanil caused lower rice grain yield than the hand-weeded check while under glyphosate at 1.0 kg ae/ha, only propanil at 2.0kg a.i/ha resulted in lower rice grain yield than

Table 4.57. Effects of levels of glyphosate, pre-emergence oxadiazon and weed control treatments on grain yield in the direct-seeded lowland rice at Badeggi.

| Treatment | | Grain yield (t/ha) | | |
|---|---|---|---|---|
| | | 1985-86 DS[1] | 1986 WS[2] | 1986 DS |
| Pre-plant Glyphosate rate (kg ae/ha) | | | | |
| 0.0 | | 1.8 b | 3.0 b | 1.8b |
| 0.5 | | 3.9 a | 4.3 a | 4.1a |
| 1.0 | | 4.1 a | 4.6 a | 4.2a |
| SE± | | 0.10 | 0.11 | 0.03 |
| Pre-emergence, Oxadiazon rate | (kg a.i./ha) | | | |
| 0.0 | | 3.1 b | 3.4 b | 3.2b |
| 0.75 | | 3.4 a | 4.7 a | 3.6a |
| SE± | | 0.04 | 0.06 | 0.03 |
| Post-emergence | Rate (kg a.i./ha) | | | |
| Butachlor + propanil | 1.8 + 2.0 | 3.5 b | 4.7 b | 3.7b |
| Bentazon + propanil | 0.96 + 2.0 | 3.3 b | 3.2 d | 3.2c |
| Benthiocarb + propanil | 1.08 + 2.0 | 3.3 b | 3.9 c | 3.7b |
| Oxadiazon + propanil | 0.75 + 2.0 | 3.5 b | 4.7 a | 3.6b |
| Dimethametryn + propanil | 0.75 + 2.0 | 3.5 b | 5.3 a | 3.5b |
| Propanil | 2.0 | 3.1 b | 3.4 dc | 3.5b |
| Hand-weeding t twice at | 20 & 40 DAS[3] | 4.6 a | 5.0 a | 4.4a |
| Control | | 1.5 c | 2.0 e | 1.7c |
| SE± | | 0.10 | 0.17 | 0.07 |

1. DS = Dry season; 2. WS = Wet season;
3. DAS = Days after seeding

Means followed by the same letter(s) are not significantly different from each other at the 5% level using DMRT.

Table 4.58. Interaction of glyphosate and post-emergence weed control treatments on grain yield in the wet-seeded lowland rice at Badeggi, 1985-86 dry season

| Treatments | Application Rate (kg a.i./ha) | Time DAS[1] | Grain yield (t/ha) Glyphosate rate (kg ae/ha) 0.0 | 0.5 | 1.0 |
|---|---|---|---|---|---|
| Post-emergence | | | | | |
| Butachlor + propanil | 1.8 + 2.0 | 14 | 1.8 de | 4.2 abc | 4.5 ab |
| Bentazon + propanil | 0.96 + 2.0 | 14 | 1.5 e | 3.7 c | 4.5 ab |
| Benthiocarb + propanil | 1.08 + 2.0 | 14 | 1.3 cf | 4.3 ab | 4.2 abc |
| Oxadiazon + propanil | 0.75 + 2.0 | 14 | 1.8 de | 4.3 ab | 4.3 ab |
| Dimethametryn + propanil | 0.75 + 2.0 | 14 | 1.8 de | 4.3 ab | 4.2 abc |
| Propanil | 2.0 | 14 | 1.1 f | 4.3 ab | 3.7 c |
| Hand-weeding twice at | | 20 & 40 | 4.1 bc | 4.7 a | 4.8 a |
| Control | | | 0.9 f | 1.2 f | 2.3 d |
| SE± Glyphosate x Post-emergence weed control | | | | 0.20 | |

1. DAS = Days after seeding.

Means followed by the same letter(s) within a column are not significantly different at 5% level of probability using DMRT.

Table 4. 59. Interaction of glyphosate and post-emergence weed control treatments on grain yield in the dry-seeded lowland rice at Badeggi, 1986 wet season.

| Treatments | Application | | Grain yield t/ha | | |
|---|---|---|---|---|---|
| | Rate | Time | Glyphosate rate (kg ae/ha | | |
| Post-emergence | (kg a.i./ha) | DAS[1] | 0.0 | 0.5 | 1.0 |
| Butachlor + propanil | 1.5 + 2.0 | 14 | 3.8 c | 5.2 ab | 5.1 ab |
| Bentazon + propanil | 0.98 + 2.0 | 14 | 2.4 f | 3.0 def | 4.2 bc |
| Benthiocarb + propanil | 1.08 + 2.0 | 14 | 2.8 ef | 4.5 bc | 4.4 bc |
| Oxadiazon + propanil | 0.75 + 2.0 | 14 | 3.5 bc | 5.4 a | 5.2 a |
| Dimethametryn + propanil | 0.75 + 2.0 | 14 | 3.9 cd | 5.3 ab | 5.6 a |
| Propanil | 2.0 | 14 | 2.6 ef | 3.4 de | 4.2 bc |
| Hand-weeding twice at | | 20 & 40 | 4.5 bc | 5.0 ab | 5.5 a |
| Control | | | 0.8 g | 2.3 f | 2.9 c |
| $SE_{\pm}$ Glyphosate x Post-emergence weed control | | | | 0.31 | |

1. DAS = Days after seeding

Means followed by the same letter(s) within a column are not significantly different from each other at the 5% level of probability using DMRT.

the hand-weeded check. (Table 4.58). In this trial without glyphosate, propanil and its mixture with benthiocarb resulted in comparable grain yield to the untreated check (Table 4.58).

In the 1986 wet season, under glyphosate at 0.5 kg ae/ha, propanil alone at 2.0 kg a.i./ha and the mixture with bentazon resulted in significantly lower yield than those of the hand-weeded check and the other post-emergence weed control treatments (Table 4.59). The mixture of propanil with butachlor, benthiocarb, oxadiazon and dimethametryne resulted in comparable grain yield to the hand-weeded control under the same glyphosate treatment. With glyphosate at 1.0 kg ae/ha, the mixture of propanil with butachlor, oxadiazon and dimethametryne produced similar rice grain yield to the hand-weeded check. Under the same glyphosate treatment, propanil alone at 2.0 kg a.i./ha, its mixture with bentazon and benthiocarb resulted in similar grain yield but significantly lower than those of dimethametryne plus propanil and oxadiazon plus propanil. Without glyphosate, dimethametryne plus propanil resulted in higher grain yield than all the other post-emergence treatments except oxadiazon plus propanil in the trial. In the 1986-87 dry season, with glyphosate at 0.5 kg a.e/ha,

Table 4.60. Interaction of glyphosate and post-emergence weed control treatments on grain yield in the dry season, wet-seeded lowland rice at Badeggi, 1986-87.

| Treatments | Application | | Grain yield (t/ha) | | |
|---|---|---|---|---|---|
| | Rate | Time | Glyphosate rate (kg ae/ha) | | |
| Post-emergence | (kg a.i./ha) | DAS[1] | 0.0 | 0.5 | 1.0 |
| Butachlor + propanil | 1.8 + 2.0 | 14 | 1.8 fg | 4.3 bc | 4.5 ab |
| Bentazon + propanil | 0.96 + 2.0 | 14 | 1.1 h | 4.0 cd | 4.3 bc |
| Benthiocarb + propanil | 1.0 + 2.0 | 14 | 1.7 g | 4.1 bcd | 4.5 ab |
| Oxadiazon + propanil | 0.75 + 2.0 | 14 | 1.0 h | 4.4 abc | 4.4 abc |
| Dimethametryn + propanil | 0.75 + 2.0 | 14 | 1.8 fg | 4.2 bcd | 4.3 bc |
| Propanil | 2.0 | 14 | 1.6 g | 4.4 abc | 4.3 bc |
| Hand-weeding twice at | | 20 & 40 | 3.6 d | 4.7 a | 4.7 a |
| Control | | | 0.5 i | 2.1 efg | 2.2 e |
| SE± Glyphosate x Post-emergence weed control | | | | 0.13 | |

1. DAS = Days after seeding

Means followed by the same letter(s) within a column are not significantly different from each other at 5% level of probability using DMRT.

Table 4.61. Interaction of pre-emergence oxadiazon and post-emergence weed control treatments on grain yield in the wet-seeded lowland rice at Badeggi 1985-86 dry season.

| Treatments | Application | | Grain yield(t/ha) | |
|---|---|---|---|---|
| | Rate (kg a.i./ha) | Time DAS[1] | Oxadiazon rate (kg a.i./ha) | |
| Post-emergence | | | 0.0 | 0.75 |
| Butachlor + propanil | 1.8 + 2.0 | 14 | 3.4bc | 3.6b |
| Bentazon + propanil | 0.96 + 2.0 | 14 | 3.0cd | 3.5b |
| Benthiocarb + propanil | 1.08 + 2.0 | 14 | 2.8d | 3.6b |
| Oxadiazon + propanil | | 14 | 3.3bcd | 3.5b |
| Dimethametryn + propanil | 0.75 + 2.0 | 14 | 3.5b | 3.4bc |
| Propanil | 2.0 | 14 | 2.9d | 3.2bcd |
| Hand-weeding twice at | | 20 & 40 | 4.5a | 4.5a |
| Control | | | 1.2e | 1.3e |
| SE± Oxadiazon x Post-emergence weed control | | | 0.14 | |

1. DAS = Days after seeding

Means followed by the same letter(s) within a column are not significantly different at 5% level of probability using DMRT.

Table 4.62. Interaction of pre-emergence oxadiazon and post-emergence weed control treatments on grain yield in the dry-seeded lowland rice at Badeggi 1986 wet season.

| Treatments | Application | | Grain yield (t/ha) | |
|---|---|---|---|---|
| | Rate | Time | Oxadiazon rate (kg a.i./ha) | |
| Post-emergence | (kg a.i./ha) | DAS[1] | 0.0 | 0.75 |
| Butachlor + propanil | 1.8 + 2.0 | 14 | 3.8 cd | 5.6 a |
| Bentazon + propanil | 0.96 + 2.0 | 14 | 2.4 d | 4.0 c |
| Benthiocarb + propanil | 1.08 + 2.0 | 14 | 3.2 d | 4.6 bc |
| Oxadiazon + propanil | 0.75 + 2.0 | 14 | 4.1 b | 5.3 ab |
| Dimethametryn + propanil | 0.75 + 2.0 | 14 | 4.9 b | 5.7 a |
| Propanil | 2.0 | 14 | 2.8 d | 4.0 c |
| Hand-weeding twice at | | 20 & 40 | 4.8 b | 5.2 ab |
| Control | | | 1.1 e | 2.9 d |
| SE± Pre-emergence oxadiazon x Post-emergence weed control | | | 0.24 | |

1. DAS = Days after seeding

Means followed by the same letter(s) within a column are not significantly different from each other at the 5% level of probability using DMRT.

Propanil alone at 2.0 kg a.i./ha and the mixture of propanil with oxadiazon at 2.0 + 0.75 kg a.i./ha produced comparable grain yield to the hand-weeded control. Under glyphosate at 1.0 kg ae/ha, mixtures of propanil with butachlor, benthiocarb and oxadiazon resulted in comparable rice grain yield production to the hand-weeded control.

The interaction between pre-emergence oxadiazon and post-emergence herbicide treatments was significant on rice grain yield in all the trials. In the dry season trials, none of the post-emergence herbicide mixtures resulted in comparable rice grain yields to the hand-weeded check under the two oxadiazon treatments. In 1985-86 dry season, without pre-emergence oxadiazon, propanil alone at 2.0 kg a.i./ha and the mixtures with benthiocarb at 2.0 + 1.8 kg a.i./ha, and bentazon at 2.0 + 0.96 kg a.i./ha resulted in significantly lower grain yield than the best herbicide treatment, dimethametryne plus propanil at 0.75 + 2.0 kg a.i./ha.

Without pre-emergence oxadiazon, mixtures of propanil with oxadiazon and dimethametryne resulted in rice grain yields that were comparable to that of the hand-weeded control but significantly higher than those of the other post-emergence herbicide treatments. However with pre-emergence oxadiazon application, in addition to the post-emergence herbicide treatments

indicated, mixtures of propanil with butachlor and benthiocarb also caused similar grain production to the hand-weeded control. As observed in the wet season, propanil and its mixture with bentazon resulted in significantly lower rice grain yield than the best herbicide treatment, oxadiazon plus propanil, when no pre-emergence oxadiazon was applied in the 1986-87 dry season. However with the pre-emergence application of oxadiazon, only bentazon plus propanil caused lower rice grain production in this trial.

Table 4.63. Interaction of pre-emergence oxadiazon and some post-emergence weed control treatments on grain yield in the wet-seeded lowland rice at Badeggi, 1986-87 wet season.

| Treatments | Application | | Grain yield (t/ha) | |
|---|---|---|---|---|
| | Rate | Time | Oxadiazon rate a.i./ha) | |
| Post-emergence | (kg a.i./ha) | DAS | 0.0 | 0.75 |
| Butachlor + propanil | 1.8 + 2.0 | 14 | 3.5 bc | 3.6 b |
| Bentazon + propanil | 0.96 + 2.0 | 14 | 3.1 d | 3.3 cd |
| Benthiocarb + propanil | 1.08 + 2.0 | 14 | 3.3 bc | 3.7 b |
| Oxadiazon + propanil | 0.75 + 2.0 | 14 | 3.7 b | 3.5 bc |
| Dimethametryn + propanil | 0.75 + 2.0 | 14 | 3.4 bc | 3.6 bc |
| Propanil | 2.0 | 14 | 3.2 cd | 3.8 b |
| Handweeding twice at | | 20 & 40 | 4.3 a | 4.4 a |
| Control | | | 0.6 f | 2.7 e |
| SE± Pre-emergence oxadiazon x Post-emergence weed control | | | 0.11 | |

1. DAS = Days after seeding

Means followed by the same letter(s) within a column are not significantly different at 5% level of probability using DMRT.

## 4.2 Correlation studies 1983 and 1983-84

Growth characters such as number of tillers, panicles and spikelets per panicle were significantly positively correlated with rice grain yield in the 1986 wet and 1986-87 dry seasons (Tables 4.64 and 4.65). On the other hand grain yield and yield attributes of rice were significantly negatively correlated with cutgrass dry weight.

The regression of crop growth characters such as plant height at harvest, number of tillers per ha at 60 DAS and yield attributes such as number of panicles per ha, spikelets per panicle, % unfilled grains and grain yield on cutgrass dry weight at 60 DAH was calculated for the two seasons as shown in table 4.66. As depicted in the regression curves (Figs 5-9), there was a significant increase in grain yield and other yield attributes as cutgrass dry weight decreased as a result of chemical control. Generally, an increase in one kg of cutgrass dry weight/ha corresponded to reduction of two kg of rice grain yield/ha.

Table 4.6. Relationship between yield, crop growth and cutgrass dry weight as affected by chemical weed control in direct-seeded lowland rice 1986 at Badeggi, 1986 wet season.

| | | Crop growth | | | | | Cutgrass | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Grain yield | Spikelet number/ha) | % unfilled grains | Panicle (number/ha) | Tiller (number 30DAS/ ha. | Tiller (number at maturity/ ha. | Plant height | 30DAH (% coverage) | 60DAH (% coverage) | 30DAH (dry weight, kg/ha) | 60DAH (dry weight, kg/ha) |
| Grain yield 1.00 | 0.80 | -0.69* | -0.61 | 0.31* | 0.53* | 0.41* | -0.34* | -0.20 | -0.63* | -0.71* |
| Spikelet (number/ha) | 1.00 | -0.80* | 0.84* | 0.64* | 0.77 | 0.33 | -0.50 | -0.61 | -0.60* | -0.66* |
| % Unfilled grains | | 1.00 | 0.34 | 0.41 | 0.48 | -0.40* | 0.35 | 0.40* | 0.49* | 0.83* |
| Panicle (number/ha) | | | 1.00 | 0.36 | 0.62* | 0.40* | -0.53 | -0.57* | -0.40* | -0.72* |
| Tiller (number/ha at 30DAS) | | | | 1.00 | 0.38* | 0.14 | -0.18 | -0.14 | -0.24 | -0.54 |
| Tiller (number/ha at maturity) | | | | | 1.00 | 0.57* | -0.48* | -0.53* | 0.47* | -0.69* |
| Plant height at maturity | | | | | | 1.00 | -0.31 | -0.38 | -0.45 | -0.58* |
| % Cutgrass coverage at 30 DAH | | | | | | | 1.00 | 0.73* | 0.57* | 0.47* |
| % Cutgrass coverage at 60 DAH | | | | | | | | 1.00 | 0.57* | 0.58* |
| Cutgrass dry weight at 30 DAH | | | | | | | | | 1.00 | 0.58* |
| Cutgrass weight at 60 DAH | | | | | | | | | | 1.00 |

1. DAS = Days after seeding. 2. DAH - Days after herbicide application

*Significant at 0.05 probability level.

Table 4.65 Relationship between yield, crop growth and cutgrass dry weight as affected by chemical weed control in direct-seeded lowland rice at Badeggi, 1986-87 dry season.

| | Crop growth | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Grain yield | Spikelet (number/ha) | % Unfilled grains | Panicle (number/ha) | Tiller (number at 30DAS/ha | Tiller (number at maturity). | Plant height | % Coverage 30DAH | % Coverage 60DAH | Dry weight 30DAH | Dry weight 60DAH |
| Grain yield 1.00 | 0.89* | -0.84* | 0.90= | 0.74* | 0.85* | 0.44* | - | -0.75* | - | -0.85* |
| Spikelet (number/ha) | 1.00 | -0.85* | 0.84= | 0.74* | 0.83* | 0.36* | - | -0.75* | - | -0.82* |
| % Unfilled grains | 1.00 | 1.00 | 0.46 | 0.37 | 0.41 | -0.47* | - | 0.80* | - | 0.80* |
| Panicle (number/ha) | | | 1.00 | 0.69* | 0.82* | 0.40* | - | -0.74* | - | -0.85* |
| Tiller (number/ha at 30 DAS) | | | | 1.00 | 0.66* | 0.18 | - | -0.57* | - | -0.62* |
| Tiller (number/ha at maturity) | | | | | 1.00 | 0.56* | - | 0.73* | - | -0.84* |
| Plant height at maturity | | | | | | 1.00 | - | 0.60 | - | -0.56* |
| % Cutgrass coverage at 30 DAH[2] | | | | | | | | - | - | - |
| % Cutgrass coverage at 60 DAH | | | | | | | | 1.00 | - | 0.79* |
| Cutgrass dry weight at 30 DAH | | | | | | | | | - | 1.00 |
| Cutgrass dry weight at 60 DAH | | | | | | | | | | 1.00 |

1. DAS = Days after seeding; 2. DAH = Days after herbicide application
*Significant at 0.05 probability level.

Table 4.66. Regression equations and coefficients of determination of crop growth parameters and yield components of rice on cutgrass dry weight at Badeggi.

| Crop growth variables and yield components | Regression equation (1986 wet season) | Coefficient of determination ($r^2$) |
|---|---|---|
| Pland height at maturity | $y = 91.80 + 0.215x-0.006x^2$ | 0.34 |
| Tillers at 60 DAS (number/$m^2$) | $y = 339.4-2.17x-0.01x^2$ | 0.48 |
| Panicles (number/$m^2$) | $y = 303.2-4.04x-0.05x^2$ | 0.52 |
| Spikelets per panicle | $y = 181.0-2.47x-0.06x^2$ | 0.43 |
| Percent unfilled grains | $y = 18.9-0.52x+0.02x^2$ | 0.69 |
| Grain yield | $y = 5.5-0.06x-0.01x^2$ | 0.51 |
| | 1986-87 dry season | |
| Plant height at maturity | $y = 100.4+0.052x-0.01x^2$ | 0.31 |
| Tillers at 60 DAS (number/$m^2$) | $y = 327.5-2.76x-0.02x^2$ | 0.71 |
| Panicle (number/$m^2$) | $y = 310.2-4.35x+0.0.06x^2$ | 0.72 |
| Spikelets per panicle | $y = 186.5-2.34x+0.04x^2$ | 0.67 |
| Percent unfilled grains | $y = 7.82-0.41x+0.01x^2$ | 0.64 |
| Grain yield | $y = 4.89-0.07x+0.09x^2$ | 0.5? |

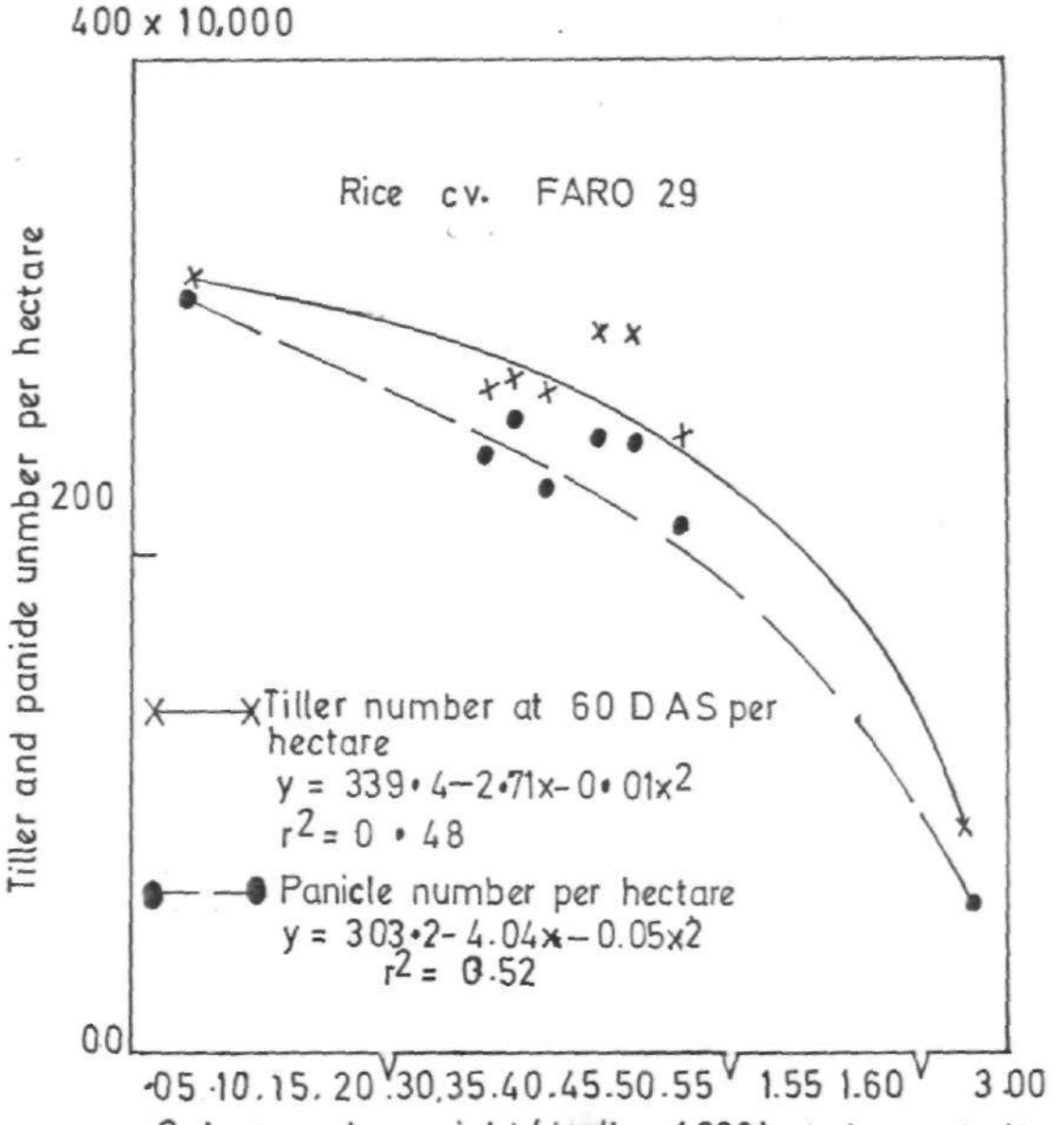



Fig. 5. Regression of panicle number and tiller number per hectave on cut grass dry weight at Badeggi 1986 wet season.

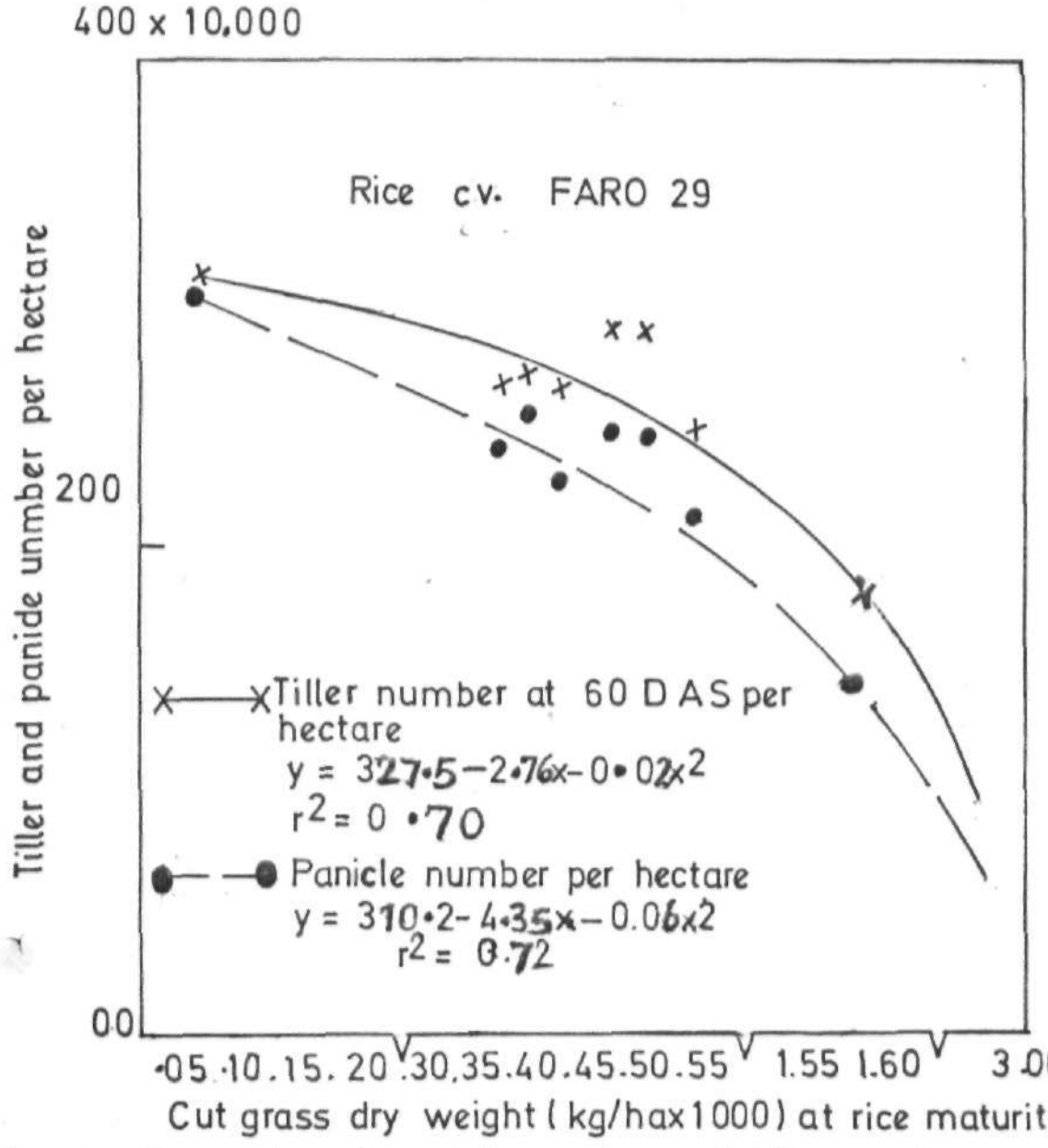



Fig. 6. Regression of panicle number and tiller number per hectave on cut grass dry weight at Badeggi 1986-87 dry season

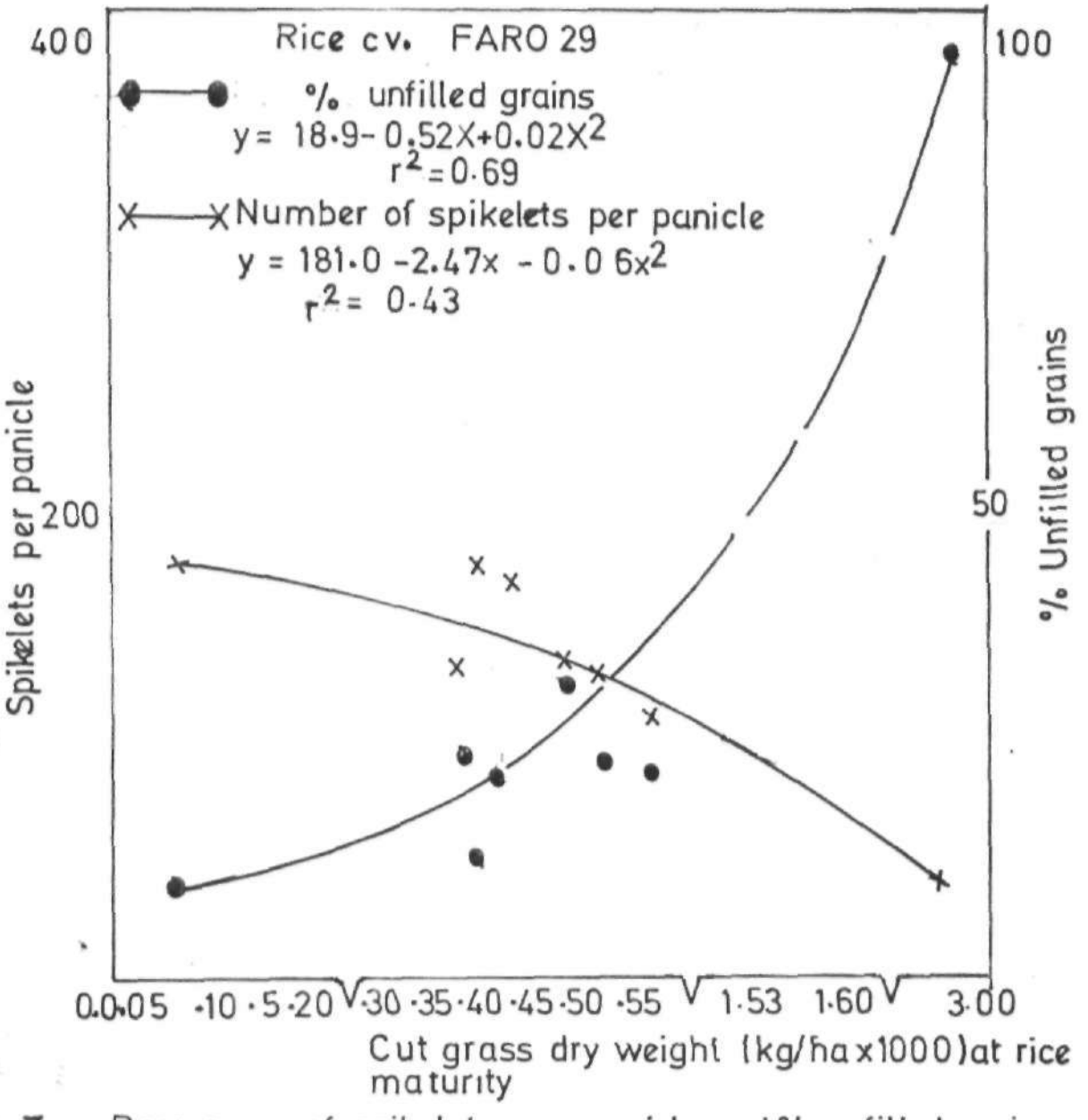



Fig. 7. Regression of spikelets per panicle and % unfilled grains on cut grass dry weight at Badeggi 1986 wet season

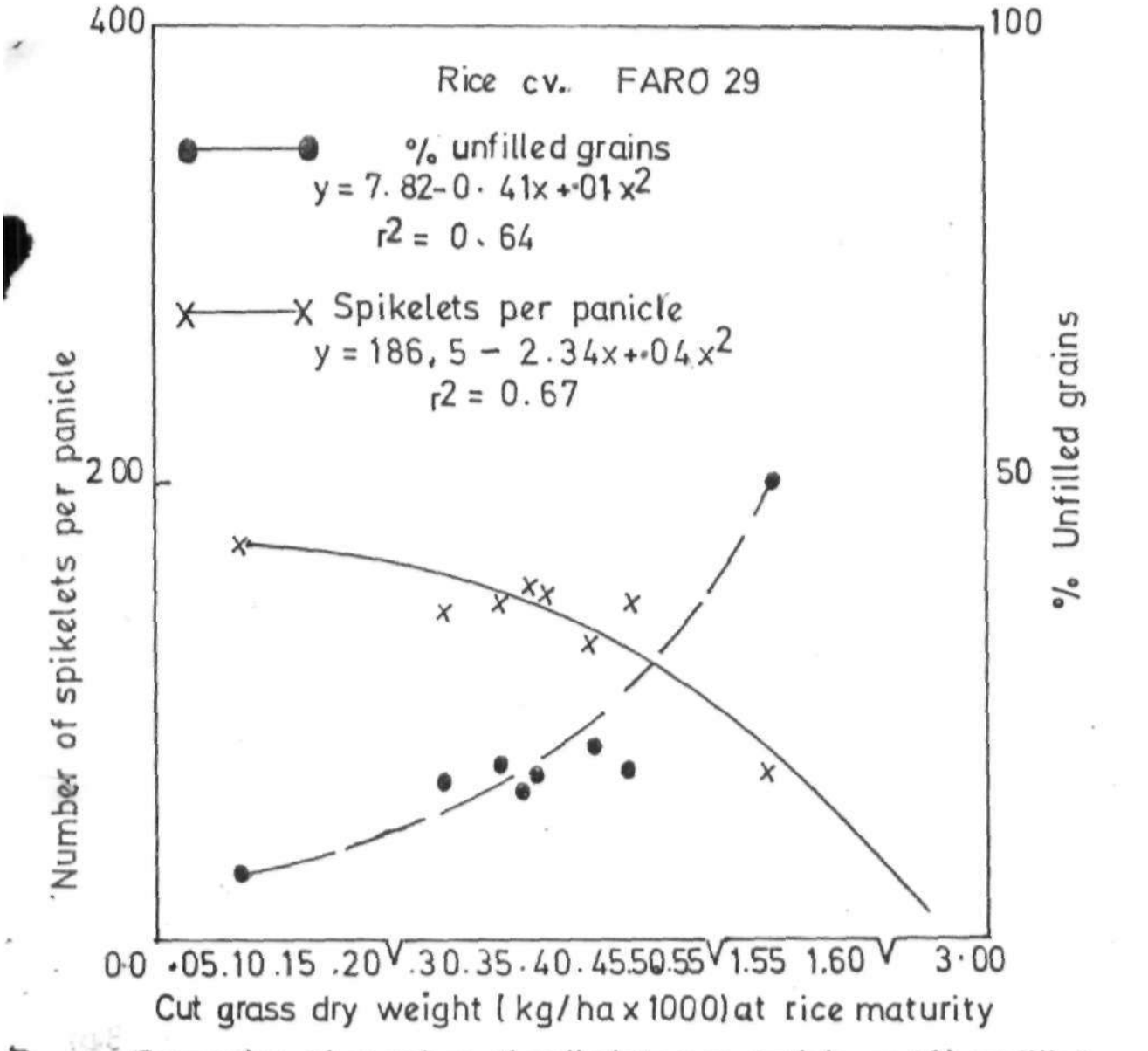



Fig. 8. Regression of number of spikelets per panicle and % unfilled grains on cut grass dry weight at Badeggi 1986–87 dry season

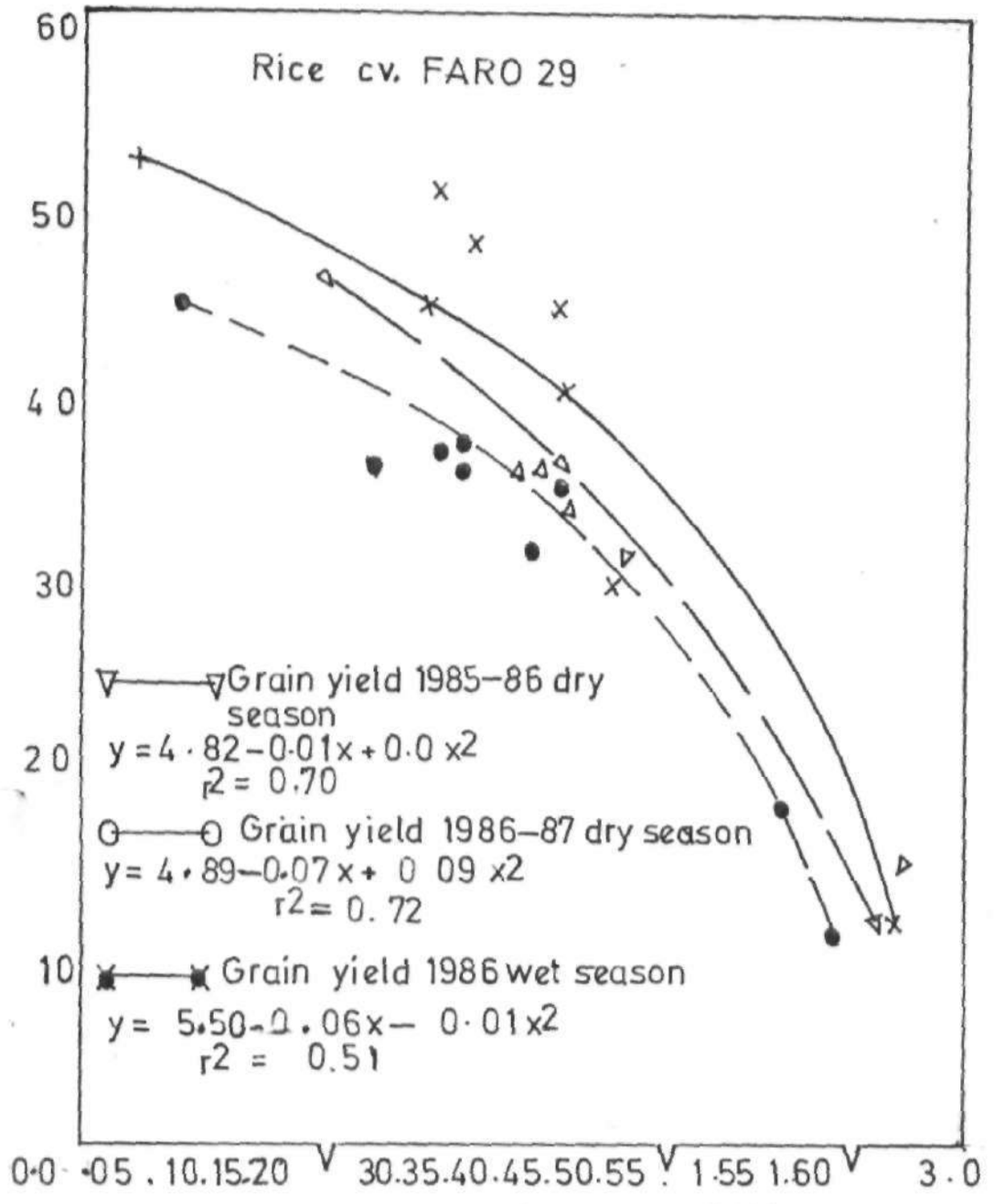



Fig-9 Cut grass dry weight ( kg/ha x 1000) at rice maturity

Regression of grain yield on cut grass dry weight at Badeggi

# Chapter 5 DISCUSSION

## 5.1 Chemical weed control in three cultivars of rice

### 5.1.1 Effect of cultivars on weed infestation and growth and yield of rice

As reflected in weed dry matter production at 60 DAH in the 1983-84 dry season and in both trials at harvest, cultivars had significant effect on weed infestation. Dry weed weight was highest on plots of the short statured FARO 27 compared with those of FARO 15 and FARO 29 which produced taller plants. This may be attributed to the effective suppresion of low growing weeds by smothering and shading by the later cultivars.

Similarly, Hoque et al. (1978) reported that the weight of weeds that grew in association with Dharial a tall cultivar of rice was lower than that obtained under BR 3 a short statured improved cultivar. In U.S.A, Smith (1974) however, observed that both plant height and maturity period influenced the ability of three cultivars of rice - Starbonnet, Nova 66 and Bluebelle to suppress weed infestation. He reported that, although Bluebelle and Starbonnet had the same height, the late maturing Starbonnet reduced barnyardgrass infestation more than the early maturing Bluebelle. He concluded therefore that height alone did not seem to affect their ability to reduce the infestation of barnyardgrass and that the maturity time was also an important factor. The results of the wet and dry season trials are in conformity with the findings of Smith (1974). Plots sown with FARO 15

which combines vigorous growth with long maturity period of 160 days had the least infestation of grass weeds in the 1983-84 dry season compared with FARO 27 and FARO 29 which mature in 100 - 120 days. Similarly because of the predominance of grasses like Digitaria debilis, Leptochloa coerulescens, Sacciolepis africana and Eragrostis gangetica in the two trials, FARO 27 had higher grass weed infestation than FARO 15, this effect was reflected in total weed weight in the same trial. In addition grass weed infestation was higher with FARO 27 and FARO 29 in 1983 wet season. A similar trend occurred on the effect of cultivars on sedges in both the wet and dry seasons. A clear trend did not emerge on the effect of cultivars on broadleaved weeds. In the 1983 wet season trial, cultivar had no significant effect on the infestation of broad-leaved weeds. In the dry season trial, plots of FARO 29 had no broadleaved weeds. In the wet season trial, the non-significant effect of cultivars on broad-leaved weeds might be due to the fact that the major broadleaved weeds at the experimental site such as Sphenoclea zeylanica were tall plants which were able to grow to the height of rice cultivars in the trial. As a result of this, they were able to escape suppression like other weeds. In the dry season trial, the poor distribution of broadleaved weeds because of subsequent flooding and puddling before direct-seeding of rice may have aided their subsequent suppression by rice cultivars. All the broadleaved weeds at the site were annual weeds like Sphenochlea zeylanica, Celosia trigyna, Heteranthena callifollia and Ipomoea

aquatica which propagate only by seeds.

The effect of cultivars on tiller number at 30 DAS did not show a consistent trend. For instance, in the 1983 wet season trial, FARO 27 had significantly higher number of tillers per hectare than the other two cultivars. In the dry season trial, FARO 15 had the highest number of tillers while FARO 27 had the least number of tillers among the three rice cultivars. FARO 29 had lower number of tillers than the best variety in both seasons. At 60 DAS, there was no significant difference in the number of tillers between the three cultivars in both the wet and dry seasons. Differences in tillering ability may not only be due to differences in the ability of the cultivars to suppress weeds but may also be due to the geneology of the different cultivars and their adaptability to growing conditions.

The effect of cultivars on number of panicles, spikelets per hectare and % unfilled grains was significant in the 1983 wet and 1983-84 dry seasons. FARO 15 consistently had significantly higher number of panicles than FARO 29 and FARO 27 in the 1983-84 dry season while in the 1983 wet season FARO 15 and FARO 29 had comparable number of panicles which were significantly higher than that of FARO 27. In the two seasons, the number of spikelets per hectare was significantly higher with FARO 29 than the other two cultivars. In the 1983 wet season, both FARO 15 and FARO 27 had comparable number of spikelets per hectare while FARO 27 had significantly higher number of spikelets than FARO 15 in the

1983-84 dry season. FARO 15 and FARO 27 were comparable in % unfilled grains while FARO 29 had the least % unfilled grains. In the 1983-84 dry season, FARO 15 recorded the highest % unfilled grains which was significantly higher than that of the other two cultivars. FARO 27 had the least % unfilled grains and the differences were significant compared with that of the other two cultivars.

It is apparent that the three varieties differ in their performance with regards to yield attributes in the same experiment. This is why breeders select for high yielding attributes in plant breeding trials. It is pertinent to note that FARO 15 produced significantly higher number of panicles than FARO 27 in the two trials and FARO 29 in the 1983-84 dry season trial. FARO 29 consistently produced higher number of spikelets than FARO 15 and FARO 27. FARO 15 which produced averagedly the highest number of panicles recorded the least number of spikelets per hectare. The results of these trials (Table 4.5) corroborate that earlier reported by Yoshida and Parao (1971) at the International Rice Research Institute Philippines which showed that high-tillering varieties like IR8 which have high number of panicles produced lower number of spikelets per panicle compared with medium-tillering varieties like IR-154-48-1 with lower panicle number.

Cultivar had significant effect on grain yield in the two seasons. In the 1983 wet season, FARO 29 and FARO 19 were comparable in grain yield production but both

out-yield FARO 27, while in the dry season, FARO 29 out-yielded FARO 27 and FARO 15 which were comparable in grain yield. Despite higher panicle number by FARO 15 in the 1983-84 dry season and the least % of unfilled grains by FARO 27 in the 1983-84 dry season trials, FARO 29 had significantly higher number of spikelets per hectare in the two trials. This factor might be responsible for the higher grain yield by this variety.

5.1.2 Effect of herbicides on annual weeds and rice

The most promising treatment in the two seasons was the mixture of benthiocarb plus propanil plus silvex at 1.8 + 3.24 + 0.75 kg a.i./ha. Among herbicide treatments, it resulted in the least weed coverage at four and eight weeks after herbicide application and at maturity and the highest number of panicles per hectare and spikelets per panicle. This treatment also effectively reduced the infestation of grasses, sedges and broadleaved weeds in the two trials giving 96% reduction in total weed weight in the 1983 wet season. Another promising treatment was the mixture of butachlor plus propanil at 3.6 + 1.02 kg a.i./ha. It compared favourably with the mixture of benthiocarb plus propanil plus silvex at 1.8 + 3.24 + 0.75 kg a.i./ha in the reduction of weed coverage and weed dry weight at maturity. Plots treated with butachlor plus propanil in the dry season, resulted in the least infestation of grass weeds among herbicide treatments and 86% reduction in the infestation of total weed dry weight. Plots treated with the mixture of benthiocarb plus propanil plus silvex at all rates had less infestation

of broadleaved weeds compared with butachlor plus propanil at the tested rates in the same trial. The two different mixtures were however similar in the control of sedge weeds at comparable rates. Except in the 1983-84 dry season when hand-weeding resulted in better control of grass weeds, benthiocarb plus propanil plus silvex at 1.8 + 3.24 + 0.75 kg a.i./ha resulted in better control of grass weeds in the 1983 wet season than hand-weeding. While benthiocarb + propanil + silvex at 1.8 + 3.24 + 0.75 kg a.i./ha resulted in comparable sedge control to hand-weeding in the 1983 wet season trial, sedge weed control was significantly better with benthiocarb plus propanil plus silvex at 1.8 + 3.24 + 0.75 kg a.i./ha than hand-weeding in the 1983-84 dry season trial. Butachlor plus propanil at 3.6 + 1.02 kg a.i./ha was comparable to hand-weeding in the control of grass and sedge weeds in the 1983 wet season but control of grass weeds was much poorer with the same treatment in the 1983-84 dry season trial.

The performance of the two different mixtures in the trials was the result of the mode of action of the herbicide components in each mixture on weeds. For instance benthiocarb a major component in one of the mixtures in the trials is a pre-emergence herbicide which has been reported by many workers to excellently control annual grasses, several sedges and a few number of broadleaved seeds (Anon., 1977; De Datta and Bernasor, 1973; Okafor 1978a; Okafor, 1986, Akobundu, 1987). But silvex another herbicide in the same mixture has excellent control of

aquatic sedges and broadleaved weeds which are resistant to commonly used broadleaved weed killers (Anon, 1983b). The second herbicide mixture used in the trial was butachlor plus propanil at varying rates. Butachlor is also a pre-emergence herbicide for the control of most annual grasses, certain broadleaved weeds and several annual sedge weeds (De Datta and Bernasor, 1973; De Datta and Lacsina, 1974; Anon, 1981). Propanil a component in the two different mixtures is a post-emergence selective contact, foliar applied herbicide for the effective control of annual grasses, a few sedges and broadleaved weeds seven to 14 days after emergence. (Smith, 1974; Okafor, 1978a; Okafor, 1986). Studies in the humid tropics show that benthiocarb and butachlor are not persistent enough to give season-long weed control in rainfed rice (Akobundu, 1987) but weed control can be considerably improved by mixing with propanil which has no soil residual properties (Okafor, 1986). The propanil in the mixture kills emerged weeds at the time of application while the pre-emergence herbicides prevent new weed seeds from germinating for long enough period to enable rice crop canopy to shade out additional weeds.

The excellent performance of the mixture of benthiocarb plus propanil plus silvex at 1.8 + 3.24 + 0.75 kg a.i./ha in the two trials is in agreement with the results of Richard and Street (1984) at the Mississippi Delta of U.S.A. where the mixture of benthiocarb plus propanil at 3.4 + 3.4 kg a.i./ha resulted in excellent control of annual grass weeds compared with benthiocarb alone at

4.5 kg a.i./ha.

Conflicting reports have been obtained in the use of butachlor alone at varying rates to control weeds. Chang (1973b) in Taiwan, De Datta and Lacsina (1974) at International Rice Research Institute Philippines found butachlor applied pre-emergence to the effective in the control of weeds. However Chang and De Datta (1974) also in Taiwan found that butachlor was ineffective in weed control under high infestation of Monochoria vaginalis. Under upland conditions in Nigeria, butachlor alone was consistently ineffective in weed control (Anon., 1980; Anon, 1981; Anon, 1982). From the results of the two trials, the performance of butachlor plus propanil as reflected in weed control and grain yield obtained was promising and comparable to that of the hand-weeded control. Earlier report by Richard and Street (1984) also at the Mississippi Delta of U.S.A., found butachlor plus propanil at 4.2 + 3.4 kg a.i./ha to combine excellent weed control with high grain yield. It has also been reported earlier that at the experimental farm of National Cereals Research Institute, Ibadan, the mixture of butachlor plus propanil at 4.0 + 3.0 kg a.i./ha resulted in comparable grain yield to hand-weeding (Anon, 1980).

Benthiocarb plus propanil plus silvex at 1.08 + 1.9 + 0.45 kg a.i./ha and butachlor plus propanil at 1.8 + 2.04 kg a.i./ha significantly reduced weed infestation in the two trials compared with the untreated control but the subsequent effect on grain yield was poorer than that of the hand-weeded control. The poor performance of

these treatments could be attributed to the low level of propanil in the mixtures. Propanil alone at 5.0 kg a.i./ha was found to give comparable grain yield to two hand-weedings in the southern Guinea Savanna of Nigeria (Williams, 1975). Okafor (1978a) obtained comparable grain yield to hand-weeding when propanil was applied at 3.0 kg/ha in a trial at the Rice Research Station Bende, south-eastern Nigeria. Propanil at 3.6 kg a.i./ha was also reported by Okafor (1984) to give comparable grain yield to hand-weeded control at Ngala in the Lake Chad Basin of Nigeria. The rate of propanil in the mixture of benthiocarb plus propanil plus silvex at 1.08 + 1.94 + 0.45 kg a.i./ha and butachlor plus propanil at 1.8 + 2.04 kg a.i./ha appears rather low compared with the reported effective rate of application of propanil. When benthiocarb + propanil + silvex at 1.08 + 1.94 + 0.45 kg a.i./ha was compared with the best treatment in the trials which was benthiocarb plus propanil plus silvex at 1.8 + 3.24 + 0.75 kg a.i./ha, the rate of propanil was 40% lower while the rate of benthiocarb was also 40% lower.

When butachlor plus propanil was applied at 1.8 + 2.04 kg a.i./ha, the concentration of butachlor was 40% lower while the rate of propanil was 50% higher compared with butachlor plus propanil at 3.6 + 1.02 kg a.i./ha another promising treatment in the trials. While the rate of butachlor and propanil in the mixture should be increased by 100% in the former mixture, only the rate of propanil in the latter mixture should be increased by 200% to obtain effective control of high

infestations of grasses, sedges and certain broadleaved weeds. The work of Richard and Street (1984) in U.S.A., in which excellent weed control with high grain yield was obtained when butachlor plus propanil was applied at 4.2 + 3.4 kg a.i./ha is in agreement with the proposition for an increment in the rate of propanil in the two mixtures of application.

The mixture of benthiocarb plus propanil plus silvex at 1.8 + 3.24 + 0.75 kg a.i./ha resulted in significantly higher number of tillers per hectare than all the herbicide treatments except butachlor plus propanil at 3.6 + 1.02 kg a.i./ha in the two seasons. However, benthiocarb plus propanil plus silvex at 1.8 + 3.24 + 0.75 kg a.i./ha resulted in significantly higher number of panicles per hectare in the wet season and spikelets per panicle in the two seasons than the hand-weeded control. In the 1983 wet season, application of benthiocarb plus propanil plus silvex at 1.8 + 3.24 + 0.75 kg a.i./ha resulted in grain yield of 4.9 t/ha which was comparable to that on plots treated with butachlor plus propanil at 3.6 + 1.02 kg a.i./ha. In the same season both treatments produced significantly lower grain yield than hand-weeding. The significantly lower % unfilled grains with hand-weeding in the wet season trial may have contributed to the production of the higher grain yield. In 1983-84 dry season, benthiocarb plus propanil plus silvex at 1.8 + 3.24 + 0.75 kg a.i./ha resulted in comparable grain yield to hand-weeding while butachlor plus propanil at 3.6 + 1.02 kg a.i./ha caused lower grain yield than hand-

weeding. In the two trials, season-long weed competition resulted in complete crop loss in the 1983 wet season and 90% reduction in rice grain yield in 1983-84 dry season trials respectively. These results are in agreement with previous research findings (IRRI, 1967; Okafor and De Datta, 1974; Okafor, 1981; Okafor, 1982; Okafor, 1986) which emphasized the severe yield reduction due to uncontrolled weed growth in direct-seeded rice and the dramatic increase in grain yield and yield attributes of rice compared with the untreated control when weeds are controlled.

### 5.1.3 Interaction of cultivars and post-emergence weed control treatments on weeds and rice plants

The interaction of rice cultivars and weed control treatments was significant on the dry weight of sedges, number of panicles and number of spikelets and grain yield in the two trials. Plots of FARO 15 and FARO 29 had lower infestation of sedges at the lower rates of treatments of herbicide mixtures of benthiocarb plus propanil plus silvex at 1.08 + 1.94 + 0.45 kg a.i./ha, 1.44 + 2.5 + 0.6 kg a.i./ha and butachlor plus propanil at 1.8 + 2.04 kg a.i./ha and 2.4 + 1.70 kg a.i./ha than those of FARO 27. In these trials, the tall vigorously growing and long duration characters of FARO 15 and FARO 19 enhanced the performance of low rates of the herbicides in suppressing weeds compared with short statured FARO 27 as similarly observed by Hoque *et al.* (1976 a, b). The ability of the tall vigorously growing cultivars to suppress weeds was also reflected in the higher number of panicles, spikelets and grain yield even

at low rates of herbicide treatments compared with the short statured FARO 27 (Tables 4.6, 4.9, 4.11 and 4.12).

The results obtained on interaction of cultivar and weed control treatments on number of panicles (Table 4.7) and number of spikelets (Table 4.8) indicate that ability to suppress weeds might not be the only factor responsible for the production of high rice yield attributes but adaptability to growing conditions and the genetic composition of the rice cultivars are important factors (Yoshida and Parao, 1972). For example in the 1983-84 dry season (Table 4.7), there was no significant difference between the number of panicles of the short statured - FARO 27, medium height - FARO 29 and the tall vigorously growing - FARO 15 at the lowest rates of treatments of benthiocarb + propanil + silvex at 1.08 + 1.94 + 0.45 kg a.i./ha and butachlor + propanil at 2.4 + 1.70 kg a.i./ha despite the lower weed weight associated with the latter varieties. Similarly FARO 27 produced comparable number of spikelets to either FARO 15 or FARO 29 at the lowest rates of herbicide treatments indicated above (Tables 4.8 and 4.9). When weed competition is suppressed, plant nutrients are available for crop growth (Roa, 1983; Okafor, 1984) but the performance of different cultivars of rice would depend on their adaptability to growing conditions.

5.2 Control of cutgrass in the greenhouse.

Glyphosate at 1.6 kg ae/ha gave the most effective control of cutgrass in the greenhouse. Glyphosate which is translocated throughout the plant when applied on the leaves of treated plants completely eradicated both the

treated leaves and the proximal root and rhizomes of cutgrass under flooded conditions in the greenhouse. Suwunamek and Cheugsai (1979) also obtained excellent control of purple nutsedge (Cyperus rotundus L) when glyphosate at 0.5 and 0.8 kg ae/ha was applied on rapidly growing plants under waterlogged conditions in a field and greenhouse trials in Thailand.

Oxadiazon at 1.25 kg a.i./ha which was applied at four days after transplanting resulted in initially good control up to one week after herbicide application but at the end of the experiment, the control of the shoot of cutgrass was unsatisfactory. In the trial, oxadiazon at 1.0 and 1.25 kg a.i./ha caused only 25.5 and 36.1% reduction in cutgrass rhizome production compared with the untreated control. The poor control of the subterranean parts exhibited by oxadiazon is in agreement with the earlier work of Ishizuka et al. (1975) and Achhireddy et al. (1985) which showed that oxadiazon was little translocated to the roots and tillered shoots of barnyardgrass when 14C labelled oxadiazon was applied to the leaf blades.

Other promising treatments in the trial were molinate at 4.0 kg a.i./ha followed by butachlor plus propanil at 3.6 + 1.02 kg a.i./ha and molinate at 4.0 kg a.i./ha followed by benthiocarb plus propanil at 1.8 + 3.24 kg a.i./ha. The former treatment resulted in 85% control of cutgrass shoots and 46.8% reduction of rhizome dry matter production. The latter treatment, resulted in 90% control of cutgrass shoots and 63.0% reduction of

rhizome dry matter production. While the two treatments were similarly comparable to glyphosate at 1.6 kg ae./ha in the control of root dry weight, glyphosate at the same rate resulted in significantly better control of rhizome dry matter. Molinate is a selective thiocarbamate herbicide for the control of grass weeds in rice (Klingman et al., 1975) but is rapidly metabolised in plants and soils (Mueller and Oelke, 1965; Fang, 1969). It has been successfully used in the control of barnyardgrass in California U.S.A. (Oelk and Morse, 1968) and in Arkansas (Smith, 1969; Smith, 1970a, Smith, 1970b; Smith, 1971; Smith et al., 1971). In the greenhouse trial, after prior application of molinate at 4.0 kg a.i./ha on cutgrass buds, successful shoot and root control was obtained when the mixture of propanil plus benthiocarb at 3.24 + 1.8 kg a.i./ha and propanil + butachlor at 1.02 + 3.6 kg a.i./ha were applied 14 days later because of the initial suppression in cutgrass growth.

Butachlor plus propanil at 1.8 + 2.04 and 3.6 + 1.02 kg a.i./ha resulted in unsatisfactory control of shoot, root and rhizome dry matter production compared with glyphosate at 1.6 kg ae/ha. Both treatments caused 14.9 and 17.0% control of above ground shoot respectively. The harvested root dry weight was not significantly different from the untreated control. Propanil inhibits the Hill reaction in plants (Good, 1961) but translocation within the leaf or from the treated leaves to the rest of the plant is limited (Yih et al., 1968a). Butachlor

is little translocated after absorption throuth the shoot to the roots and rhizomes (Anon., 1979), hence, unsatisfactory control of rhizomes and roots. The application of benthiocarb + propanil at 1.08 + 1.94 and 1.8 + 3.24 kg a.i./ha also resulted in unsatisfactory control in this trial. Reduction of rhizome dry matter production was 20.2 and 36.6% respectively.

## 5.3 Control of cutgrass in rice

### 5.3.1 Effect of glyphosate

The results of the 1985-86 and 1986-87 dry and 1986 wet season trials indicate that preplant application of glyphosate at 0.5 and 1.0 kg ae/ha significantly reduced the dry matter production and % coverage of cutgrass and increased the plant height at 56 and 98 DAS, number of panicles, number of spikelets per panicle and grain yield of rice in all the trials. Even with parameters like rice plant height at 28 DAS and number of tillers per hectare, glyphosate at both rates caused a significant increase in the 1986-87 dry season trial compared with no glyphosate treatment. In the wet season trial, where moisture was less limiting especially at the early stage of crop growth, plant height at 28 DAS and tiller number were not increased by glyphosate. Reduction in the dry weight and % coverage of cutgrass decreased with the rate of glyphosate in the 1985-86 dry season. Similar trend was observed in the 1986 wet season with regards to cutgrass dry weight. In the 1986-87 dry season, plant height at 56 DAS, number of tillers at 30 and 60 DAS, number of

spikelets per panicle all increased with the rate of applied glyphosate, while % unfilled grains also decreased with glyphosate rate. For instance, application of glyphosate at 1.0 kg ae/ha resulted in 56.1% increase in rice grain yield in 1985-86 dry season, 30.9% in 1986 wet season and 57.1% in 1986-87 dry season compared with the untreated control. In the same trial, glyphosate at 0.5 kg ae/ha increased rice grain yield by 53.8% in 1985-86 dry season, 27.5% in 1986 wet season and 56.1% in 1986-87 dry season compared with no glyphosate treatment. The results of the field trials also showed that glyphosate at 0.5 kg ae/ha caused 24.5% reduction in cutgrass dry weight in 1985-86 dry season, 35.2% reduction in 1986 wet season and 53.1% reduction in 1986-87 dry season compared with the untreated control. Increase in glyphosate rate from 0.5 to 1.0 kg ae/ha only caused 6.6%, 13.4% and 7.1% further reductions in cutgrass dry weight in 1985-86 dry, 1986 wet and 1986-87 dry seasons respectively. In the field trials, low rates of glyphosate at 1.0 and 0.5 kg ae/ha were used because pre-emergence oxadiazon at 0.75 kg a.i./ha and post-emergence selective herbicide treatments were used later.

It is obvious that the effective control of cutgrass was responsible for the favourable performance of rice on plots treated with glyphosate. Cutgrass is a stoloniferous and rhizomatous perennial grass (Hutchinson and Dalziel, 1931). However there is very little published

literature on the effect of cutgrass on rice performance. Smith (1981) reported that cutgrass was economically troublesome world-wide since it causes major yield and quality losses in rice culture. He did not show the effect of different herbicide treatments on cutgrass infestation in rice fields and subsequent effect on rice grain yield. Rice farmers of the Nupe tribe in north-western Nigeria have also reported severe yield losses as a result of cutgrass competition with rice for space and plant nutrients. The difficulty of control by hoe-weeding and hand-pulling has also been reported by local farmers. Elsewhere, glyphosate has also been found to be an effective weapon for the control of stoloniferous grasses like bermudagrass (Cynodon dactylon Pers) (Anon., 1980). It is also effective against rhizomatous grasses like speargrass (Olunuga, 1975; Lagoke, 1979) and quackgrass (Claus and Behrens, 1972).

The differences in the performance of glyphosate between the 1986 wet season trial, and the 1985-86 and 1986-87 dry season trials could be attributed to the fact that the period of dry-seeding of rice is usually accompanied by a dry spell. Pre-spraying droughting was reported by Dybing and Currier (1961) to cause probable reduction in foliar absorption of sprayed herbicide. There is also remarkable reduction in translocation of the herbicide in the leaf and rhizome tissue caused by moisture stress as reported by Crafts (1961).

### 5.3.2. Effect of pre-emergence oxadiazon

Pre-emergence oxadiazon at 0.75 kg a.i./ha resulted in a significant reduction in cutgrass dry weight except at 60 DAH in the 1985-86 dry season trial and in % coverage of cutgrass except at 60 DAH in the 1986-87 dry season. Oxadiazon however did not have any significant effect on vegetative growth parameters of rice such as plant height, number of tillers and panicle number which is strictly influenced by tillering in the 1986 wet season trial. In the 1986-87 dry season trial, these parameters were increased by oxadiazon at 0.75 kg a.i./ha. However, it caused slight but non-significant stunted growth of rice at 56 and 98 DAS in the 1986 wet and 1986-87 dry season trials.

Pre-emergence application of oxadiazon at 0.75 kg a.i./ha significantly increased spikelet number per panicle in 1986 wet and 1986-87 dry seasons and grain yield in all the trials. It also reduced % unfilled grains in 1986 wet and 1986-87 dry seasons. Season-long control of cutgrass was not achieved despite the application of pre-emergence oxadiazon at 0.75 kg a.i./ha because pre-emergence oxadiazon is not expected to be very effective on perennial cutgrass except at seedling and sprouting stages.

The non-significant effect on rice vegetative growth was because of less effect on cutgrass even though some level of control was achieved. Richard and Street (1984) at the Mississippi Delta of U.S.A. reported excellent control of barnyardgrass when oxadiazon was applied alone

at 1.1 kg a.i./ha and in mixture with propanil at 0.8 + 3.4 kg a.i./ha. The differences in the growth habit between annual barnyardgrass and perennial cutgrass might be responsible for the varying level of control. Excellent weed control with high grain yield was obtained when oxadiazon was applied pre-emergence to weeds at 1.0 and 0.75 kg a.i./ha (IRRI, 1978, 1979). Okafor (1979) also obtained satisfactory control of weeds mainly annual with high grain yield at the Lake Chad Basin of Nigeria when pre-emergence oxadiazon was applied at 0.5 kg a.i./ha.

5.3.3. Effect of post-emergence herbicide treatments

The application of post-emergence herbicide mixtures 14 DAS caused significant reduction in percentage coverage and dry weight of cutgrass compared with the untreated control in all the trials. The effective control of cutgrass was also reflected in the performance of rice, where the post-emergence treatments caused a significant increase in plant height at 56 and 98 DAS, number of tillers, number of panicles, number of spikelets per panicle and consequently rice grain yield and reduced percentage of unfilled grains compared with the control in all the trials where these parameters were taken. However, inspite of the effective control of cutgrass and the favourable effect on yield, only mixtures of propanil with dimethametryn at 2.0 + 0.75, benthiocarb at 2.0 + 1.08 and oxadiazon at 2.0 + 0.75 kg a.i./ha gave consistently effective control of cutgrass and in 1986 wet and 1986-87 dry seasons resulted in comparable values to those of the hand-weeded check. In most cases, propanil alone and its

mixture with bentazon resulted in higher cutgrass infestation values than the hand-weeded control.

Oxadiazon plus propanil at 0.75 + 2.0 kg a.i./ha offered the best control of late emerging cutgrass. Oxadiazon which is one of the component of the herbicide mixture is an oxadiazole compound (Anon., 1982) of low solubility in water, is nonvolatile and moderately persistent in the soil, therefore giving season-long weed control. It has strong selective activity against grass weeds which compete with rice for plant nutrients (Audus, 1976). Abundant moisture which is present under lowland conditions is necessary for activation of oxadiazon. It is compatible with propanil which gives only contact control of grasses. When the two herbicides are in mixture, the propanil provides the control of already emerged grass weeds while the oxadiazon in the mixture inhibits the emergence of new weeds. Bentazon plus propanil which was not very promising in the trial has been reported by many workers (Okeleye et al., 1979; Moody, 1980) to be ineffective under a high infestation of grass weeds. It has been reported that bentazon is mainly active against broadleaved weeds and annual sedges in rice cultivation (Anon., 1978). Propanil the second component of the mixture provides only contact control of grasses. It is apparent therefore that late emerging grasses will not be controlled by the mixture of bentazon with propanil.

Except for plant height at 98 DAS and tiller number at 30 DAS in the 1986-87 dry season, all the herbicide

treatments resulted in lower crop growth parameters than the hand-weeded control.

The post-emergence herbicide treatments also caused lower values of yield attributes such as panicle number and number of spikelets and also higher percentage of unfilled grains than the hand-weeded control. Comparable grain yield with the hand-weeded control was however obtained in the 1986 wet season with oxadiazon plus propanil at 0.75 + 2.0 kg a.i./ha and dimethametryne plus propanil at 0.75 + 2.0 kg a.i./ha. The comparable grain yield to hand-weeding obtained on plots treated with oxadiazon plus propanil at 0.75 + 2.0 kg a.i./ha was due to the substantial control of late emerging cutgrass by post-emergence oxadiazon. Though dimethametryne is a trazine effective against broad-leaved weeds when used alone, it was observed to improve the performance of propanil against already emerged grass weeds without reducing rice grain yields as demonstrated in all the trials.

Hand-weeding performed better than post-emergence herbicide treatments in all the trials but hand-weeding cannot be economically used for weed control where the hectarage under lowland rice cultivation is large. Hand-weeding operations are slow, labour intensive and unattractive due to the drudgery associated with it. In broadcast-seeded rice, hand-weeding cannot be successfully carried out because of the difficulty of distinguishing between rice seedlings and grass weeds. Post-emergence selective herbicides therefore offer the best weed control alternative under all seeding conditions of rice. When

applied at the seedling stage of weeds, selective control of abundant weeds, is achieved without injury to rice seedlings.

5.4 Interaction of herbicide combinations on cutgrass and rice

In this investigation, the significant interaction between glyphosate and pre-emergence oxadiazon on cutgrass dry weights at 60 DAH in the 1986 wet season further emphasizes the important role of both herbicides in this weed situation in rice production. It is apparent that once glyphosate was applied at 1.0 kg ae/ha significant reduction of cutgrass dry weight occurred even without pre-emergence oxadiazon. With lower rate of 0.5 kg ae/ha of glyphosate, supplementary pre-emergence oxadiazon was necessary for significant reduction in cutgrass dry weight.

The interaction of glyphosate and post-emergence weed control treatments was significant on cutgrass dry weight at 30 DAH in the 1986 wet and 60 DAH in the 1985-86 and 1986-87 dry season trials.

In the 1986 wet season trial, even at 0.5 kg ae/ha of glyphosate, propanil at 2.0 kg a.i./ha resulted in comparable cutgrass dry weight to other weed control treatments at 30 DAH. Similarly at 30 DAH bentazon plus propanil at 0.96 + 2.0 kg a.i./ha, resulted in comparable cutgrass dry weight to hand-weeding with the application of glyphosate at 0.5 and 1.0 kg ae/ha. On plots without glyphosate, cutgrass dry weight with the application of bentazon plus propanil at 0.96 + 2.0 kg a.i./ha did not differ significantly from that of the untreated control at

30 DAH (Table 4.26).

In the 1985-86 and 1986-87 dry seasons (Tables 4.27 and 4.28) at 60 DAH, similar to 1986 wet season at 30 DAH, propanil alone at 2.0 kg a.i./ha and bentazon plus propanil at 0.96 + 2.0 kg a.i./ha resulted in comparable cutgrass dry weight to other herbicide treatments which were at least comparable to hand-weeding with the application of glyphosate at 0.5 and 1.0 kg ae/ha. Dimethametryn plus propanil at 0.75 + 2.0 kg a.i./ha was found to be most effective under high glyphosate treatment in all the trials. Dimethametryn is mainly a post-emergence herbicide effective on broad-leaved weeds but also has some activities on young grasses and possibly seedlings of cutgrass. At the time of application, the suppression due to high rate of glyphosate might just allow seedlings of cutgrass on the field to be controlled with dimethametryn plus propanil at 0.75 + 2.0 kg a.i./ha. Dimethametryn is also absorbed by green leaves of susceptible weeds with a strong effect on Hill reaction of photosynthesis. Activation of propanil against emerged grass weeds by dimethametryn has been demonstrated in trials on weed control in rice (Anon., 1984; 1985).

Significant interaction was obtained between glyphosate and post-emergence weed control treatments on % unfilled grains, spikelet number per panicle in 1986 wet and 1986-87 dry seasons and grain yield in all the trials. Without glyphosate, all the post-emergence herbicide treatments resulted in higher percentage of unfilled grains, lower spikelet number per panicle and

lower grain yield than hand-weeding. Under glyphosate at 0.5 and 1.0 kg ae/ha, propanil mixtures with oxadiazon, dimethametryne and in some cases butachlor and benthiocarb resulted in comparable grain yield and yield attributes to hand-weeding. Propanil alone and its mixtures with bentazon were either found to give comparable grain yield and yield attributes to hand-weeding in one trial or lower in another trial under glyphosate at 0.5 kg ae/ha.

The interaction between pre-emergence oxadiazon and post emergence weed control treatments was significant on cutgrass dry weight and % coverage of cutgrass at 30 DAH in the 1986 wet season trial. Irrespective of the rate of pre-emergence oxadiazon, bentazon plus propanil at 0.96 + 2.0 kg a.i./ha resulted in higher cutgrass dry weight than hand-weeding. Similarly, without pre-emergence oxadiazon, oxadiazon plus propanil at 0.75 + 2.0 kg a.i./ha was slightly higher in cutgrass dry weight than hand-weeding. Even with the application of pre-emergence oxadiazon at 0.75 kg a.i./ha, butachlor plus propanil at 1.8 + 2.0 kg a.i./ha and propanil alone at 2.0 kg a.i./ha, cutgrass dry weight was higher than hand-weeding in the trial. Also, in the % cutgrass coverage, bentazon plus propanil at 0.96 + 2.0 kg a.i./ha resulted in higher % cutgrass coverage than hand-weeding, with and without pre-emergence oxadiazon. Whereas, butachlor plus propanil was comparable to hand-weeding without pre-emergence oxadiazon, it caused higher cutgrass coverage than hand-weeding with the application of pre-

emergence oxadiazon at 0.75 kg a.i./ha.

The interaction between pre-emergence oxadiazon and post-emergence weed control treatments was also significant on cutgrass dry weight at 60 DAH in the 1986-87 dry season trial (Table 4.31). The mixture of propanil with butachlor at 2.0 + 1.8 kg a.i./ha, and oxadiazon at 2.0 + 0.75 kg a.i./ha resulted in the least cutgrass dry weight irrespective of the rate of application of pre-emergence oxadiazon. Benthiocarb plus propanil was also found to cause comparable cutgrass dry weight to the minimum obtained among herbicide treatments under both rates of pre-emergence oxadiazon. However, dimethametryn plus propanil at 0.75 + 2.0 kg a.i./ha was only comparable to the least cutgrass dry weight in the trial under oxadiazon at 0.75 kg a.i./ha. Similar trend on interaction was obtained between pre-emergence oxadiazon and post-emergence weed control treatments on % coverage of cutgrass at 60 DAH in the 1986-87 dry season trial. In the 1986 wet season trial (Table 4.30), at 60 DAH bentazon plus propanil resulted in the highest weed coverage among herbicide treatments without pre-emergence oxadiazon. Under pre-emergence oxadiazon at 0.75 kg a.i./ha, propanil alone at 2.0 kg a.i./ha caused the highest % weed coverage among herbicide treatments.

The application of pre-emergence oxadiazon at 0.75 kg a.i./ha suppressed the growth of cutgrass seedlings after land preparation. Although propanil alone at 2.0 kg a.i./ha and its mixture with bentazon at 2.0 + 0.96 kg a.i./ha consistently resulted in higher cutgrass dry weight than

hand-weeding, dimethametryn plus propanil at 0.75 + 2.0 kg a.i./ha and oxadiazon plus propanil at 0.75 + 2.0 kg a.i./ha further suppressed cutgrass growth. The cutgrass dry weight obtained with the latter treatment was comparable to that on plots hand-weeded twice under pre-emergence oxadiazon at 0.75 kg a.i./ha. Propanil alone and bentazon plus propanil only have contact effect on emerged grasses. In fact, bentazon a component in the latter mixture has effect only on broad-leaved weeds and sedges. Dimethametryn though a broad-leaved contact herbicide has also been found to activate the action of propanil against grass weeds as demonstrated after the initial suppression in growth by pre-emergence oxadiazon. Post-emergence oxadiazon at 0.75 kg a.i./ha further suppressed the growth of grass weeds therefore making it possible for propanil at 2.0 kg a.i./ha to effect considerable reduction in the infestation of cutgrass. The performance of butachlor plus propanil at 1.8 + 2.0 kg a.i./ha and benthiocarb plus propanil at 1.08 + 2.0 kg a.i./ha was erratic under both rates of pre-emergence oxadiazon in the 1986 wet and 1986-87 dry season trials. An increase by 50% in the rate of the component herbicides in the two mixtures will introduce some degree of consistency in the performance of the two herbicide treatments. For instance, in the 1985 greenhouse trial, satisfactory control of cutgrass was obtained when molinate, a weak soil residual herbicide, was applied in combination with either benthiocarb plus propanil at 1.8 + 3.24 kg a.i./ha or butachlor plus propanil at 3.6 + 1.02 kg a.i./ha.

There was significant interaction between pre-emergence oxadiazon and post-emergence weed control treatments on spikelet number per panicle in the 1986 wet season trial (Table 4.53). Oxadiazon plus propanil at 0.75 + 2.0 kg a.i./ha resulted in lower spikelet number per panicle than hand-weeding without pre-emergence application of oxadiazon. With the application of pre-emergence oxadiazon at 0.75 kg a.i./ha, post-emergence oxadiazon plus propanil caused comparable number of spikelets to hand-weeding. Other post-emergence herbicide treatments that caused comparable spikelet number to hand-weeding under the same oxadiazon rate were butachlor plus propanil at 1.8 + 2.0 kg a.i./ha and dimethametryne plus propanil at 0.75 + 2.0 kg a.i./ha. Propanil alone at 2.0kg a.i./ha and its mixture with bentazon at 2.0 + 0.96 kg a.i./ha resulted in the least number of spikelets per panicle among herbicide treatments irrespective of the rate of pre-emergence oxadiazon. Benthiocarb plus propanil at 1.08 + 2.0 kg a.i./ha resulted in higher number of spikelets per panicle than the former herbicide treatments but lower than hand-weeding.

5.5 Correlation and regression

In the 1986 wet and 1986-87 dry seasons (Table 4.66), the significantly high positive correlation between grain yield and number of tillers per ha at 30 DAS and at maturity, number of panicles per ha and spikelets per panicle showed that these growth parameters contributed solely to grain yield production. Percentage of unfilled grains was also significantly positively correlated with cutgrass dry weight per ha. Number of tillers per ha at 30

DAS and at maturity, number of panicles per ha, spikelets per panicle and grain yield (Table 4.66) were significantly negatively correlated with % coverage of cutgrass and dry weight of cutgrass per ha at 30 and 60 DAH (Figs 5-9). This was due to the severe competition exhibited by cutgrass plants with rice plants for nutrients, space and light as demonstrated in the reduction of rice grain yield and other yield attributes of rice in all the trials.

# Chapter 6 SUMMARY AND CONCLUSIONS

Weed competition in direct-seeded lowland rice constitutes one of the major limiting factors to high rice grain yields in lowland rice production areas in Nigeria. The traditional method of weed control in Nigeria is by hoe-weeding and hand-pulling. Alternative weed control methods which will remove the drudgery of hoe-weeding and hand-pulling resulting in improved weed control efficacy and higher rice grain yields were investigated in all the trials.

The effects of cultivar and weed control treatments on weeds, growth and yield of direct-seeded lowland rice were evaluated at Badeggi in 1983 wet and 1983-84 dry seasons. A split plot design with cultivar as main and weed control treatments as sub-treatments replicated four times was adopted in the trials. The main treatments evaluated were three rice cultivars FARO 15, FARO 29 and FARO 27. The sub-plot treatments consisted of mixtures of propanil with butachlor and benthiocarb, an untreated and a hand-weeded control. The species composition of weeds 28 days before the land was prepared was grass weeds (70%), sedges (20%) and broad-leaved weeds (10%)

In 1985 wet season, a greenhouse pot trial was conducted at Badeggi to evaluate twelve treatments including an untreated control for the control of cutgrass in a completely randomised design with four replications. Single herbicide treatments of glyphosate at 1.6 kg ae/ha, oxadiazon at 1.0, 1.25 kg a.i./ha, treatments of mixtures

of propanil with butachlor and benthiocarb at varying rates and herbicide combinations of molinate at 4.0kg a.i./ha followed by mixtures of propanil with butachlor and benthiocarb were investigated in the trial. Except glyphosate, all the herbicides used in the trial were selective herbicides in rice weed control.

In 1985-86 dry, 1986 wet and 1986-87 dry seasons, herbicide combinations applied preplant, pre-emergence and post-emergence were evaluated for the control of cutgrass in lowland rice fields. The cutgrass infestation was about 100% in the experimental sites 28 days before land preparation. The experimental design was a split-split plot design in three replicates with preplant glyphosate as the main plot treatment, pre-emergence oxadiazon as the subplot treatment and some selective post-emergence herbicide mixtures, an untreated and hand-weeded controls as the sub-subplot treatments.

The results obtained from the 1983 wet, and 1983-84 dry season trials showed that cultivar had significant effect on weed dry weight, tiller number per/ha, plant height at 28, 56 and 98 days after seeding. Significantly higher grass weed weight (473.4kg/ha) was found on plots of FARO 27 than plots of FARO 29 and FARO 15 which recorded 360.4kg/ha and 384.7kg/ha respectively in 1983 wet season. Sedge weed weight on plots of FARO 27, FARO 29 and FARO 15 were 391.0kg/ha, 241.0kg/ha and 218.2kg/ha respectively in the same season. Comparable broad-leaved weed weight was found on plots of the three cultivars as follows: FARO 27 (284.0kg/ha), FARO 29 (321.5kg/ha) and FARO 15 (301.0kg/ha)

in the same trial. Higher grass weed weight and lower broad-leaved weed weight was found in association with the three cultivars in the 1983-84 dry season compared with the 1983-84 wet season trial.

FARO 15 was significantly taller than FARO 27 and FARO 29 at 56 and 98 DAS in both trials. The maximum height reached by FARO 15 at 98 DAS was 105.5cm while that of FARO 27 and FARO 29 were 84.6cm and 90.8cm. Plant height was of practical importance in the two trials since it aided in weed suppression by the rice cultivars.

In the 1983 wet season, FARO 15 out-yielded FARO 27 by 23.5% while FARO 29 also out-yielded FARO 27 by 21.1%. In 1983-84 dry season, FARO 29 out-yielded FARO 27 by 21.2% while FARO 15 showed a yield increase of 7.7% over the same cultivar, the significantly higher weed weight on plots of FARO 27 may have accounted for the relatively poor performance of the cultivar in grain yield production.

The post-emergence herbicide treatments in the 1983 wet and 1983-84 dry seasons significantly reduced weed dry weight compared with the untreated control and increased tiller number per ha, plant height, panicles per ha and spikelets per ha and grain yield compared with the untreated control in all the trials. In 1983, all the treatments, caused lower grain yield than the hand-weeded check plots while in 1983-84 dry season, the mixture of propanil with benthiocarb plus silvex at 3.24 +1.8 + 0.75kg a.i./ha caused comparable grain yield to hand-weeding. Generally, in all the trials, an increase in the rate of benthiocarb from 1.08kg a.i./ha to 1.8kg a.i./ha resulted in lower weed dry weight

and higher grain yield. Similarly an increase in the rate of butachlor from 1.8 to 3.6kg a.i./ha caused lower weed dry weight and higher grain yield. Uncontrolled weed growth throughout the crop life cycle in 1983 wet season resulted in complete crop loss. In the 1983-84 dry season trial, weed associated with FARO 15, FARO 29 and FARO 27 throughout their growth cycle resulted in 84.4%, 94.1% and 97.9% losses in rice grain yield respectively.

The interaction between cultivar and post-emergence herbicide treatments was significant on the number of panicles per ha, spikelets per panicle and the final grain yield in the two trials. The mixture of propanil with benthiocarb plus silvex at 3.24 + 1.8 + 0.75kg a.i./ha resulted in comparable grain yield to the hand-weeded check plots under FARO 15 and FARO 29 in both trials. Whereas in the 1983-84 dry season, the same treatment caused comparable grain yield to the hand-weeded check plots under the three cultivars. Significantly higher grain yield was recorded under FARO 15 and FARO 29 at the lower rates of the mixture of propanil with benthiocarb plus silvex than under FARO 27. The differences were less dramatic at the lower rates of the mixture of propanil with butachlor under the three cultivars in both trials. The same trend on interaction was manifested between cultivar and herbicide treatments on the number of panicles per ha and spikelets per ha in both trials.

The results obtained from the greenhouse showed that glyphosate at 1.6kg ae/ha resulted in complete control

(100%) of shoot, root and rhizome dry matter production. Other treatments which caused comparable cutgrass control were molinate at 4.0 kg a.i./ha followed by butachlor plus propanil at 3.6 + 1.02kg a.i./ha and molinate at 4.0kg a.i./ha followed by benthiocarb plus propanil at 1.8 + 3.24kg a.i./ha. The treatments resulted in 85% and 90% control of cutgrass shoots at 12 weeks after herbicide application. Rhizome dry matter production control was 46.8% and 64.9% while root dry matter production control was 85.6% and 87.9%. Another promising treatment was oxadiazon at 1.25kg a.i./ha applied at bud initiation. It caused 74% control of shoots, 36.2% control of rhizome and 84.9% control of root dry matter production compared with the untreated control.

Under field conditions in all the trials, application of glyphosate significantly reduced cutgrass dry weight and increased tiller number per ha, panicles per ha, spikelets per panicle and final grain yield. In the 1985-86 preliminary trial, glyphosate at 1.0kg ae/ha reduced cutgrass dry weight at 60 DAH by 29.5% and increased rice grain yield by 56.1%. In 1986 wet season, the same glyphosate rate reduced cutgrass dry weight at 60 DAH by 53.1% and increased rice grain yield by 30.9%. While in 1986-87 dry season, the same treatment reduced cutgrass dry weight at 60 DAH by 67.5% and increased rice grain yield by 57.1%.

Application of pre-emergence oxadiazon also significantly reduced cutgrass dry weight and increased rice grain yield. In the 1985-86 dry, 1986 wet and 1986-87 dry season, pre-emergence oxadiazon reduced cutgrass dry weight at 60 DAH by

3.2%, 39.9%, 2.4% and increased rice grain yield by 8.1%, 27.6% and 11.1% respectively. The above figures emphasize the importance of glyphosate and oxadiazon in the control of cutgrass which is capable of rapid propagation through rhizomes, seeds and surface creeping stems in lowland rice fields.

Post-emergence herbicide treatments further reduced cutgrass dry weight and increased crop growth, yield attributes and final grain yield compared with the untreated control. In 1985-86, 1986-87 dry seasons, all the post-emergence herbicide treatments caused significantly higher cutgrass dry weight and lower grain yield than the hand-weeded check plots. In 1986 wet season, butachlor plus propanil at 1.8+2.0 kg a.i./ha, mixtures of propanil with oxadiazon and dimethametryne each at 2.0 + 0.75kg a.i./ha caused significantly higher cutgrass dry weight but comparable grain yield to hand-weeding.

Significant interaction was obtained between preplant glyphosate and pre-emergence oxadiazon on cutgrass dry weight at 60 DAH in 1986 wet season and on plant height at 56 DAS in 1986-87 dry season. While both rates of glyphosate caused significant reduction of cutgrass dry weight when pre-emergence oxadiazon was applied later at 0.75kg a.i./ha only glyphosate at 1.0kg ae/ha significantly reduced the weight without pre-emergence oxadiazon. This interaction is of practical importance to large scale rice farmers who use tractor mounted sprayers. The interaction between pre-plant glyphosate and post-emergence herbicide

treatments was significant on tiller number per ha, non-significant on panicles per ha. significant on spikelets per panicle, % unfilled grains and final grain yield in all the trials. This interaction was also of practical importance. For instance, under glyphosate at 1.0kg ae/ha and 0.5kg ae/ha, the mixtures of propanil with oxadiazon and dimethametryn each at 2.0 + 0.75kg a.i./ha, butachlor plus propanil at 1.8 + 2.0kg a.i./ha and sometimes benthiocarb plus propanil at 1.08 + 2.0kg a.i./ha resulted in comparable grain yield to the hand-weeded check plots in all the trials. Without glyphosate all the post-emergence herbicide treatments caused significantly lower grain yield than hand-weeding except in 1986 wet season.

The interaction between pre-emergence oxadiazon and post-emergence herbicide treatments was significant on % cutgrass coverage, cutgrass dry weight at 60 DAH and plant height of rice at 98 DAS. A non-significant interaction was obtained betweed pre-emergence oxadiazon and post-emergence herbicide treatments on tiller number of rice at 30 DAS and 60 DAS and panicles per ha in all the trials. The interaction between pre-emergence oxadiazon and post-emergence herbicide treatments was significant on % unfilled grains, spikelets per panicle and grain yield in all the trials. The significant interaction between pre-emergence oxadiazon and post-

emergence herbicide treatments on grain yield in 1986 wet season was of practical importance. Under pre-emergence oxadiazon in this trial, the mixtures of propanil with oxadiazon and dimethametryne each at 2.0 + 0.75kg a.i./ha caused comparable grain yield to the hand-weeded check plots.

Rice grain yields were significantly positively correlated with spikelets per panicle, number of panicles per ha, tiller number per ha and negatively correlated with % cutgrass coverage and cutgrass dry weight at 30 DAH and 60 DAH. In the 1986 wet season, corresponding values were r = 0.80, 0.61, 0.53, -0.54, -0.70, -0.063 and -0.71; while in the 1986-87 dry season, the values were (r = 0.89, 0.90, 0.85, -0.75 and -0.85). At 30 DAH in 1986-87 dry season, cutgrass did not emerge to compete with rice plants.

The results obtained from this study indicated, that cutgrass infestation throughout the crop life cycle depressed various crop growth parameters such as tiller number, plant height, yield and yield attributes such as panicles per ha and spikelets per panicle compared with the weeded control plots.

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Appendix 1:
Ambient temperature, relative humidity and rainfall at Badeggi, 1983.

| Day | June Temperature min. °C | June Max | June Relative humidity % | June Precip. (mm) | July Temperature Min. °C | July Max. | July Relative humidity % | July Precip. (mm) |
|---|---|---|---|---|---|---|---|---|
| 1 | 25 | 34 | 72 | - | 23 | 32 | 77 | - |
| 2 | 26 | 35 | 78 | 5.5 | 24 | 30 | 77 | 34.1 |
| 3 | 23 | 32 | 83 | - | 21 | 29 | 96 | - |
| 4 | 25 | 32 | 76 | - | 22 | 31 | 84 | - |
| 5 | 26 | 34 | 73 | - | 24 | 32 | 84 | 21.3 |
| 6 | 25 | 34 | 81 | - | 21 | 30 | 89 | - |
| 7 | 25 | 34 | 81 | 25.6 | 23 | 32 | 86 | 11.4 |
| 8 | 22 | 28 | 91 | - | 21 | 30 | 91 | - |
| 9 | 21 | 33 | 84 | - | 23 | 32 | 84 | 11.0 |
| 10 | 24 | 32 | 79 | 6.5 | 21 | 82 | 82 | 0.9 |
| 11 | 22 | 31 | 84 | - | 24 | 33 | 81 | - |
| 12 | 24 | 28 | 81 | 6.3 | 25 | 32 | 86 | - |
| 13 | 21 | 31 | 88 | - | 21 | 30 | 85 | 16.6 |
| 14 | 25 | 30 | 77 | - | 23 | 32 | 84 | - |
| 15 | 23 | 32 | 80 | - | 24 | 31 | 94 | - |
| 16 | 24 | 32 | 82 | - | 22 | 29 | 92 | 20.5 |
| 177 | 24 | 33 | 82 | - | 23 | 30 | 89 | - |
| 18 | 25 | 33 | 81 | 0.3 | 24 | 31 | 88 | - |
| 19 | 24 | 30 | 84 | 21.4 | 25 | 30 | 81 | - |
| 20 | 21 | 29 | 91 | - | 23 | 32 | 85 | - |
| 21 | 23 | 31 | 88 | - | 25 | 33 | 81 | - |
| 22 | 25 | 33 | 81 | - | 22 | 31 | 83 | 25.3 |
| 23 | 24 | 32 | 81 | - | 24 | 30 | 92 | - |
| 24 | 24 | 30 | 91 | 0.1 | 23 | 33 | 80 | - |
| 25 | 24 | 31 | 80 | - | 24 | 32 | 81 | - |
| 26 | 24 | 32 | 87 | - | 23 | 31 | 88 | - |
| 27 | 25 | 33 | 83 | 8.0 | 24 | 32 | 84 | - |
| 28 | 24 | 32 | 88 | 0.3 | 24 | 32 | 77 | 23.2 |
| 29 | 23 | 33 | 84 | - | 23 | 29 | 89 | 0,4 |
| 30 | 24 | 31 | 88 | - | 23 | 29 | 80 | 15.6 |
| 31 | | | | | 23 | 28 | 87 | - |
| Total | | | | 74.0 | | | | 170.3 |
| Mean | 24 | 32 | 83 | | 23 | 31 | | |

Appendix 2. Ambient temperature, relative humidity and rainfall at Badeggi, 1983

| Day | August | | | | September | | | |
|---|---|---|---|---|---|---|---|---|
| | Temperature Min. °C | Max. | Relative humidity % | Precip. (mm) | Temperature Min. °C | Max. | Relative humidity % | Precip. (mm) |
| 1 | 22 | 30 | 77 | - | 23 | 32 | 81 | - |
| 2 | 23 | 31 | 77 | 5.9 | 24 | 27 | 81 | 7.7 |
| 3 | 23 | 26 | 96 | 5.8 | 22 | 31 | 84 | - |
| 4 | 23 | 30 | 84 | 0.3 | 24 | 23 | 81 | 69.4 |
| 5 | 24 | 32 | 84 | 0.6 | 21 | 28 | 96 | - |
| 6 | 24 | 27 | 89 | 2.7 | 21 | 30 | 84 | - |
| 7 | 23 | 29 | 86 | 25.3 | 24 | 31 | 81 | - |
| 8 | 24 | 31 | 91 | 5.2 | 23 | 32 | 86 | - |
| 9 | 23 | 31 | 84 | - | 24 | 33 | 80 | 7.5 |
| 10 | 24 | 29 | 82 | - | 24 | 32 | 83 | - |
| 11 | 24 | 28 | 81 | 9.2 | 24 | 30 | 88 | 2.5 |
| 12 | 24 | 31 | 86 | - | 21 | 31 | 88 | 0.1 |
| 13 | 23 | 28 | 85 | - | 24 | 32 | 84 | - |
| 14 | 22 | 30 | 84 | - | 22 | 32 | 84 | - |
| 15 | 23 | 32 | 94 | - | 24 | 33 | 81 | 6.5 |
| 16 | 23 | 31 | 92 | - | 23 | 32 | 86 | 15.5 |
| 17 | 23 | 31 | 87 | - | 23 | 32 | 85 | - |
| 18 | 23 | 31 | 88 | 14.4 | 23 | 30 | 90 | 4.9 |
| 19 | 21 | 29 | 81 | 3.9 | 22 | 33 | 89 | - |
| 20 | 23 | 30 | 85 | 4.9 | 24 | 32 | 85 | - |
| 21 | 24 | 31 | 81 | 1.2 | 24 | 32 | 90 | 3.4 |
| 22 | 23 | 31 | 83 | - | 22 | 31 | 88 | 11.3 |
| 23 | 24 | 32 | 92 | - | 21 | 32 | 92 | - |
| 24 | 24 | 32 | 80 | 1.8 | 22 | 33 | 87 | 3.8 |
| 25 | 23 | 29 | 81 | 21.2 | 23 | 32 | 86 | 34.5 |
| 26 | 21 | 30 | 88 | 2.9 | 21 | 27 | 96 | 0.7 |
| 27 | 23 | 30 | 84 | - | 22 | 32 | 88 | - |
| 28 | 24 | 32 | 77 | 25.7 | 22 | 33 | 76 | - |
| 29 | 21 | 29 | 89 | - | 24 | 34 | 84 | 5.3 |
| 30 | 23 | 30 | 80 | - | 22 | 31 | 79 | 2.0 |
| 31 | 24 | 31 | 87 | - | | | | |
| Total | | 144.0 | | | | | | 175.1 |
| Mean | 23 | 30 | 85 | | 23 | 31 | 85 | |

Appendix 3. Ambient temperature, relative humidity and rainfall at Badeggi, 1983

| Day | October | | | | November | | | |
|---|---|---|---|---|---|---|---|---|
| | Temperature Min. °C | Max. | Relative humidity % | Precip. (mm) | Temperature Min. °C | Max. | Relative humidity % | Precip (mm) |
| 1 | 22 | 32 | 84 | - | 20 | 34 | 43 | - |
| 2 | 24 | 33 | 83 | - | 22 | 34 | 69 | - |
| 3 | 23 | 32 | 70 | - | 22 | 34 | 80 | - |
| 4 | 23 | 32 | 83 | - | 22 | 34 | 67 | - |
| 5 | 24 | 33 | 86 | - | 22 | 35 | 66 | - |
| 6 | 23 | 32 | 71 | - | 21 | 35 | 72 | - |
| 7 | 24 | 34 | 83 | - | 20 | 35 | 74 | - |
| 8 | 24 | 34 | 85 | - | 21 | 35 | 74 | - |
| 9 | 24 | 34 | 72 | - | 20 | 34 | 77 | - |
| 10 | 23 | 34 | 76 | - | 20 | 34 | 73 | - |
| 11 | 23 | 34 | 79 | - | 18 | 35 | 75 | - |
| 12 | 23 | 33 | 87 | - | 20 | 35 | 81 | - |
| 13 | 22 | 33 | 81 | - | 21 | 35 | 83 | - |
| 14 | 24 | 33 | 84 | - | 22 | 35 | 79 | - |
| 15 | 24 | 34 | 81 | - | 22 | 35 | 82 | - |
| 16 | 24 | 34 | 82 | - | 21 | 34 | 72 | - |
| 17 | 25 | 34 | 86 | - | 20 | 36 | 71 | - |
| 18 | 24 | 33 | 86 | - | 18 | 36 | 59 | - |
| 19 | 24 | 35 | 78 | - | 19 | 36 | 63 | - |
| 20 | 23 | 34 | 74 | - | 17 | 35 | 71 | - |
| 21 | 22 | 34 | 88 | - | 19 | 36 | 74 | - |
| 22 | 21 | 33 | 90 | - | 19 | 34 | 76 | - |
| 23 | 21 | 34 | 84 | - | 18 | 34 | 67 | - |
| 24 | 19 | 34 | 86 | - | 20 | 35 | 81 | - |
| 25 | 21 | 34 | 73 | - | 16 | 34 | 72 | - |
| 26 | 24 | 34 | 88 | - | 17 | 34 | 62 | - |
| 27 | 21 | 34 | 68 | - | 17 | 35 | 49 | - |
| 28 | 24 | 34 | 88 | - | 15 | 34 | 47 | - |
| 29 | 21 | 34 | 83 | - | 18 | 34 | 74 | - |
| 30 | 22 | 35 | 75 | - | 20 | 33 | 67 | - |
| 31 | 20 | 35 | 47 | - | | | | |
| Total | - | - | - | - | - | - | - | - |
| Mean | 23 | 34 | 80 | | 20 | 35 | 70 | |

Appendix 4:
Ambient temperature, relative humidity and rainfall at Badeggi, 1983-84

| Day | June Temperature Min. °C | June Temperature Max | June Relative humidity % | June Precip. (mm) | July Temperature Min. °C | July Temperature Max | July Relative humidity % | July Preci (mm) |
|---|---|---|---|---|---|---|---|---|
| 1 | 20 | 34 | 69 | - | 17 | 33 | 39 | - |
| 2 | 18 | 34 | 66 | - | 14 | 33 | 33 | - |
| 3 | 19 | 34 | 63 | - | 15 | 32 | 28 | - |
| 4 | 17 | 35 | 63 | - | 18 | 34 | 49 | - |
| 5 | 16 | 35 | 69 | - | 17 | 31 | 38 | - |
| 6 | 19 | 35 | 63 | - | 16 | 31 | 56 | - |
| 7 | 19 | 35 | 71 | - | 14 | 33 | 34 | - |
| 8 | 18 | 35 | 68 | - | 15 | 33 | 50 | - |
| 9 | 19 | 36 | 83 | - | 17 | 34 | 62 | - |
| 10 | 20 | 34 | 82 | - | 15 | 34 | 39 | - |
| 11 | 22 | 34 | 70 | - | 16 | 33 | 50 | - |
| 12 | 23 | 36 | 81 | - | 14 | 34 | 51 | - |
| 13 | 21 | 35 | 81 | - | 15 | 33 | 57 | - |
| 14 | 21 | 35 | 71 | - | 16 | 35 | 53 | - |
| 15 | 21 | 35 | 81 | - | 14 | 33 | 51 | - |
| 16 | 22 | 36 | 81 | - | 17 | 31 | 31 | - |
| 17 | 21 | 34 | 84 | - | 17 | 32 | 70 | - |
| 18 | 21 | 34 | 76 | - | 16 | 31 | 36 | - |
| 19 | 17 | 36 | 46 | - | 14 | 33 | 44 | - |
| 20 | 20 | 36 | 71 | - | 14 | 36 | 39 | - |
| 21 | 20 | 36 | 68 | - | 13 | 35 | 38 | - |
| 22 | 19 | 35 | 38 | - | 14 | 36 | 35 | - |
| 23 | 15 | 34 | 37 | - | 15 | 36 | 35 | - |
| 24 | 13 | 33 | 47 | - | 14 | 36 | 50 | - |
| 25 | 13 | 32 | 33 | - | 12 | 36 | 32 | - |
| 26 | 14 | 33 | 45 | - | 14 | 35 | 48 | - |
| 27 | 15 | 31 | 27 | - | 14 | 37 | 48 | - |
| 28 | 15 | 32 | 44 | - | 18 | 36 | 39 | - |
| 29 | 16 | 31 | 59 | - | 17 | 35 | 42 | - |
| 30 | 16 | 33 | 61 | - | 18 | 36 | 28 | - |
| 31 | 15 | 33 | 40 | - | 15 | 33 | 30 | - |
| Total | - | - | - | - | - | - | - | - |
| Mean | 18 | 34 | 63 | - | 15 | 34 | 43 | - |

Appendix 5. Ambient temperature, relative humidity and rainfall at Badeggi, 1984.

| Day | February | | | | March | | | |
|---|---|---|---|---|---|---|---|---|
| | Temperature Min. °C | Max | Relative humidity % | Precip (mm) | Temperature Min. °C | Max. | Relative humidity % | Precip. (mm) |
| 1 | 18 | 37 | 50 | - | 22 | 37 | 48 | - |
| 2 | 16 | 37 | 26 | - | 23 | 38 | 66 | - |
| 3 | 16 | 38 | 28 | - | 20 | 40 | 44 | - |
| 4 | 17 | 36 | 16 | - | 20 | 39 | 68 | - |
| 5 | 16 | 33 | 21 | - | 23 | 38 | 70 | - |
| 6 | 17 | 33 | 21 | - | 24 | 39 | 68 | - |
| 7 | 16 | 32 | 83 | - | 25 | 39 | 69 | - |
| 8 | 15 | 34 | 83 | - | 25 | 38 | 67 | - |
| 9 | 17 | 34 | 31 | - | 25 | 35 | 64 | - |
| 10 | 17 | 35 | 66 | - | 23 | 35 | 66 | - |
| 11 | 18 | 37 | 58 | - | 24 | 38 | 67 | - |
| 12 | 17 | 37 | 53 | - | 24 | 38 | 70 | - |
| 13 | 17 | 39 | 37 | - | 25 | 39 | 81 | - |
| 14 | 17 | 38 | 65 | - | 24 | 38 | 73 | - |
| 15 | 20 | 38 | 41 | - | 26 | 39 | 73 | - |
| 16 | 21 | 37 | 48 | - | 24 | 37 | 66 | - |
| 17 | 20 | 38 | 58 | - | 25 | 39 | 69 | - |
| 18 | 19 | 38 | 54 | - | 25 | 38 | 65 | - |
| 19 | 18 | 36 | 58 | - | 26 | 39 | 65 | 4.0 |
| 20 | 16 | 38 | 22 | - | 24 | 37 | 66 | - |
| 21 | 28 | 19 | 26 | - | 25 | 38 | 63 | - |
| 22 | 18 | 38 | 37 | - | 26 | 37 | 64 | - |
| 23 | 19 | 37 | 43 | - | 24 | 36 | 68 | - |
| 24 | 20 | 38 | 37 | - | 25 | 39 | 33 | - |
| 25 | 23 | 38 | 63 | - | 22 | 39 | 28 | - |
| 26 | 22 | 38 | 62 | - | 26 | 37 | 66 | - |
| 27 | 19 | 38 | 58 | - | 26 | 38 | 66 | - |
| 28 | 21 | 39 | 38 | - | 25 | 37 | 65 | - |
| 29 | 23 | 38 | 42 | - | 26 | 39 | 42 | - |
| 30 | - | - | - | - | 25 | 38 | 23 | - |
| 31 | - | - | - | - | 25 | 38 | 61 | - |
| Total | - | - | - | - | - | - | - | 4.0 |
| Mean | 18 | 36.8 | 46 | - | 24 | 38 | 61 | - |

Appendix 6. Ambient temperature, relative humidity and rainfall at Badeggi, 1984

| Day | April | | | | May | | | |
|---|---|---|---|---|---|---|---|---|
| | Temperature Min. °C | Max | Relative humidity % | Precip. (mm) | Temperature Min. °C | Max. | Relative humidity % | Precip. (mm) |
| 1 | 24 | 39 | 27 | - | 26 | 33 | 72 | 10.5 |
| 2 | 27 | 38 | 65 | - | 22 | 32 | 82 | - |
| 3 | 27 | 38 | 64 | - | 25 | 34 | 88 | - |
| 4 | 26 | 39 | 62 | - | 26 | 36 | 73 | 11.2 |
| 5 | 24 | 37 | 60 | - | 24 | 32 | 81 | 31.5 |
| 6 | 27 | 39 | 64 | - | 23 | 33 | 87 | - |
| 7 | 27 | 38 | 57 | - | 25 | 34 | 78 | - |
| 8 | 25 | 38 | 63 | - | 25 | 34 | 77 | - |
| 9 | 24 | 36 | 60 | - | 25 | 35 | 75 | - |
| 10 | 26 | 39 | 61 | - | 26 | 30 | 82 | 30.7 |
| 11 | 24 | 39 | 53 | - | 21 | 31 | 84 | - |
| 12 | 27 | 38 | 52 | - | 24 | 35 | 82 | - |
| 13 | 27 | 38 | 52 | - | 26 | 34 | 76 | 22.0 |
| 14 | 24 | 34 | 50 | - | 21 | 32 | 77 | - |
| 15 | 25 | 37 | 56 | - | 25 | 35 | 76 | - |
| 16 | 24 | 38 | 62 | - | 25 | 31 | 83 | - |
| 17 | 24 | 38 | 63 | - | 24 | 35 | 82 | - |
| 18 | 25 | 39 | 60 | - | 23 | 32 | 83 | - |
| 19 | 25 | 35 | 58 | - | 23 | 34 | 73 | - |
| 20 | 24 | 38 | 57 | - | 24 | 35 | 85 | - |
| 21 | 26 | 39 | 56 | 44.1 | 25 | 34 | 77 | 24.8 |
| 22 | 23 | 30 | 66 | - | 20 | 31 | 91 | - |
| 23 | 23 | 34 | 68 | - | 24 | 33 | 72 | - |
| 24 | 26 | 33 | 67 | - | 25 | 35 | 72 | - |
| 25 | 25 | 36 | 72 | - | 23 | 33 | 77 | - |
| 26 | 27 | 29 | 18 | 34.5 | 24 | 34 | 82 | 4.3 |
| 27 | 21 | 33 | 79 | - | 22 | 33 | 81 | - |
| 28 | 24 | 35 | 77 | - | 24 | 34 | 78 | 0.8 |
| 29 | 25 | 31 | 73 | - | 23 | 32 | 68 | - |
| 30 | 23 | 34 | 75 | - | 23 | 32 | 76 | - |
| 31 | - | - | - | - | 22 | 29 | 91 | 4.4 |
| Total | - | - | - | 78.6 | - | - | - | - |
| Mean | 25 | 33.5 | 62 | - | 24 | 33 | 79 | 140.2 |

Appendix 7. Ambient temperature, relative humidity and rainfall at Badeggi, 1986.

| Day | June | | | | July | | | |
|---|---|---|---|---|---|---|---|---|
| | Temperature Min. °C | Max. | Relative humidity % | Precip. (mm) | Temperature Min. °C | Max. | Relative humidity % | Precip. (mm) |
| 1 | 24 | 35 | 83 | 11.6 | 28 | 28 | 85 | - |
| 2 | 21 | 34 | 81 | 1.2 | 22 | 31 | 80 | - |
| 3 | 22 | 33 | 83 | - | 23 | 30 | 84 | 3.8 |
| 4 | 22 | 33 | 73 | 13.7 | 24 | 31 | 84 | 0.1 |
| 5 | 22 | 28 | 86 | - | 21 | 31 | 89 | - |
| 6 | 22 | 29 | 94 | 3.1 | 23 | 30 | 96 | - |
| 7 | 22 | 32 | 76 | - | 22 | 31 | 73 | 4.6 |
| 8 | 24 | 33 | 84 | - | 24 | 29 | 83 | - |
| 9 | 24 | 33 | 71 | 1.1 | 22 | 31 | 81 | - |
| 10 | 22 | 31 | 79 | 23.2 | 24 | 32 | 72 | - |
| 11 | 21 | 31 | 84 | - | 23 | 30 | 82 | - |
| 12 | 24 | 30 | 74 | 9.7 | 22 | 30 | 80 | - |
| 13 | 24 | 33 | 70 | - | 23 | 31 | 84 | - |
| 14 | 21 | 32 | 87 | - | 22 | 31 | 73 | - |
| 15 | 24 | 32 | 87 | 93.1 | 23 | 30 | 79 | 4.2 |
| 16 | 25 | 32 | 81 | - | 23 | 29 | 92 | 2.4 |
| 17 | 21 | 33 | 83 | 10.0 | 23 | 30 | 96 | - |
| 18 | 24 | 34 | 77 | - | 22 | 31 | 82 | - |
| 19 | 22 | 32 | 83 | 10.1 | 23 | 33 | 91 | - |
| 20 | 24 | 33 | 73 | - | 24 | 34 | 87 | 38.1 |
| 21 | 22 | 30 | 91 | - | 22 | 30 | 92 | 31.5 |
| 22 | 24 | 33 | 87 | 11.5 | 22 | 27 | 97 | 0.8 |
| 23 | 23 | 32 | 83 | 1.5 | 23 | 30 | 87 | - |
| 24 | 22 | 31 | 91 | - | 22 | 28 | 85 | - |
| 25 | 22 | 27 | 83 | - | 23 | 30 | 92 | - |
| 26 | 22 | 31 | 84 | - | 22 | 30 | 81 | 9.0 |
| 27 | 24 | 31 | 68 | - | 22 | 29 | 94 | - |
| 28 | 24 | 33 | 90 | - | 22 | 30 | 98 | - |
| 29 | 24 | 34 | 83 | 13.5 | 21 | 31 | 87 | - |
| 30 | 22 | 30 | 85 | 41.7 | 23 | 31 | 80 | 42.7 |
| 31 | - | - | - | - | 21 | 33 | 96 | 2.7 |
| Total | - | - | - | 245.0 | - | - | - | 140.7 |
| Mean | 23 | 32 | 82 | - | 23 | 30 | 86 | - |

Appendix 8. Ambient temperature, relative humidity and rainfall at Badeggi, 1986.

| | August | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Day | Temperature Min. °C | Max. | Relative humidity % | Precip. (mm) | Temperature Min. °C | Max. | Relative humidity % | Precip. (mm) |
| 1 | 22 | 26 | 91 | - | 24 | 26 | 94 | - |
| 2 | 21 | 29 | 84 | - | 24 | 31 | 92 | - |
| 3 | 22 | 32 | 92 | - | 26 | 32 | 77 | 28.0 |
| 4 | 23 | 31 | 77 | 48.2 | 22 | 28 | 85 | - |
| 5 | 23 | 29 | 96 | - | 24 | 30 | 76 | 4.7 |
| 6 | 22 | 31 | 85 | 20.4 | 24 | 30 | 80 | 2.1 |
| 7 | 22 | 29 | 93 | - | 25 | 30 | 85 | 3.5 |
| 8 | 23 | 31 | 88 | - | 24 | 31 | 93 | 13.5 |
| 9 | 24 | 32 | 82 | 17.3 | 23 | 29 | 93 | 4.6 |
| 10 | 21 | 29 | 93 | - | 23 | 29 | 92 | 0.7 |
| 11 | 22 | 31 | 88 | 2.9 | 23 | 31 | 79 | 0.5 |
| 12 | 21 | 29 | 93 | - | 25 | 31 | 84 | 0.5 |
| 13 | 22 | 30 | 80 | 1.2 | 25 | 32 | 75 | 14.0 |
| 14 | 22 | 30 | 92 | - | 23 | 30 | 96 | 13.1 |
| 15 | 22 | 30 | 83 | - | 25 | 32 | 84 | 2.5 |
| 16 | 22 | 33 | 75 | - | 25 | 32 | 85 | - |
| 17 | 23 | 30 | 91 | - | 24 | 33 | 77 | 10.5 |
| 18 | 24 | 32 | 74 | 3.0 | 23 | 31 | 83 | - |
| 19 | 23 | 29 | 88 | - | 24 | 32 | 81 | - |
| 20 | 23 | 31 | 81 | - | 24 | 31 | 84 | 13.6 |
| 21 | 22 | 32 | 84 | 15.3 | 24 | 27 | 95 | 8.4 |
| 22 | 21 | 30 | 87 | - | 23 | 29 | 81 | 11.7 |
| 23 | 23 | 31 | 74 | - | 24 | 32 | 75 | 2.7 |
| 24 | 23 | 32 | 77 | - | 25 | 39 | 88 | 14.8 |
| 25 | 23 | 31 | 84 | 17.2 | 23 | 29 | 92 | - |
| 26 | 23 | 31 | 91 | - | 24 | 32 | 77 | 14.8 |
| 27 | 24 | 29 | 90 | - | 22 | 29 | 82 | - |
| 28 | 23 | 31 | 84 | - | 22 | 33 | 90 | - |
| 29 | 21 | 32 | 85 | 5.3 | 23 | 32 | 81 | 14.0 |
| 30 | 22 | 31 | 88 | 1.4 | 23 | 31 | 76 | 4.6 |
| 31 | 23 | 32 | 77 | 13.6 | - | - | - | - |
| Total | - | - | - | 145.8 | - | - | - | 182.3 |
| Mean | 22 | 31 | 85 | - | 24 | 30 | 84 | - |

Appendix 9. Ambient temperature, relative humidity and rainfall at Badeggi, 1986.

| Day | October | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Temperature Min. °C | Max. | Relative humidity % | Precip. (mm) | Temperature Min. °C | Max. | Relative humidity % | Precip. (mm) |
| 1 | 23 | 28 | 97 | 4.7 | 22 | 31 | 85 | - |
| 2 | 22 | 31 | 79 | - | 22 | 33 | 85 | - |
| 3 | 23 | 33 | 81 | 4.6 | 24 | 33 | 86 | - |
| 4 | 22 | 31 | 84 | 0.7 | 24 | 32 | 77 | - |
| 5 | 22 | 29 | 95 | 0.7 | 24 | 28 | 83 | - |
| 6 | 23 | 31 | 77 | - | 24 | 32 | 92 | - |
| 7 | 24 | 33 | 86 | - | 23 | 34 | 81 | - |
| 8 | 25 | 33 | 76 | - | 25 | 34 | 82 | - |
| 9 | 24 | 33 | 74 | - | 25 | 34 | 84 | - |
| 10 | 24 | 34 | 77 | 25.9 | 24 | 32 | 73 | - |
| 11 | 23 | 33 | 81 | - | 23 | 32 | 56 | - |
| 12 | 24 | 34 | 86 | - | 23 | 32 | 70 | - |
| 13 | 24 | 33 | 78 | - | 24 | 34 | 60 | - |
| 14 | 24 | 33 | 82 | - | 25 | 34 | 63 | - |
| 15 | 23 | 34 | 82 | - | 20 | 33 | 56 | - |
| 16 | 24 | 34 | 79 | 11.9 | 20 | 34 | 63 | - |
| 17 | 22 | 34 | 88 | - | 21 | 33 | 83 | - |
| 18 | 23 | 30 | 89 | - | 22 | 33 | 69 | - |
| 19 | 24 | 28 | 78 | 0.6 | 22 | 34 | 83 | - |
| 20 | 22 | 33 | 78 | - | 22 | 32 | 76 | - |
| 21 | 23 | 34 | 81 | - | 21 | 34 | 75 | - |
| 22 | 24 | 34 | 87 | - | 23 | 34 | 84 | - |
| 23 | 23 | 34 | 81 | - | 22 | 30 | 87 | - |
| 24 | 24 | 32 | 74 | - | 19 | 32 | 76 | - |
| 25 | 23 | 33 | 82 | - | 22 | 33 | 71 | - |
| 26 | 23 | 34 | 84 | 2.4 | 21 | 33 | 83 | - |
| 27 | 23 | 33 | 84 | - | 23 | 34 | 71 | - |
| 28 | 23 | 32 | 79 | - | 21 | 33 | 57 | - |
| 29 | 22 | 31 | 90 | - | 21 | 33 | 59 | - |
| 30 | 23 | 33 | 70 | 23.6 | 20 | 34 | 77 | - |
| 31 | 22 | 32 | 83 | 13.8 | - | - | - | - |
| Total | - | - | - | 88.9 | - | - | - | - |
| Mean | 23 | 32 | 82 | - | 22 | 33 | 75 | - |

Appendix 10. Ambient temperature, relative humidity and rainfall at Badeggi, 1986-87.

| Day | December | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Temperature Min. °C | Max. | Relative humidity % | Precip. (mm) | Temperature Min. °C | Max. | Relative humidity % | Precip. (mm) |
| 1 | 16 | 33 | 57 | - | 17 | 31 | 64 | - |
| 2 | 18 | 32 | 60 | - | 17 | 33 | 44 | - |
| 3 | 20 | 31 | 55 | - | 17 | 34 | 54 | - |
| 4 | 18 | 31 | 52 | - | 17 | 35 | 82 | - |
| 5 | 15 | 31 | 44 | - | 17 | 36 | 44 | - |
| 6 | 16 | 31 | 71 | - | 16 | 33 | 38 | - |
| 7 | 15 | 32 | 72 | - | 15 | 32 | 56 | - |
| 8 | 18 | 32 | 51 | - | 15 | 31 | 43 | - |
| 9 | 12 | 34 | 51 | - | 16 | 32 | 38 | - |
| 10 | 13 | 34 | 66 | - | 16 | 33 | 50 | - |
| 11 | 13 | 34 | 69 | - | 14 | 34 | 76 | - |
| 12 | 13 | 34 | 62 | - | 14 | 33 | 60 | - |
| 13 | 14 | 33 | 60 | - | 15 | 34 | 70 | - |
| 14 | 14 | 34 | 45 | - | 13 | 35 | 76 | - |
| 15 | 14 | 32 | 44 | - | 17 | 35 | 75 | - |
| 16 | 15 | 32 | 71 | - | 18 | 35 | 67 | - |
| 17 | 14 | 31 | 63 | - | 21 | 35 | 67 | - |
| 18 | 14 | 30 | 55 | - | 22 | 36 | 84 | - |
| 19 | 14 | 31 | 32 | - | 21 | 36 | 84 | - |
| 20 | 13 | 29 | 69 | - | 21 | 36 | 74 | - |
| 21 | 17 | 29 | 65 | - | 17 | 38 | 74 | - |
| 22 | 16 | 32 | 52 | - | 16 | 37 | 47 | - |
| 23 | 16 | 33 | 45 | - | 15 | 37 | 32 | - |
| 24 | 16 | 34 | 85 | - | 14 | 36 | 66 | - |
| 25 | 17 | 34 | 86 | - | 16 | 34 | 75 | - |
| 26 | 17 | 34 | 62 | - | 13 | 35 | 70 | - |
| 27 | 17 | 33 | 73 | - | 15 | 34 | 34 | - |
| 28 | 20 | 34 | 42 | - | 16 | 35 | 45 | - |
| 29 | 16 | 33 | 50 | - | 16 | 35 | 52 | - |
| 30 | 14 | 33 | 44 | - | 17 | 34 | 86 | - |
| 31 | 17 | 31 | 71 | - | 18 | 35 | 54 | - |
| Total | - | - | - | - | - | - | - | - |
| Mean | 16 | 32 | 59 | - | 19 | 34 | 61 | - |

Appendix 11
Ardient temperature, relative humidity and rainfall at Badeggi, 1987.

| Day | June Temperature Min. °C | Max | Relative humidity % | Precip. (mm) | July Tenperature Min. °C | Max | Relative humidity % | Precip. (- ) |
|---|---|---|---|---|---|---|---|---|
| 1 | 16 | 36 | 73 | - | 17 | 37 | 43 | - |
| 2 | 17 | 37 | 27 | - | 17 | 38 | 23 | - |
| 3 | 19 | 36 | 65 | - | 17 | 36 | 25 | - |
| 4 | 15 | 37 | 40 | - | 18 | 37 | 27 | - |
| 5 | 17 | 36 | 33 | - | 17 | 39 | 29 | - |
| 6 | 15 | 36 | 68 | - | 18 | 37 | 35 | - |
| 7 | 14 | 36 | 66 | - | 18 | 38 | 35 | - |
| 8 | 15 | 37 | 37 | - | 19 | 39 | 62 | - |
| 9 | 14 | 34 | 28 | - | 24 | 36 | 65 | - |
| 10 | 13 | 36 | 41 | - | 24 | 37 | 59 | - |
| 11 | 13 | 37 | 65 | - | 21 | 38 | 80 | 10.5 |
| 12 | 13 | 39 | 69 | - | 19 | 39 | 46 | - |
| 13 | 12 | 37 | 70 | 2.7 | 22 | 36 | 73 | - |
| 14 | 13 | 37 | 60 | - | 25 | 37 | 72 | - |
| 15 | 15 | 37 | 80 | - | 25 | 36 | 75 | - |
| 16 | 17 | 36 | 66 | - | 26 | 35 | 75 | - |
| 17 | 21 | 36 | 68 | - | 27 | 37 | 68 | - |
| 18 | 20 | 36 | 71 | - | 26 | 38 | 66 | - |
| 19 | 17 | 37 | 70 | - | 26 | 37 | 62 | - |
| 20 | 16 | 37 | 73 | - | 27 | 39 | 75 | - |
| 21 | 17 | 37 | 76 | - | 27 | 35 | 77 | 9.5 |
| 22 | 17 | 38 | 68 | - | 23 | 35 | 87 | - |
| 23 | 18 | 39 | 68 | - | 24 | 37 | 68 | - |
| 24 | 17 | 38 | 69 | - | 26 | 37 | 70 | - |
| 25 | 17 | 38 | 64 | - | 25 | 37 | 69 | - |
| 26 | 18 | 38 | 64 | - | 26 | 34 | 73 | - |
| 27 | 23 | 37 | 56 | - | 25 | 36 | 73 | - |
| 28 | 24 | 38 | 60 | - | 27 | 33 | 74 | - |
| 29 | - | - | - | - | 27 | 35 | 82 | - |
| 30 | - | - | - | - | 27 | 35 | 69 | - |
| 31 | - | - | - | - | 26 | 37 | 74 | - |
| Total | - | - | - | 2.7 | - | - | - | 28. |
| Mean | 17 | 37 | 61 | - | 23 | 37 | 62 | - |

Appendix 12

Ambient temperature, relative humidity and rainfall at Badeggi, 1987.

| Day | April | | | |
|---|---|---|---|---|
| | Temperature Min. °C | Max. | Relative humidity % | Precip. (mm) |
| 1 | 25 | 37 | 65 | 28.0 |
| 2 | 22 | 33 | 86 | - |
| 3 | 24 | 35 | 77 | - |
| 4 | 26 | 37 | 77 | - |
| 5 | 26 | 38 | 81 | - |
| 6 | 26 | 36 | 75 | - |
| 7 | 25 | 38 | 69 | - |
| 8 | 18 | 37 | 50 | - |
| 9 | 20 | 37 | 39 | - |
| 10 | 21 | 38 | 64 | - |
| 11 | 22 | 39 | 70 | - |
| 12 | 22 | 38 | 74 | - |
| 13 | 24 | 38 | 68 | - |
| 14 | 24 | 39 | 58 | - |
| 15 | 27 | 37 | 69 | - |
| 16 | 25 | 38 | 61 | - |
| 17 | 26 | 37 | 69 | - |
| 18 | 25 | 38 | 63 | - |
| 19 | 24 | 40 | 62 | - |
| 20 | 24 | 38 | 61 | - |
| 21 | 26 | 37 | 19 | - |
| 22 | 23 | 38 | 21 | - |
| 23 | 24 | 39 | 26 | - |
| 24 | 25 | 39 | 28 | - |
| 25 | 24 | 40 | 59 | - |
| 26 | 24 | 39 | 41 | - |
| 27 | 25 | 39 | 56 | - |
| 28 | 27 | 40 | 70 | - |
| 29 | 23 | 40 | 67 | - |
| 30 | 25 | 39 | 68 | - |
| 31 | - | - | - | - |
| Total | - | - | - | - |
| Mean | 24 | 38 | 60 | - |

Appendix 13. Analysis of variance of plant height at 28 days after seeding at Badeggi, 1983 wet season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication (R) | 3 | 17.95 | 3.98 | 1.33 | NS |
| Variety (V) | 2 | 257.06 | 128.53 | 51.70** | SIG. |
| Error (a) | 6 | 12.49 | 2.08 | 0.46 | SIG. |
| Total | 11 | 369.56 | 33.60 | 7.50 | |
| Sub-plot | | | | | |
| Weed control treatment (W) | 7 | 393.72 | 56.24 | 12.53** | SIG. |
| V x W | 14 | 131.11 | 9.36 | 2.08* | SIG. |
| Error (b) | 63 | 282.70 | 4.48 | | |
| Total | 84 | 807.53 | 9.61 | | |
| Grand Total | 95 | 1095.06 | | | |
| Grand Mean | 28.19 | | | | |
| Total number of observations | 96 | | | | |

NS = Not significant at 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 14. Analysis of variance of plant height at 28 days after seeding in the direct-seeded lowland rice at Badeggi, 1983-84 dry season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication (R) | 3 | 292.46 | 97.48 | 17.16** | SIG. |
| Variety (V) | 2 | 23.52 | 11.76 | 8.49** | SIG. |
| Error (a) | 6 | 8.31 | 1.38 | 0.24 | |
| Total | 11 | 31.83 | 2.94 | 0.52 | |
| Sub-plot | | | | | |
| Weed control treatments | 7 | 1223.08 | 174.72 | 30.76** | SIG. |
| V x W | 14 | 89.07 | 5.36 | 1.12 | NS |
| Error (b) | 63 | 357.82 | 5.68 | | |
| Total | 84 | 1669.97 | 19.88 | | |
| Grand Total | 95 | 1994.27 | | | |
| Grand Mean | 30.71 | | | | |
| Total number of observations | 96 | | | | |

NS = Not significant at 0.05 level, *, **, significant difference at the 0.05 and 0.01 levels, respectively.

Appendix 15. Analysis of variance of plant height at 56 days after seeding at Badeggi, 1983 wet season

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication (R) | 3 | 418.60 | 139.53 | 13.28** | SIG. |
| Variety (V) | 2 | 201.21 | 100.60 | 13.08** | SIG. |
| Error (a) | 6 | 46.14 | 7.89 | 0.73 | |
| Total | 11 | 247.35 | 22.48 | 2.14 | |
| Sub-plot | | | | | |
| Weed control treatments (W) | 7 | 2669.54 | 361.36 | 36.31** | SIG. |
| V x W | 24 | 693.93 | 49.93 | 4.72** | SIG. |
| Error (b) | 63 | 661.55 | 10.50 | | |
| Total | 84 | 4025.02 | 47.90 | | |
| Grand Total | 95 | | | | |
| Grand Mean | 75.71cm | | | | |
| Total number of observations | 96 | | | | |

NS = Not significant at 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 16. Analysis of variance of plant height at 56 days after seeding in the direct-seeded lowland rice at Badeggi, 1983-84 dry season.

| Source of variation | Degrees of freedom | Sum of squares | Means squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication (R) | 3 | 275.78 | 91.92 | 13.53** | SIG. |
| Variety (V) | 2 | 1298.64 | 649.34 | 54.99** | SIG. |
| Error (a) | 6 | 70.84 | 11.80 | 1.73 | |
| Total | 11 | 1369.53 | 124.59 | 21.50 | |
| Sub-plot | | | | | |
| Weed control treatments | 7 | 7543.89 | 1077.69 | 158.69** | SIG. |
| V x W | 14 | 2213.53 | 158.11 | 23.28** | SIG. |
| Error (b) | 63 | 427.83 | 5.79 | | |
| Total | 84 | 10185.26 | 121.25 | | |
| Grand Total | 95 | 11830.57 | | | |
| Grand Mean | 68.1 | | | | |
| Total number of observations | 96 | | | | |

NS = Not significant at 0.05 level, *, **, significant differences at the 0.05 and 0.01 level respectively.

Appendix 17. Analysis of variance of plant height at 98 days after seeding at Badeggi, 1983 wet season

| Source of variation | Degrees of freedom | Sum of squares | Means squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication (R) | 3 | 247.29 | 82.43 | 5.43** | SIG. |
| Variety (V) | 2 | 3254.25 | 2627.13 | 183.57** | SIG. |
| Error (a) | 6 | 85.82 | 14.30 | 0.94 | NS |
| Total | 11 | 5340.07 | 485.46 | 32.00 | |
| Sub-plot | | | | | |
| Weed control treatments (W) | 7 | 119709.30 | 17101.33 | 1126.77** | SIG. |
| V x W | 14 | 1090.68 | 77.91 | 5.13 | SIG. |
| Error (b) | 63 | 956.17 | | | |
| Total | 84 | 121756.18 | | | |
| Grand Total | 95 | 1217343.52 | | | |
| Grand Mean | 93.31 | | | | |
| Total number of observations | 96 | | | | |

NS = Not significant at the 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 18. Analysis of variance of plant height at 98 days after seeding in the direct-seeded lowland rice at Badeggi, 1983-84 dry season.

| Source of variation | Degrees of freedom | Sum of squares | Means squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication (R) | 3 | 1065.78 | 355.26 | 16.35** | SIG. |
| Variety (V) | 2 | 8179.15 | 4089.57 | 54.48** | SIG. |
| Error (a) | 6 | 450.38 | 75.06 | 3.45 | |
| Total | 11 | 8629.53 | 784.50 | 36.10 | |
| Sub-plot | | | | | |
| Weed control **treatments** | 7 | 119934.36 | 17133.40 | 788.50** | SIG. |
| V x W | 14 | 1514.85 | 108.20 | 4.98* | SIG. |
| Error (b) | 63 | 1368.93 | 21.73 | | |
| Total | 84 | 122818.14 | 1452.12 | | |
| Grand Total | 95 | 132513.45 | | | |
| Grand Mean | 93.46 | | | | |
| Total number of observations | 96 | | | | |

NS = Not significant at 0.05 level; *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 19 Analysis of variance of number of tillers per $m^2$ at 30 days after seeding at Badeggi, 1983 wet season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main plot | | | | | |
| Replication (R) | 3 | 2467.1 | 822.4 | 1.45 | NS |
| Variety (V) | 2 | 12901.0 | 6450.5 | 5.44** | SIG |
| Error (a) | 6 | 7107.0 | 1184.4 | 2.10 | |
| Total | 11 | 20008.4 | 1818.9 | 3.32 | |
| Sub plot | | | | | |
| Weed control treatments (W) | 7 | 255511.3 | 36581.6 | 64.69** | SIG. |
| V x W | 14 | 25221.7 | 1801.5 | 3.193** | SIG. |
| Error (b) | 63 | 35543.5 | 564.2 | | |
| Total | 84 | 316276.5 | 3765.2 | | |
| Grand Total | 95 | 338752.0 | | | |
| Grand Mean | 328.8 | | | | |
| Total number of observations | 96 | | | | |

NS = Not significant at the 0.05 level. *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 20: Analysis of variance of number of tillers per $m^2$ at 30 DAS[1] in the direct-seeded lowland rice at Badeggi, 1983-84 dry season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main plot | | | | | |
| Replication (R) | 3 | 2257.3 | 752.5 | 1.00 | NS |
| Variety (V) | 2 | 113789.1 | 56894.5 | 51.34** | SIG. |
| Error (a) | 6 | 6648.2 | 1108.0 | 1.48 | |
| Total | 11 | 120437.2 | 10948.8 | 14.65 | |
| Sub-plot | | | | | |
| Weed control treatments | 7 | 272149.0 | 38878.4 | 52.03** | SIG. |
| V x W | 14 | 43072.9 | 3076.6 | 4.11** | SIG. |
| Error (b) | 63 | 47079.4 | 747.3 | | |
| Total | 84 | 362301.2 | 4313.1 | | |
| Grand Total | 95 | 484996.0 | | | |
| Grand Mean | 383.9 | | | | |
| Total number of observations | 96 | | | | |

DAS = Days after seeding.

NS = Not significant at 0.05 level, *, **, significant differences at the 0.05 and 0.0, level respectively.

Appendix 21: Analysis of variance of number of tillers at 60 days after seeding at Badeggi, 1983 wet season

| Source of variation | Degrees of freedom | Sum of squares | Means squares | F | Significance |
|---|---|---|---|---|---|
| Main plot | | | | | |
| Replication (R) | 3 | 19446.6 | 6482.2 | 11.48** | SIG. |
| Variety (V) | 2 | 6713.1 | 3356.6 | 2.634 | NS |
| Error (a) | 6 | 7645.1 | 1274.2 | 2.258 | |
| Total | 11 | 14358.3 | 1305.3 | 2.31 | |
| Sub-plot | | | | | |
| Weed control treatments (W) | 7 | 1423303.6 | 203329.1 | 360.35** | SIG. |
| V x W | 14 | 26361.0 | 1882.9 | 3.33** | SIG. |
| Error (b) | 63 | 35548.0 | 564.3 | | |
| Total | 84 | 1485212.6 | 17581.1 | | |
| Grand Total | 95 | 1519017.5 | | | |
| Grand Mean | 313.2 | | | | |
| Total number of observations | 96 | | | | |

NS = Not significant at the 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 22: Analysis of variance of number of tillers $m^2$ at 60 days after seeding in the direct-seeded lowland rice at Badeggi, 1983-84 dry season.

| Source of variation | Degree of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication (R) | 3 | 67139 | 22380 | 16.65** | SIG. |
| Variety (V) | 2 | 3723 | 1862 | 4.96* | SIG. |
| Error (a) | 6 | 2252 | 375 | 0.27 | |
| Total | 11 | 5975 | 543.18 | 0.40 | |
| Sub-plot | | | | | |
| Weed control treatments (W) | 7 | 1374063 | 196295 | 146.09** | SIG. |
| V x W | 14 | 50068 | 3576 | 2.6** | SIG. |
| Error (b) | 63 | 84649 | 1344 | | |
| Total | 84 | 1508780 | 17962 | | |
| Grand Total | 95 | 158193 | | | |
| Grand Mean | 373.1 | | | | |
| Total number of observations | 96 | | | | |

NS = Not significant at 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 23: Analysis of variance of number of panicles/$m^2$ in the direct-seeded lowland rice at Badeggi, 1983 wet season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication (R) | 3 | 2339.1 | 779.5 | 1.45 | NS |
| Variety (V) | 2 | 93472.8 | 46736.4 | 22.69** | SIG. |
| Error (a) | 6 | 12358.8 | 2059.8 | 3.83 | |
| Total | 11 | 105831.5 | 9621.0 | 17.91 | |
| Sub-plot | | | | | |
| Weed control treatments (W) | 7 | 1152555.3 | 164650.8 | 306.611** | SIG. |
| V x W | 14 | 56954.6 | 4068.2 | 7.57** | SIG. |
| Error (b) | 63 | 33831.1 | 537.0 | | |
| Total | 84 | 1243341.0 | 14801.7 | | |
| Grand Total | 95 | 1351511.6 | 100.0 | | |
| Grand Mean | 252.4 | | | | |
| Total number of observations | 96 | | | | |

NS = Not significant at the 0.05 level; *, ** significant differences at the 0.05 and 0.01 levels respectively.

Appendix 24: Analysis of variance of number of panicles/$m^2$ in the direct-seeded lowland rice at Badeggi, 1983-84 dry season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication (R) | 3 | 56950 | 18983 | 12.81** | SIG. |
| Variety (V) | 2 | 12692 | 6346 | 5.21* | SIG. |
| Error (a) | 6 | 7303 | 1217 | 0.82 | |
| Total | 11 | 19995 | 1817072 | 1.22 | |
| Sub-plot | | | | | |
| Weed control treatments (W) | 7 | 1256137 | 179448 | 121.11** | SIG. |
| V x W | 14 | 40004 | 2915 | 1.96* | SIG. |
| Error (b) | 64 | 93343 | 1482 | | |
| Total | 84 | 1390284 | 16551 | | |
| Grand Total | 95 | 1467229 | | | |
| Grand Mean | 537.1 | | | | |
| Total number of observations | 96 | | | | |

NS = Not significant at 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 25: Analysis of variance of spikelets (no/$m^2$ x $10^2$) in the direct-seeded lowland rice at Badeggi 1983, wet season.

| Sources of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Replication (R) | 3 | 6715 | 2238 | 2.12 | NS |
| Variety (V) | 2 | 66673 | 33337 | 89.14** | SIG. |
| Error (a) | 6 | 2244 | 374 | 0.35 | |
| Total | 11 | 68917 | 6265.18 | 5.93 | |
| Sub-plot | | | | | |
| Weed control treatments (W) | 7 | 3167381 | 452483 | 429.05** | SIG. |
| V x W | 14 | 145428 | 10388 | 9.85 | SIG. |
| Error (b) | 63 | 66440 | 1055 | | |
| Total | 84 | 3379251 | 40229 | | |
| Grand Total | 95 | 3454883 | | | |
| Grand Mean | 415.8 | | | | |
| Total number of observations | 96 | | | | |

NS = Not significant at 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 26: Analysis of variance of spikelet (no/$m^2$ x $10^2$) in the direct-seeded lowland rice at Badeggi, 1983-84 dry season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication (R) | 3 | 64102 | 21367 | 8.56** | SIG. |
| Variety (V) | 2 | 604245 | 302123 | 50.00** | SIG. |
| Error (a) | 6 | 30212 | 5035 | 2.01 | |
| Total | 11 | 634457 | 57677.90 | 23.10 | |
| Sub-plot | | | | | |
| Weed control treatments (W) | 7 | 2894456 | 413494 | 165.66** | SIG. |
| V x W | 14 | 265880 | 18991 | 7.60** | SIG. |
| Error (b) | 63 | 157248 | 2495 | | |
| Total | 84 | 3317584 | 39495 | | |
| Grand Total | 95 | 4016143 | | | |
| Grand Mean | 427.3 | | | | |
| Total number of observations | 96 | | | | |

NS = Not significant at 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 27: Analysis of variance of % unfilled grains in the direct-seeded lowland rice at Badeggi, 1983 wet season.

| Source of variation | Degree of freedom | Sum of sources | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Replication (R) | 3 | 3.11 | 1.03 | 0.21 | NS |
| Variety (V) | 2 | 199.64 | 99.82 | 9.56** | SIG. |
| Error (a) | 6 | 62.60 | 10.43 | 2.10 | |
| Total | 11 | 262.25 | 23.84 | 4.81 | |
| Sub-plot | | | | | |
| Weed control treatments (W) | 7 | 88284.57 | 12612.08 | 2546.41** | SIG. |
| V x W | 14 | 306.52 | 21.89 | 4.42** | SIG. |
| Error (b) | 63 | 312.02 | 4.95 | | |
| Total | 84 | 88903.12 | 1058.37 | | |
| Grand total | 95 | 89168.49 | | | |
| Grand mean 19.93 | | | | | |
| Total number of observations | 96 | | | | |

NS = Not significant at 0.05 level, *, **, significant differences at the 0,05 and 0.01 levels respectively.

Appendix 28: Analysis of variance of % unfilled grains in the direct-seeded lowland rice at Badeggi, 1983-84 dry season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication (R) | 3 | 20.25 | 6.75 | 1.12 | NS |
| Variety (V) | 2 | 5628.00 | 2814.00 | 261.76** | SIG. |
| Error (a) | 6 | 64.50 | 10.75 | 1.78 | |
| Total | 11 | 5692.50 | 517.50 | 85.96 | |
| Sub-plot | | | | | |
| Weed control treatments (W) | 7 | 1614.66 | 230.66 | 38.31** | SIG. |
| V x W | 14 | 441.33 | 31.52 | 5.23** | SIG. |
| Error (b) | 63 | 379.25 | 6.02 | | |
| Total | 84 | 2435.25 | 28.99 | | |
| Grand total | 95 | 8148.00 | | | |
| Grand mean | 21.25 | | | | |
| Total number of observations | 96 | | | | |

NS = Not significant at 0.05 level, *,**, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 29: Analysis of variance of 1000 grain weight (g) in the direct-seeded lowland rice at Badeggi, 1983 wet season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication (R) | 3 | 3.54 | 1.18 | 1.34 | NS |
| Variety (V) | 2 | 14.17 | 7.09 | 8.10** | SIG. |
| Error (a) | 6 | 5.25 | 0.88 | | |
| Total | 11 | 19.42 | 1.76 | 6.30 | |
| Sub-plot | | | | | |
| Weed control treatments (W) | 7 | 3.38 | 0.48 | 1.72 | NS |
| V x W | 14 | 4.23 | 0.30 | 1.08 | NS |
| Error (b) | 63 | 17.56 | 0.28 | | |
| Total | 84 | 25.17 | | | |
| Grand Total | 95 | 48.13 | | | |
| Grand Mean | 29.03 | | | | |
| Total number of observations | 96 | | | | |

NS = Not significant at 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 30: Analysis of variance of 1000 grain weight (g) in the direct-seeded lowland rice at Badeggi, 1983-84 dry season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication (R) | 3 | 0.04 | 0.01 | 0.08 | NS |
| Variety (V) | 2 | 3.86 | 1.93 | 57.90** | SIG. |
| Error (a) | 6 | 0.20 | 0.03 | | |
| Total | 11 | 4.06 | 0.37 | 0.72 | |
| Sub-plot | | | | | |
| Weed control treatments (W) | 7 | 0.67 | 0.096 | 1 | NS |
| V x W | 14 | 0.74 | 0.053 | 1 | NS |
| Error (b) | 63 | 32.36 | 0.51 | | |
| Total | 84 | | | | |
| Grand total | 95 | 37.87 | | | |
| Grand mean | 29.78 | | | | |
| Total number of observations | 96 | | | | |

NS = Not significant at 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 31: Analysis of variance of grain yield in the direct-seeded lowland rice at Badeggi, 1983 wet season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication (R) | 3 | 5.20 | 1.73 | 11.81** | SIG. |
| Variety (V) | 2 | 10.39 | 5.19 | 17.71** | SIG. |
| Error (a) | 6 | 1.76 | 0.29 | 1.99 | |
| Total | 11 | 12.15 | 1.10 | 7.89 | |
| Sub-plot | | | | | |
| Weed control treatments (W) | 7 | 283.58 | 40.51 | 276.01** | SIG. |
| V x W | 14 | 7.20 | 0.51 | 3.50** | SIG. |
| Error (b) | 63 | 9.24 | 0.14 | | |
| Total | 84 | 300.03 | 3.51 | | |
| Grand total | 95 | 317.39 | | | |
| Grand mean | 3.11 | | | | |
| Total number of observations | 96 | | | | |

NS = Not significant at 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 32: Analysis of variance of grain yield in the direct-seeded lowland rice at Badeggi, 1983-84 dry season

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication (R) | 3 | 2.91 | 0.97 | 8.8** | SIG. |
| Variety (V) | 2 | 7.97 | 3.98 | 34.00** | SIG. |
| Error (a) | 6 | 0.70 | 0.11 | 1.07 | |
| Total | 11 | 8.68 | 0.79 | 7.89 | |
| Sub-plot | | | | | |
| Weed control treatments (W) | 7 | 192.86 | 26.12 | 238.33** | SIG. |
| V x W | 14 | 7.23 | 0.51 | 4.71** | SIG. |
| Error (b) | 63 | 6.90 | 0.10 | | |
| Total | 84 | 197.00 | 2.34 | | |
| Grand total | 95 | 208.60 | | | |
| Grand mean | 2.97 | | | | |
| Total number of observations | 96 | | | | |

NS = Not significant at 0.05 level, *, **, significances at the 0.05 and 0.10 levels respectively.

Appendix 33: Analysis of variance of % weed coverage at 4WAH[1] in the direct-seeded lowland rice at Badeggi, 1983 wet season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication (R) | 3 | 5.25 | 1.75 | 1.44 | NS |
| Variety (V) | 2 | 65.33 | 32.66 | 19.12** | SIG. |
| Error (a) | 6 | 10.25 | 1.70 | 1.40 | |
| Total | 11 | 75.58 | 6.87 | 5.67 | |
| Sub-plot | | | | | |
| Weed control treatments (W) | 7 | 81583.33 | 11654.767 | 9598.03** | SIG. |
| V x W | 14 | 390.65 | 27.90 | 22.98** | SIG. |
| Error (b) | 63 | 76.50 | 1.21 | | |
| Total | 84 | 82090.50 | 976.79 | | |
| Grand total | 95 | 82131.33 | | | |
| Grand mean | 24.58 | | | | |
| Total number of observations | 96 | | | | |

1. Weeks after herbicide application

NS = Not significant 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 34: Analysis of variance of % weed coverage at four weeks after herbicide application in the direct-seeded lowland rice at Badeggi 1983-84 dry season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication (R) | 3 | 3.58 | 1.19 | 1.67 | NS |
| Variety (V) | 2 | 547.0 | 273.50 | 1156.35** | SIG. |
| Erro (a) | 6 | 1.41 | 0.23 | 0.33 | |
| Total | 11 | 548.41 | 49.85 | 70.21 | |
| Sub-plot | | | | | |
| Weed control treatments (W) | 7 | 90022.5 | 12860.35 | 18004.5** | SIG. |
| V x W | 14 | 509.0 | 36.35 | 50.9** | SIG. |
| Error (b) | 63 | 45.0 | 0.71 | | |
| Total | 84 | 90576.5 | 1078.29 | | |
| Grand Total | 95 | 91128.5 | | | |
| Grand mean | 19.6 | | | | |
| Total number of observations | 96 | | | | |

NS = Not significant at 0.05 level, *, **, significant differences at 0.05 and 0.01 levels respectively.

Appendix 35: Analysis of variance of % weed coverage at eight weeks after herbicide application in the direct-seeded lowland rice at Badeggi 1983 wet season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| **Main-plot** | | | | | |
| Replication (R) | 3 | 3.70 | 1.23 | 0.95 | NS |
| Variety (V) | 2 | 126.58 | 63.29 | 57.01** | SIG. |
| Error (a) | 6 | 5.66 | 0.94 | 0.72 | |
| Total | 11 | 132.25 | 12.02 | 9.31 | |
| **Sub-plot** | | | | | |
| Weed control treatments (W) | 7 | 87283.29 | 12469.84 | 9623.88** | SIG. |
| V x W | 14 | 234.08 | 15.72 | 12.90** | SIG. |
| Error (b) | 63 | 81.62 | 1.29 | | |
| Total | 84 | 87599.00 | 1042.84 | | |
| Grand total | 95 | 87734.95 | | | |
| Grand mean | 21.77 | | | | |
| Total number of observations | 96 | | | | |

NS = Not significant at 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 36: Analysis of variance of % weed coverage at eight weeks after herbicide application in the direct-seeded lowland rice at Badeggi, 1983-84 dry season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication (R) | 3 | 11.91 | 3.97 | 1.75 | NS |
| Variety (V) | 2 | 313.00 | 156.50 | 158.17** | SIG. |
| Error (a) | 6 | 5.58 | 0.93 | 0.41 | |
| Total | 11 | 318.58 | 23.96 | 12.80 | |
| Sub-plot | | | | | |
| Weed control treatments (W) | 7 | 78621.16 | 11231.59 | 4965.54** | SIG. |
| V x W | 14 | 524.33 | 37.45 | 16.55** | SIG. |
| Error (b) | 63 | 142.50 | 2.26 | | |
| Total | 84 | 79288.00 | 943.98 | | |
| Grand total | 95 | 79618.50 | | | |
| Grand mean | 27.88 | | | | |
| Total number of observations | 96 | | | | |

NS= Not significant at 0.05 level, *, **, significant differences at 0.05 and 0.01 levels respectively.

Appendix 37: Analysis of variance of % weed coverage at maturity in the direct-seeded lowland rice at Badeggi, 1983 wet season

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F8 | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication (R) | 3 | 7.58 | 2.52 | 1.76 | NS |
| Variety (V) | 2 | 60.33 | 30.16 | 18.25** | SIG. |
| Error (a) | 6 | 9.91 | 1.69 | 1.15 | |
| Total | 11 | 70.25 | 6.38 | 4.46 | |
| Sub-plot | | | | | |
| Weed control treatments (W) | 7 | 93094.50 | 13299.21 | 9258.01** | SIG. |
| V x W | 14 | 153.00 | 10.92 | 7.50** | SIG. |
| Error (b) | 63 | 90.50 | 1.43 | | |
| Total | 84 | 93338.00 | 1111.16 | | |
| Grand Total | 95 | 93415.83 | 11 | | |
| Grand mean | 18.29 | | | | |
| Total number of observations | 96 | | | | |

NS = Not significant at the 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 38: Analysis of variance of % weed coverage at maturity in the direct-seeded lowland rice at Badeggi, 1983-84 dry season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication (R) | 3 | 13.54 | 4.51 | 0.34 | NS |
| Variety (V) | 2 | 1.75 | 0.87 | 0.14 | NS |
| Error (a) | 6 | 36.58 | 6.10 | 0.46 | |
| Total | 11 | 38.33 | 3.48 | 0.26 | |
| Sub-plot | | | | | |
| Weed control treatments (W) | 7 | 75734.96 | 10819.28 | 816.32** | SIG. |
| V x W | 14 | 586.92 | 41.92 | 3.16* | SIG. |
| Error (b) | 63 | 834.88 | 13.25 | | |
| Total | 84 | 77156.75 | 918.53 | | |
| Grand total | 95 | 77208.62 | | | |
| Grand mean 41% | | | | | |

NS = Not significant at 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 39: Analysis of variance of dry-weight of grasses at harvest in the direct-seeded lowland rice at Badeggi, 1983-84 dry season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-Plot | | | | | |
| Replication (R) | 3 | 33920.5 | 11306.9 | 21.18** | SIG. |
| Variety (V) | 2 | 16839.8 | 8419.9 | 25.53** | SIG. |
| Error (a) | 6 | 1978 | 329.8 | 0.51 | |
| Total | 11 | 18818.5 | 1710.77 | 3.20 | |
| Sub-plot | | | | | |
| Weed control treatments (W) | 7 | 1122001.6 | 160285.9 | 300.29** | SIG. |
| V x W | 14 | 143529.7 | 10252.1 | 19.20** | SIG. |
| Error (b) | 63 | 33627.2 | 533.8 | | |
| Total | 84 | 1299158.4 | 15466.2 | | |
| Grand Total | 95 | 1331897.5 | | | |
| Grand Mean | 118.9 | | | | |
| Total number of observations | 96 | | | | |

NS = Not significant at 0.05 level; *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 40: Analysis of variance of dry weight of grasses at harvest at Badeggi, 1983 wet season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication (R) | 3 | 1359.35 | 453.12 | 15.49** | SIG. |
| Variety (V) | 2 | 2265.54 | 1132.77 | 21.91** | SIG. |
| Error (a) | 6 | 310.21 | 51.70 | 1.76 | |
| Total | 11 | 2575.74 | 234.15 | 8.0 | |
| Sub-plot | | | | | |
| Weed control treatments (W) | 7 | 402256.06 | 57463.15 | 1965.28** | SIG. |
| V x W | 14 | 5264.59 | 376.04 | 12.86** | SIG. |
| Error (b) | 63 | 1842.12 | 29.24 | | |
| Total | 84 | 409362.77 | 4873.37 | | |
| Grand Total | 95 | 413297.87 | | | |
| Grand Mean | 40.62 | | | | |
| Total number of observations | 96 | | | | |

NS = Not significant at 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 41: Analysis of variance of dry weight of broadleaved weeds at harvest at Badeggi, 1983 wet season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication (R) | 3 | 2652.13 | 884.04 | 30.59** | SIG. |
| Variety (V) | 2 | 166.61 | 83.30 | 0.56 | NS |
| Error (a) | 6 | 747.67 | 124.61 | 4.312 | |
| Total | 11 | 914.28 | 83.11 | 2.87 | |
| Sub-plot | | | | | |
| Weed control treatments (W) | 7 | 58300.24 | 8328.61 | 288.19** | SIG. |
| V x W | 14 | 8331.17 | 595.08 | 20.59** | SIG. |
| Error (b) | 63 | 1820.65 | 28.98 | | |
| Total | 84 | 68452.07 | 814.94 | | |
| Grand mean | 30.21 | | | | |
| Total number of observations | 96 | | | | |

NS = Not significant at 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 42: Analysis of variance of dry weight of broad-leaved weeds at harvest in the direct-seeded lowland rice at Badeggi, 1983-84 dry season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication (R) | 3 | 324.15 | 108.05 | 9.61** | SIG. |
| Variety (V) | 2 | 812.19 | 406.09 | 14.32** | SIG. |
| Error (a) | 6 | 170.06 | 28.34 | | |
| Total | 11 | 982.25 | 89.29 | | |
| Sub-plot | | | | | |
| Weed control treatments (W) | 7 | 1457.08 | 216.15 | 18.53** | SIG. |
| V x W | 14 | 1438.99 | 102.78 | 9.15** | SIG. |
| Error (b) | 63 | 707.71 | 11.23 | | |
| Total | 84 | 3603.77 | 42.98 | | |
| Grand Total | 95 | 4910.17 | | | |
| Grand mean | 4.06 | | | | |
| Total number of observations | 96 | | | | |

NS = Not significant at 0.05 level, *, **, significant differences at 0.05 and 0.01 levels respectively.

Appendix 43. Analysis of variance of dry weight of sedges at harvest at Badeggi, 1983 wet season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication (R) | 3 | 11917.2 | 3972.4 | 8.98** | SIG. |
| Variety (V) | 2 | 6094.4 | 3047.2 | 9.97** | SIG. |
| Error (a) | 6 | 1833.0 | 305.5 | 0.69 | |
| Total | 11 | 7927.4 | 720.67 | 2.97 | |
| Sub-plot | | | | | |
| Weed control treatments (W) | 7 | 266854.0 | 29550.0 | 66.86** | SIG. |
| V x W | 14 | 8961.8 | 840.1 | 1.86* | SIG. |
| Error (b) | 63 | 27843.0 | 242.0 | | |
| Total | 84 | 243658.8 | 2900.7 | | |
| Grand Total | 95 | 263503.4 | | | |
| Grand Mean | 28.0 | | | | |
| Total number of observations | 96 | | | | |

NS = Not significant at the 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 44: Analysis of variance of dry weight of sedges at harvest in the direct-seeded lowland rice at Badeggi 1983-84 dry season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication (R) | 3 | 23.87 | 7.96 | 0.537 | NS |
| Variety (V) | 2 | 1069.63 | 534.81 | 43.10** | SIG. |
| Error (a) | 6 | 74.44 | 12.41 | 0.83 | SIG. |
| Total | 11 | 1144.07 | 104.00 | 6.99 | |
| Sub-plot | | | | | |
| Weed control treatments (W) | 7 | 37406.96 | 5343.85 | 360.97** | |
| V x W | 14 | 12162.85 | 858.78 | 58.68** | SIG. |
| Error (b) | 63 | 932.64 | 14.88 | | |
| Total | 84 | 50502.46 | 601.22 | | |
| Grand total | 95 | 51670.40 | | | |
| Grand mean | 19.10 | | | | |
| Total number of observations | 96 | | | | |

NS = Not significant at 0.05 level, *, **, significant differences at 0.05 and 0.01 levels respectively.

Appendix 45: Analysis of variance of dry weed weight at 30 days after herbicide application at Badeggi 1983 wet season.

| Source of variation 45 | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication (R) | 3 | 16171.9 | 5390.6 | 7.26** | SIG. |
| Variety (V) | 2 | 5818.5 | 2909.2 | 9.97** | SIG. |
| Error (a) | 6 | 1750.7 | 291.8 | 0.39 | |
| Total | 11 | 7569.2 | 688.10 | 0.92 | |
| Sub-plot | | | | | |
| Weed control treatments (W) | 7 | 4122030.0 | 588861.4 | 793.91** | SIG. |
| V x W | 14 | 25017.6 | 1787.0 | 2.40* | SIG. |
| Error (b) | 63 | 46728.6 | 741.7 | | |
| Total | 84 | 4193776.1 | 49925.9 | | |
| Grand Total | 95 | 4217517.2 | | | |
| Grand Mean | 148.5 | | | | |
| Total number of observations | 96 | | | | |

NS = Not significant at the 0.05 level; *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 46: Analysis of variance of weed dry weight at 30 days after herbicide application in the 1983-84 dry season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication (R) | 3 | 3958.6 | 1319.5 | 2.09 | NS. |
| Variety (V) | 2 | 738.5 | 369.3 | 0.58 | NS |
| Error (a) | 6 | 3805.3 | 634.2 | 1.00 | |
| Total | 11 | 4543.8 | 413.07 | 0.77 | |
| Sub-plot | | | | | |
| Weed control treatments (W) | 7 | 698660.1 | 99808.6 | 158.36** | SIG. |
| V x W | 14 | 2565.4 | 183.2 | 0.29 | NS |
| Error (b) | 63 | 89705.4 | 530.2 | | |
| Total | 84 | 740931.0 | 8820.6 | | |
| Grand Total | 95 | 749433.4 | | | |
| Grand Mean | 77.6 | | | | |
| Total number of observations | 96 | | | | |

NS = Not significant at 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 47: Analysis of variance of weed dry weight at 60 days after herbicide application at Badeggi, 1983 wet season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| **Main-plot** | | | | | |
| Replication (R) | 3 | 24048 | 8016 | 2.18 | NS |
| Variety (V) | 2 | 10228 | 5114 | 1.06 | NS |
| Error (a) | 6 | 28945 | 4824 | 1.32 | |
| Total | 11 | 39173 | 3561.18 | 0.97 | |
| Sub-plot | | | | | |
| Weed control treatments (W) | 7 | 2878904 | 411272 | 112.07** | SIG. |
| V x W | 14 | 21961 | 1569 | 0.43 | NS |
| Error (b) | 63 | 231188 | 3670 | | |
| Total | 84 | 3132053 | 37286 | | |
| Grand Total | 95 | | | | |
| Grand Mean | 115.2/$m^2$ | | | | |
| Total number of observations | 96 | | | | |

NS = Not significant at 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 48: Analysis of variance of weed dry weight at 60 days after herbicide application in the direct-seeded lowland rice at Badeggi, 1983-84.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication (R) | 3 | 73838 | 24613 | 15.47** | SIG. |
| Variety (V) | 2 | 3101 | 1550 | 4.58* | SIG. |
| Error (a) | 6 | 2027 | 338 | 0.21 | |
| Total | 11 | 5128 | 466.18 | 0.29 | |
| Sub-plot | | | | | |
| Weed control treatments (W) | 7 | 1837644 | 262521 | 155.03** | SIG. |
| V x W | 14 | 11404 | 815 | 0.51 | NS |
| Error (b) | 63 | 100213 | 1591 | | |
| Total | 84 | 1949251 | 23205 | | |
| Grand Total | 95 | 2028227 | | | |
| Grand Mean | 136.2 | | | | |
| Total number of observations | 96 | | | | |

NS + Not significant at 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 49: Analysis of variance of weed dry weight at harvest at Badeggi, 1983 wet season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication (R) | 3 | 43805 | 14602 | 13.32** | SIG. |
| Variety (V) | 2 | 9016 | 44508 | 7.81** | SIG. |
| Error (a) | 6 | 3463 | 577 | 0.52 | |
| Total | 11 | 12479 | 1134.45 | 1.03 | |
| Sub-plot | | | | | |
| Weed control treatments (W) | 7 | 1654821 | 236403 | 215.66** | SIG. |
| V x W | 14 | 11703 | 836 | 0.76 | NS |
| Error (b) | 63 | 69058 | 1096 | | |
| Total | 84 | 1735582 | 20662 | | |
| Grand Total | 95 | 1791666 | | | |
| Grand Mean | 97.7 | | | | |
| Total number of observations | 96 | | | | |

NS = Not significant at 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 50: Analysis of variance of weed dry weight at harvest in the direct-seeded lowland rice at Badeggi, 1983-84 dry season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication (R) | 3 | 42573.7 | 14191.2 | 23.21** | SIG. |
| Variety (V) | 2 | 10566.8 | 5283.4 | 12.83** | SIG. |
| Error (a) | 6 | 2470.3 | 411.7 | 0.67 | |
| Total | 11 | 13637.1 | 1239.73 | 2.02 | |
| Sub-plot | | | | | |
| Weed control treatments (W) | 7 | 1534294.5 | 219184.9 | 358.59** | SIG. |
| V x W | 14 | 107216.7 | 7658.3 | 12.52** | SIG. |
| Error (b) | 63 | 38507.9 | 611.2 | | |
| Total | 84 | 1580019.1 | 20000.2 | | |
| Grand Total | 95 | | | | |
| Grand Mean | 142.5 | | | | |
| Total number of observations | 96 | | | | |

NS = Not significant at 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 51: Analysis of variance of % control of cutgrass at 1 week after herbicide application in the green house at Badeggi 1985 wet season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| **Main-plot** | 3 | 327.85 | 109.30 | 2.1 | NS |
| Herbicide treatments | 11 | 19723.95 | 1793.09 | 34.5** | SIG. |
| Error | 33 | 1715.3 | 51.98 | | |
| Total | 47 | 21967.09 | | | |
| Grand mean 50.75 | | | | | |

Appendix 52: Analysis of variance of % control of cutgrass at 2 weeks after herbicide application in the green house at Badeggi, 1985 wet season.

| Sources of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Replication | 3 | 285.13 | 95.04 | 2.6* | SIG. |
| Herbicide treatments | 11 | 18278.88 | 1661.81 | 45.48** | SIG. |
| Error | 33 | 1205.86 | 36.54 | | |
| Total | 47 | 19770.87 | | | |
| Grand mean 44.00 | | | | | |

NS = Not significant at 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 53: Analysis of variance of % control of cutgrass at 4 weeks after herbicide application in the green house at Badeggi, 1985 wet season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Replication | 3 | 1207.13 | 402.35 | 4.06* | SIG. |
| Herbicide treatments | 11 | 25348.19 | 2304.38 | 16.26** | SIG. |
| Error | 33 | 4695.30 | 142.28 | | |
| Total | 47 | 31250.71 | | | |
| Grand mean 51.96 | | | | | |



Appendix 54: Analysis of variance of % control of cutgrass at 8 weeks after herbicide application in the greenhouse at Badeggi, 1985 wet season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Replication | 3 | 468.86 | 156.29 | 2.0 | NS |
| Herbicide treatments | 11 | 25499.65 | 2319.15 | 29.15** | SIG. |
| Error | 33 | 2624.23 | 79.52 | | |
| Total | 47 | 28592.73 | | | |
| Grand Mean 70.08 | | | | | |

NS = Not significant at 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 55: Analysis of variance of % control of cutgrass at 12 weeks after herbicide application in the green house at Badeggi 1985 wet season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Replication | 3 | 481.32 | 160.44 | 1.03 | NS |
| Herbicide treatments | 11 | 22554.71 | 2054.07 | 13.20** | SIG. |
| Error | 33 | 5437.94 | 155.7 | | |
| Total | 47 | 28213.97 | | | |
| Grand mean 51.12 | | | | | |



Appendix 56: Analysis of variance of tiller number of cutgrass per pot at 30 days after herbicide application in the greenhouse at Badeggi 1985 wet season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Replication | 3 | 22084.83 | 7361.60 | 2.83 | NS |
| Herbicide treatments | 11 | 177574.0 | 16143.07 | 5.7** | SIG. |
| Error | 33 | 85607.16 | 2594.15 | | |
| Total | 47 | 285266.00 | - | | |
| Grand mean 179.18 | | | | | |

NS = Not significant at 0.05 level, *, **, sigificant differences at the 0.05 and 0.01 levels respectively.

Appendix 57: Analysis of variance of tiller number of cutgrass per pot at 60 days after herbicide application in the greenhouse at Badeggi, 1985 wet season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Replication | 3 | 64782.56 | 21594.18 | 1.92 | NS |
| Herbicide treatments | 11 | 1031734.10 | 933794.00 | 8.34** | SIG. |
| Error | 33 | 370798.69 | 11236.32 | - | |
| Total | 47 | 1467315.30 | - | | |

Grand Mean = 52.5



Appendix 58: Analysis of variance of plant height (cm) of cutgrass at 30 days after herbicide application in the greenhouse at, Badeggi, 1985 wet season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Replication | 3 | 3259.97 | 1086.65 | 4.05 | SIG. |
| Herbicide treatments | 11 | 105662.98 | 9685.7 | 35.83** | SIG. |
| Error | 33 | 8846.39 | 268.07 | - | |
| Total | 47 | 117769.35 | - | | |

Grand Mean = 51.70

NS = Not significant at 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 59: Analysis of variance of plant height (cm) at 60 days after herbicide application in the greenhouse at Badeggi, 1985 wet season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Replication | 3 | 15288.75 | 5096.25 | 10.60 | SIG. |
| Herbicide treatments | 11 | 149085.92 | 13553.26 | 103.35** | SIG. |
| Error | 33 | 47603.25 | 1442.52 | | |
| Grand Mean 111.79 | | | | | |

Appendix 60: Analysis of variance of tiller number per pot at harvest in the greenhouse at Badeggi, 1985 wet season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Replication | 3 | 91899 | 30633 | 0.56 | NS |
| Herbicide treatments | 11 | 897462.67 | 81587.5 | 1.51 | NS |
| Error | 33 | 17754.56 | 59148.5 | | |
| Total | 47 | 2764817.7 | | | |
| Grand Mean 223.33 | | | | | |

NS = Not significant at 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 61. Analysis of variance of plant height (cm) at harvest in the greenhouse at Badeggi, 1985 wet season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Replication | 3 | 41286.56 | 13762.88 | 9.31** | SIG. |
| Herbicide treatments | 11 | 134594.73 | 12235.88 | 8.28** | SIG. |
| Error | 33 | 48748.68 | 1477.23 | | |
| Grand mean 136.52 | | | | | |

Appendix 62: Analysis of variance of shoot dry weight of cutgrass (g/pot) in the greenhouse at Badeggi, 1985 wet season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Replication | 3 | 4198.05 | 1399.35 | 0.57 | NS |
| Herbicide treatments | 11 | 175156.43 | 15923.3 | 6.53** | SIG. |
| Error | 33 | 80383.38 | 2435.86 | | |
| Total | 47 | 259737.87 | | | |
| Grand mean | | | | | |

NS = Not significant at 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 63: Analysis of variance of root dry weight of cutgrass (g/pot) in the greenhouse at Badeggi, 1985 wet season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Replication | 3 | 164402.02 | 54800.67 | 19.94** | SIG. |
| Herbicide treatments | 11 | 186465.43 | 16951.40 | 6.17 | SIG. |
| Error | 33 | 90689.67 | 2748.71 | | |
| Total | 47 | 441557 | - | | |

Grand mean 167.55g/pot

Appendix 64: Analysis of variance of rhizome dry weight of cutgrass (g/pot), in the greenhouse at Badeggi, 1985 wet season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Replication | 3 | 180.56 | 60.19 | 1.0 | NS |
| Herbicide treatments | 11 | 2012.73 | 182.98 | 3.04** | SIG. |
| Error | 33 | 1984.19 | 60.13 | | |
| Total | 47 | 4177.48 | | | |

Grand mean = 15.75

NS = Not significant at 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 65: Analysis of variance of outgrass dry weight at 60 FAH in the direct seeded lowland rice at Badeggi, 1983-86 dry season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication | 2 | 163.93 | 81.97 | 1.49 | NS |
| Glyphosate | 2 | 4181.12 | 2090.56 | 153.01** | SIG. |
| Error (a) | 4 | 51.30 | 12.82 | 0.23 | |
| Total | 8 | 4232.42 | 329.05 | 12.89 | |
| Sub-plot | | | | | |
| Oxadiazon | 1 | 487.49 | 487.49 | 3.89 | NS |
| Glyphosate x oxadiazon | 2 | 63.83 | 31.92 | 0.25 | NS |
| Error (b) | 6 | 751.19 | 125.20 | 2.28 | |
| Total | 9 | 1302.51 | 144.72 | 2.64 | |
| Sub-sub-plot | | | | | |
| Sub-sub-plot treatment (Post emergence herbicide) | 7 | 26151.73 | 3735.96 | 68.28** | SIG. |
| Glyposate x sub treatment | 14 | 1383.88 | 98.85 | 1.80 | NS |
| Oxadiazon x sub-sub treatment | 17 | 368.76 | 52.68 | 0.96 | NS |
| Glyphosate x oxadiazon x sub sub treatment | 14 | 853.63 | 60.97 | 1.11 | NS |
| Error (c) | 84 | 4595 | 54.71 | | |
| Total | 126 | 33353.59 | 264.71 | | |
| Grand total | 143 | 39052.45 | | | |
| Total number 27.72 | | | | | |
| Total number of observations | 144 | | | | |

NS = Not significant at the 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.
DAH = Days after herbicide application.

Appendix 66: Analysis of variance of cutgrass weight/0.5m$^2$ at 30 days after herbicide application in the direct-seeded lowland rice at Badeggi, 1986 wet season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| **Main-plot** | | | | | |
| Replication | 2 | 261.1 | 130.5 | 0.83 | NS |
| Glyphosate | 2 | 6492.8 | 3216.4 | 50.11** | SIG. |
| Error (a) | 4 | 216.0 | 54.0 | 0.34 | |
| Total | 8 | 6708.8 | 838.6 | 5.38 | |
| **Sub-plot** | | | | | |
| Oxadiazon | 1 | 6986.2 | 6986.2 | 51.84** | SIG. |
| Glyphosate x **oxadiazon** | 2 | 1980.7 | 998.3 | 7.34* | SIG. |
| Error (b) | 6 | 808.6 | 134.8 | 0.86 | |
| Total | 9 | 7775.4 | 1086.2 | 6.98 | |
| **Sub sub plot** | | | | | |
| Sub sub treatments (Post emergence herbicides) | 7 | 12735.7 | 1819.4 | 11.69** | **SIG** |
| Glyphosate x sub sub treatments (Post emergence) | 14 | 662.7 | 47.3 | 0.20 | |
| Oxadiazon x sub sub treatments (Post emergence) | 7 | 621.5 | 88.8 | 0.57 | |
| Glyphosate x oxadiazon x Post emergence | 14 | 544.8 | 38.9 | 0.25 | |
| Error (c) | 84 | 13069.7 | 155.6 | | |
| Total | 126 | 27634.14 | 219.3 | | |
| Grand Total | 143 | 44379.7 | | | |
| Grand mean 30.7 | | | | | |
| Total number of observations | 144 | | | | |

NS = Not significant at 0.05 level, *, **, **significant differences** at the 0.05 and 0.01 levels respectively.

Appendix 67: Analysis of variance of cutgrass dry weight/0.5m$^2$ at 60 days after herbicide application in the direct-seeded lowland rice at Badeggi, 1986 wet season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication | 2 | 2199.8 | 1099.9 | 8.02* | SIG |
| Glyphosate | 2 | 12302.4 | 6151.2 | 3.01 | NS |
| Error (a) | 4 | 8149.0 | 2037.3 | 14.86 | |
| Total | 8 | 20451.4 | 2556.42 | 18.64 | |
| Sub-plot | | | | | |
| Oxadiazon | 1 | 4466.7 | 4466.7 | 38.09** | SIG. |
| Glyphosate x Oxadiazon | 2 | 231.7 | 115.8 | 0.98 | NS |
| Error (b) | 6 | 703.5 | 117.2 | 0.85 | |
| Total | 9 | 5401.8 | 600.2 | 4.27 | |
| Sub sub plot | | | | | |
| Sub sub treatments (Post emergence herbicides) | 7 | 5491.7 | 784.5 | 5.72** | SIG. |
| Glyphosate x Sub sub treatments (Post emergence) | 14 | 8419.8 | 501.4 | 4.30** | SIG. |
| Oxadiazon x Sub sub treatments (Post emergence) | 7 | 4511.7 | 644.5 | 4.70** | SIG. |
| Glyphosate x Oxadiazon x Post emergence | 14 | 13404.2 | 957.4 | 6.98** | SIG. |
| Error (c) | 84 | 11515.1 | 137.1 | | |
| Total | 126 | 43342.4 | 344.0 | | |
| Grand total | 143 | 71395.4 | | | |
| Grand mean 23.9 | | | | | |
| Total number of observations | 144 | | | | |

NS = Not significant at 0.05 level, **, significant differences at the 0.05 and 0.01 respectively.

Appendix 68: Analysis of variance of cutgrass dry weight/0.5m$^2$ at 60 days after herbicide application in the direct-seeded lowland rice at Badeggi, 1986-87 dry season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication | 2 | 154.58 | 77.29 | 2.17 | NS |
| Glyphosate | 2 | 20247.04 | 10123.52 | 107.71** | SIG. |
| Error (a) | 4 | 375.94 | 93.99 | 2.63 | |
| Total | 8 | 20622.98 | 2577.87 | 72.39 | |
| Sub-plot | | | | | |
| Oxadiazon | 1 | 1051.76 | 1051.76 | 36.58** | SIG. |
| Glyphosate x oxadiazon | 2 | 4.22 | 2.11 | 0.07 | NS |
| Error (b) | 6 | 172.51 | 28.75 | 0.01 | |
| Total | 9 | 1225.49 | 136.50 | 3.83 | |
| Sub sub plot | | | | | |
| Sub-sub treatments (Post emergence herbicides) | 7 | 12127.89 | 1732.56 | 48.65** | SIG. |
| Glyphosate x sub-sub treatments (Post emergence) | 14 | 3026.74 | 216.20 | 6.07** | SIG. |
| Oxadiazon x sub-sub treatments (Post emergence) | 7 | 141.33 | 20.19 | 0.56 | NS |
| Glyphosate x oxadiazon x sub-sub-treatments | 14 | 2991.23 | 35.61 | | |
| Error (c) | 84 | 18744.38 | 148.76 | | |
| Total | 126 | 18744.38 | 148.76 | | |
| Grand total | 143 | 40750.43 | | | |
| Grand mean 21.10 | | | | | |
| Total number of observations | 144 | | | | |

NS = Not significant at 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 69: Analysis of variance of % coverage of cutgrass at 30 days after herbicide application in the direct-seeded lowland rice at Badeggi, 1986 wet season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication | 2 | 6807.7 | 3403.9 | 0.4** | SIG. |
| Glyphosate | 2 | 19552.7 | 9776.4 | 4.4 | NS |
| Error (a) | 4 | 8790.0 | 2197.5 | 6.0 | |
| Total | 8 | 28342.7 | 3542.83 | 10.16 | |
| Sub-plot | | | | | |
| Oxadiazon | 1 | 6214.7 | 6214.7 | 6.84** | SIG. |
| Glyphosate x oxadiazon | 2 | 4317.7 | 2158.9 | 2.37 | NS |
| Error (b) | 6 | 5451.1 | 908.5 | 2.51 | NS |
| Total | 9 | 15983.5 | 1775.9 | 4.91 | NS |
| Sub-sub-plot | | | | | |
| Sub-sub-plot treatments(Post emergence herbicides) | 7 | 33320.9 | 4788.7 | 13.25** | SIG. |
| Glyphosate x Sub-sub-treatments (Post emergence) | 14 | 6869.3 | 490.7 | 1.35 | NS |
| Oxadiazon x Sub-sub treatments (Post emergence) | 7 | 7943.5 | 1134.8 | 3.14** | SIG. |
| Glyphosate x oxadiazon x Post emergence | 14 | 4878.7 | 348.5 | 0.96 | NS. |
| Error (c) | 84 | 30349.8 | 361.3 | | |
| Total | 126 | 83562.2 | 663.2 | | |
| Grand total | 143 | 134696.2 | | | |
| Total mean 30.1 | | | | | |
| Total number of observations | 144 | | | | |

NS = Not significant at the 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels, respectively.

Appendix 70: Analysis of variance of % outgrass coverage at 60 days after herbicide application in the direct-seeded lowland rice at Badeggi, 1985-86 dry season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication | 2 | 952.43 | 476.22 | 5.16 | NS |
| Glyphosate | 2 | 8795.43 | 4397.72 | 41.80** | SIG. |
| Error (a) | 4 | 420.82 | 105.20 | 1.11 | |
| Total | 8 | 9216.25 | 3542.83 | 10.16 | |
| Sub-plot | | | | | |
| Oxadiazon | 1 | 309.17 | 309.17 | 5.19 | NS |
| Glyphosate x Oxadiazon | 2 | 720.18 | 360.09 | 6.05* | |
| Error (b) | 6 | 357.08 | 59.51 | 0.63 | |
| Total | 9 | 1366.44 | 154.05 | 1.63 | |
| Sub-sub plot | | | | | |
| Sub-sub treatments (Post emergence) | 7 | 68840.38 | 9834.34 | 104.63** | SIG. |
| Glyphosate x Sub-sub treatments (Post emergence) | 14 | 7566.68 | 540.48 | 5.75** | SIG. |
| Oxadiazon x Sub-sub treatments (Post emergence) | 7 | 217.88 | 31.13 | 0.33 | NS |
| Glyphosate x Oxadiazon x Sub-sub treatment (Post emergence) | 14 | 951.93 | 68.00 | 0.72 | NS |
| Error (c) | 84 | 7895.00 | 93.99 | | |
| Total | 126 | 85471.87 | 678.35 | | |
| Grand total | 143 | 97026.99 | | | |
| Grand mean 21.12 | | | | | |
| Total number of observations | 144 | | | | |

NS = Not significant at the 0.05 level, *, **, significant differences at the 0.05 and 0.01 level respectively.

Appendix 71: Analysis of variance of % converage of cutgrass at 60 days after herbicide application in the direct-seeded lowland rice at Badeggi, 1986 wet season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication | 2 | 7492.8 | 3746.4 | 24.36** | SIG. |
| Glyphosate | 2 | 23224.3 | 11612.2 | 2.73 | NS |
| Error (a) | 4 | 17016.9 | 4254.2 | 27.66 | |
| Total | 8 | 40241.3 | 5030.16 | 56.32 | |
| Sub-plot | | | | | |
| Oxadiazon | 1 | 8025.2 | 8025.2 | 18.88** | SIG. |
| Glyphosate x Oxadiazon | 2 | 234.4 | 117.2 | 0.27 | NS |
| Error (b) | 6 | 2549.5 | 424.9 | 2.76 | |
| Total | 9 | 10809.1 | 1201.0 | 7.81 | |
| Sub-sub plot | | | | | |
| Sub-sub-treatments (Post emergence herbicides) | 7 | 24502.1 | 3500.3 | 22.76** | SIG. |
| Glyphosate x Sub-sub treatments (Post emergence) | 14 | 4998.2 | 357.0 | 2.32** | SIG. |
| Oxadiazon x Sub-sub treatments (Post mergence) | 7 | 2709.0 | 387.0 | 2.51* | SIG. |
| Glyphosate x Oxadiazon x Post emergence | 14 | 1250.6 | 89.3 | 0.58 | NS |
| Error (c) | 84 | 12917.5 | 153.8 | | |
| Total | 126 | 46377.4 | 368.1 | | |
| Grand total | 143 | 104920.5 | | | |
| Grand mean 22.8 | | | | | |
| Total number of observations | 144 | | | | |

NS = Not significant at the 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 72: Analysis of variance of % cutgrass coverage at 60 days after herbicide application in the direct-seeded lowland rice at Padeggi, 1986-87.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication | 2 | 1538.89 | 769.44 | 14.72** | SIG. |
| Glyphosate | 2 | 15726.01 | 7853.01 | 10.81** | SIG. |
| Error (a) | 4 | 3895.28 | 773.02 | 14.81 | |
| Total | 8 | 18821.29 | 2352.66 | 45.02 | |
| Sub-plot | | | | | |
| Oxadiazon | 1 | 98.34 | 98.34 | 6.99** | SIG. |
| Glyphosate x Oxadiazon | 2 | 11.26 | 5.63 | 0.40 | NS |
| Error (b) | 6 | 84.33 | 14.06 | 0.26 | |
| Total | 9 | 193.94 | 21.55 | 0.41 | |
| Sub-sub plot | | | | | |
| Sub-sub treatments (Post emergence herbicide) | 7 | 19403.94 | 2771.00 | 53.05** | |
| Glyphosate x Sub-sub treatments (Post emergence) | 14 | 7806.21 | 563.30 | 10.78** | |
| Oxadiazon x Sub-sub treatments (Post emergence) | 7 | 72.49 | 10.36 | 0.19 | NS |
| Glyphosate x Oxadiazon x Sub-sub-treatments) | 14 | 141.40 | 10.10 | 0.19 | NS |
| Error (c) | 84 | 4388.83 | 52.25 | | |
| Total | 126 | 31892.87 | 253.12 | | |
| Grand total | 143 | 52446.99 | | | |
| Grand mean 13.12 | | | | | |
| Total number of observations | 144 | | | | |

NS = Not significant at 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 73: Analysis of variance of plant height (cm) at 28 days after seeding in the direct-seeded lowland rice at Badeggi, 1986 wet season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication | 2 | 29.07 | 14.53 | 1.97 | NS |
| Glyphosate | 2 | 209.96 | 104.98 | 2.91 | NS |
| Error (a) | 4 | 144.18 | 36.04 | 4.88 | |
| Total | 8 | 354.15 | 44.26 | 6.00 | |
| Sub-plot | | | | | |
| Oxadiazon | 1 | 5.04 | 5.04 | 0.10 | NS |
| Glyphosate x **Oxadiazon** | 2 | 125.71 | 62.85 | 1.34 | NS |
| Error (b) | 6 | 280.43 | 46.73 | 0.33 | |
| Total | 9 | 411.19 | 45.68 | 6.19 | |
| Sub sub-plot | | | | | |
| Sub sub-treatments (Post emergence herbicides) | 7 | 286.34 | 40.90 | 5.54** | SIG. |
| Glyphosate x Sub sub treatments (Post emergence) | 14 | 73.64 | 5.36 | 0.71 | NS |
| Oxadiazon x Sub sub-treatments (Post emergence) | 7 | 48.18 | 6.88 | 0.93 | NS |
| Glyphosate x Oxadiazon x Post emergence | 14 | 88.79 | 6.34 | 0.86 | NS |
| Error (c) | 84 | 619.59 | 7.37 | | |
| Total | 126 | 1116.56 | 8.86 | | |
| Grand total | 143 | 1910.98 | | | |
| Grand mean 28.45 | | | | | |
| Total number of observations | 144 | | | | |

NS = Not significant at the 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 74: Analysis of variance of plant height (cm) at 28 days after seeding in the direct-seeded lowland rice at Badeggi 1986-87 dry season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication | 2 | 3.40 | 1.70 | 0.03 | NS |
| Glyphosate | 2 | 53.29 | 26.64 | 12.06** | SIG. |
| Error (a) | 4 | 8.83 | 2.20 | 1.07 | |
| Total | 8 | 62.13 | 7.76 | 3.78 | SIG. |
| Sub-plot | | | | | |
| Oxadiazon | 1 | 9.62 | 9.62 | 5.84** | SIG. |
| Glyphosate x Oxadiazon | 2 | 18.75 | 9.37 | 5.69 | SIG. |
| Error (b) | 6 | 9.87 | 1.64 | 0.80 | |
| Total | 9 | 38.25 | 4.35 | 2.07 | |
| Sub sub-plot | | | | | |
| Sub sub-treatments (Post emergence herbicides) | 7 | 277.83 | 39.69 | 19.25** | SIG. |
| Glyphosate x Sub sub treatments (Post emergence) | 14 | 39.78 | 2.84 | 1.38 | NS |
| Oxadiazon x Sub sub treatments (Post emergence) | 7 | 14.09 | 2.01 | 0.98 | NS |
| Glyphosate x oxadiazon x sub-sub treatments | 14 | 35.99 | 2.57 | 1.25 | NS |
| Error (c) | 84 | 172.22 | 2.05 | | |
| Total | 126 | 539.93 | 4.28 | | |
| Grand total | 143 | 643.72 | | | |
| Grand mean 27.10 | | | | | |
| Total number of observations | 144 | | | | |

NS = Not significant at 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 75: Analysis of variance of plant height (cm) at 56 days after seeding in the direct-seeded lowland rice at Badeggi, 1986 wet season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication | 2 | 4470.2 | 2235.1 | 10.86** | **SIG.** |
| Glyphosate | 2 | 9182.2 | 4591.1 | 6.98* | **SIG.** |
| Error (a) | 4 | 2629.2 | 657.3 | 3.19 | |
| Total | 8 | 11811.5 | 1476.43 | 7.17 | |
| Sub-plot | | | | | |
| Oxadiazon | 1 | 36.5 | 36.5 | 0.07 | NS |
| Glyphosate x Oxadiazon | 2 | 5721.1 | 2860.5 | 6.04** | SIG. |
| Error (b) | 6 | 2841.5 | 473.6 | 2.30 | |
| Total | 9 | 8599.0 | 955.4 | 4.64 | |
| Sub-sub-plot | | | | | |
| Sub sub treatments (Post emergence herbicides) | 7 | 11673.3 | 1667.6 | 8.10** | SIG. |
| Glyphosate x Sub sub treatments (Post emergence) | 14 | 1999.8 | 142.8 | 0.69 | NS |
| Oxadiazon x Sub sub treatments (Post emergence) | 7 | 1351.0 | 193.0 | 0.93 | NS |
| Glyphosate x Oxadiazon x Post emergence | 14 | 3807.3 | 272.0 | 1.32 | NS |
| Error (c) | 84 | 17285.8 | 205.8 | | |
| Total | 126 | 36117.2 | 286.6 | | |
| Grand total | 143 | 60998.0 | | | |
| Grand mean 67.7 | | | | | |
| Total number of observations | 144 | | | | |

NS = Not significant at the 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 76: Analysis of variance of plant height (cm) at 56 days after seeding in the direct-seeded lowland rice at Badeggi, 1986-87 dry season

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication | 2 | 644.0 | 322.0 | 2.53 | NS |
| Glyphosate | 2 | 9163.1 | 4591.6 | 22.55** | SIG. |
| Error (a) | 4 | 814.4 | 203.6 | 1.60 | NS |
| Total | 8 | 9997.5 | 1249.68 | 9.87 | |
| Sub-plot | | | | | |
| Oxadiazon | 1 | 49.2 | 49.2 | 0.22 | NS |
| Glyphosate x Oxadiazon | 2 | 5281.5 | 2640.8 | 11.91** | SIG. |
| Error (b) | 6 | 1329.4 | 221.6 | 1.74 | |
| Total | 9 | 6660.2 | 740.0 | 5.83 | |
| Sub sub plot | | | | | |
| Sub sub treatments (Post emergence herbicides) | 7 | 12284.2 | 1754.9 | 13.83** | SIG. |
| Glyphosate x Sub sub treatments (Post emergence) | 14 | 2017.3 | 201.2 | 1.58 | NS |
| Oxadiazon x Sub sub treatments (Post emergence) | 7 | 688.6 | 898.4 | 0.77 | NS |
| Glyphosate x Oxadiazon x Sub-sub treatments | 14 | 3155.0 | 225.4 | 1.77 | |
| Error (c) | 84 | 10657.8 | 126.9 | | |
| Total | 126 | 29603.0 | 234.9 | | |
| Grand total | 143 | 46904.6 | | | |
| Grand mean 72.06 | | | | | |
| Total number of observations | 144 | | | | |

NS = Not significant at the 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 77: Analysis of variance of plant height (cm) at 98 days after seeding in the direct-seeded lowland rice at Badeggi, 1986 wet season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F. | Significance |
|---|---|---|---|---|---|
| **Main-plot** | | | | | |
| Replication | 2 | 4837.8 | 2418.9 | 10.56** | SIG. |
| Glyphosate | 2 | 5069.2 | 2534.6 | 4.54 | NS |
| Error (a) | 4 | 2230.0 | 557.5 | 2.43 | |
| Total | 8 | 7291.1 | 1249.68 | 9.84 | |
| **Sub-plot** | | | | | |
| Oxadiazon | 1 | 24.4 | 24.4 | 0.09 | NS |
| Glyphosate x Oxadiazon | 2 | 6412.9 | 3206.4 | 12.37** | SIG. |
| Error (b) | 6 | 1554.5 | 259.1 | 1.13 | |
| Total | 9 | 7991.7 | 888.0 | 3.87 | |
| **Sub-sub-plot** | | | | | |
| Sub-sub treatments (Post emergence herbicides) | 7 | 6605.4 | 943.6 | 4.12** | SIG. |
| Glyphosate x Sub-sub treatments (Post emergence) | 14 | 5346.7 | 381.9 | 1.66 | NS |
| Oxadiazon x Sub-sub treatments (Post emergence) | 7 | 2736.8 | 391.0 | 1.70 | NS |
| Glyphosate x Oxadiazon x Post emergence) | 14 | 7636.9 | 545.5 | 2.38 | NS |
| Error (c) | 84 | 19230.4 | 228.9 | | |
| Total | 126 | 41556.2 | 329.8 | | |
| Grand total | 143 | 61684.9 | | | |
| Grand mean 90.4 | | | | | |
| Total number of observations | 144 | | | | |

NS = Not significant at the 0.05 level, *, **, significant differences at the 0.05 and 0.01 level respectively.

Appendix 78: Analysis of variance of plant height (cm) at 98 DAS in the direct seeded lowland rice at Badeggi, 1986-87.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication | 2 | 2871.7 | 1435.8 | 7.61* | SIG. |
| Glyphosate | 2 | 13678.8 | 6839.4 | 11.77** | SIG. |
| Error (a) | 4 | 2324.2 | 581.0 | 3.08 | |
| Total | 8 | 16003.0 | 2000.3 | 10.61 | |
| Sub-plot | | | | | |
| Oxadiazon | 1 | 180.8 | 180.8 | 1.27 | NS |
| Glyphosate x Oxadiazon | 2 | 3369.0 | 1684.5 | 11.88** | SIG. |
| Error (b) | 6 | 850.8 | 141.8 | 0.75 | |
| Total | 9 | 4400.6 | 489.0 | 2.59 | |
| Sub-sub-plot | | | | | |
| Sub-sub-plot treatments (Post emergence herbicides) | 7 | 14536.7 | 2076.7 | 11.01** | SIG. |
| Glyphosate x Sub-sub-treatments (Post emergence) | 14 | 8030.5 | 573.6 | 3.04** | SIG. |
| Oxadiazon x Sub-sub-treatments (Post emergence) | 7 | 1501.2 | 214.5 | 1.13 | |
| Glyphosate x Oxadiazon x Sub-sub-treatments | 14 | 5903.2 | 421.7 | 2.23 | |
| Error (c) | 84 | | | | |
| Total | 126 | | | | |
| Grand total | 143 | | | | |
| Grand mean 91.6 | | | | | |
| Total number of observations | 144 | | | | |

NS = Not significant at 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels, respectively.

Appendix 79: Analysis of variance of number of tillers per $m^2$ at 30 days after seeding in the direct-seeded lowland rice at Badeggi 1986 wet season

| Sources of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication | 2 | 92607 | 46303 | 30.36** | SIG. |
| Glyphosate | 2 | 1874 | 937 | 0.25 | NS. |
| Error (a) | 4 | 14445 | 3611 | 2.36 | |
| Total | 8 | 16319 | 2039.87 | 1.34 | |
| Sub-plot | | | | | |
| Oxadiazon | 1 | 2517 | 2517 | 0.65 | NS |
| Glyphosate x Oxadiazon | 2 | 38567 | 19283 | 5.05 | NS |
| Error (b) | 6 | 22897 | 3816 | 2.50 | |
| Total | 9 | 63980 | 7109 | 4.66 | |
| Sub-sub-plot | | | | | |
| Sub-sub treatments (Post emergence herbicides) | 7 | 76652 | 10950 | 7.18** | SIG. |
| Glyphosate x Sub-sub treatments (Post emergence) | 14 | 73769 | 5269 | 3.45** | SIG. |
| Oxadiazon x Sub-sub-treatments (Post emergence) | 7 | 8620 | 1374 | 0.98 | NS |
| Glyphosate x Oxadiazon x Post emergence | 14 | 10975 | 771 | 0.50 | NS |
| Error (c) | 84 | 128107 | 1525 | | |
| Total | 126 | 298944 | 2373 | | |
| Grand Total | 143 | 471850 | | | |
| Grand mean 170.5 | | | | | |
| Total number of observations | 144 | | | | |

NS = Not significant at the 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 80: Analysis of variance of number of tillers/$m^2$ at 30 days after seeding in the direct-seeded lowland rice at Badeggi, 1986-87 dry season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication | 2 | 5272.3 | 2636.1 | 5.05 | SIG. |
| Glyphosate | 2 | 15094.7 | 47547.3 | 49.30** | SIG. |
| Error (a) | 4 | 3857.4 | 964.4 | 1.84 | |
| Total | 8 | 98952.1 | 12369.0 | 23.71 | |
| Sub-plot | | | | | |
| Oxadiazon | 1 | 1701.6 | 1701.6 | 1.53 | NS |
| Glyphosate x Oxadiazon | 2 | 1161.5 | 580.8 | 0.52 | NS |
| Error (b) | 6 | 6666.0 | 1111.0 | 3.13 | |
| Total | 9 | 9529.1 | 1058.8 | 2.03 | |
| Sub-sub-plot | | | | | |
| Sub-sub-treatments (Post emergence herbicides) | 7 | 63338.3 | 9048.3 | 17.34** | SIG. |
| Glyphosate x Sub-sub treatments (Post emergence) | 14 | 12323.2 | 915.9 | 1.75 | NS |
| Oxadiazon x Sub-sub treatments (Post emergence) | 7 | 1744.8 | 249.3 | 0.47 | NS |
| Glyphosate x Oxadiazon x Sub-sub treatments | 14 | 5255.9 | 375.4 | 0.72 | |
| Error (c) | 84 | 43819.7 | | | |
| Total | 126 | 126981.9 | | | |
| Grand Total | 143 | 240735.3 | | | |
| Grand mean 164.3 | | | | | |
| Total number of observations | 144 | | | | |

NS = Not significant at 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 81: Analysis of variance of tiller number/$m^2$ at 60 days after seeding in the direct-seeded lowland rice at Badeggi, 1986 wet season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication | 2 | 115072 | 57536 | 12.43** | SIG. |
| Glyphosate | 2 | 162163 | 81082 | 7.12** | SIG. |
| Error (a) | 4 | 45497 | 11374 | 2.45 | |
| Total | 8 | 207661 | 25957.62 | 5.61 | |
| Sub-plot | | | | | |
| Oxadiazon | 1 | 21316 | 21316 | 1.75 | NS |
| Glyphosate x Oxadiazon | 2 | 58895 | 29448 | 2.42 | NS |
| Error (b) | 6 | 72909 | 12152 | 2.62 | NS |
| Total | 9 | 153121 | 17013 | 3.57 | |
| Sub-sub plot | | | | | |
| Sub-sub treatments (Post (emergence herbicides) | 7 | 378056 | 54008 | 11.57** | SIG. |
| Glyphosate x Sub-sub treatments (Post emergence) | 14 | 75008 | 5358 | 1.15 | NS |
| Oxadiazon x Sub-sub treatments (Post emergence) | 7 | 30440 | 4349 | 0.94 | NS |
| Glyphosate x Oxadiazon Post emergence | 14 | 73971 | 5284 | 1.14 | NS |
| Error (c) | 84 | 388702 | 4627 | | |
| Total | 126 | 946177 | 7509 | | |
| Grand Total | 143 | 1422030 | | | |
| Grand mean 259.0 | | | | | |
| Total number of observations | 144 | | | | |

NS = Not significant at the 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 82: Analysis of variance of number of tillers/$m^2$ at 60 days after seeding in the direct-seeded lowland rice at Badeggi, 1986-87 dry season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| **Main-plot** | | | | | |
| Replication | 2 | 812.5 | 406.3 | 0.50 | NS |
| Glyphosate | 2 | 491898.4 | 245949.2 | 606.81** | SIG. |
| Error (a) | 4 | 1621.2 | 405.3 | 0.50 | |
| Total | 8 | 493519.6 | 61689.9 | 77.13 | |
| **Sub-plot** | | | | | |
| Oxadiazon | 1 | 480.3 | 480.3 | 0.35 | NS |
| Glyphosate x Oxadiazon | 2 | 3764.1 | 1882.0 | 1.37 | |
| Error (b) | 6 | 8226.9 | 1371.2 | 1.71 | |
| Total | 9 | 12471.3 | 1385.7 | 1.73 | |
| **Sub-sub plot** | | | | | |
| Sub-sub treatments (Post emergence) | 7 | 171110.3 | 24444.3 | 30.56** | SIG. |
| Glyphosate x Sub-sub treatments | 14 | 100155.8 | 7154.0 | 0.94** | SIG. |
| Oxadiazon x Sub sub treatments | 7 | 10570.9 | 1510.1 | 1.88 | NS |
| Glyphosate x Oxadiazon x Sub-sub treatments | 14 | 12403.5 | 886.0 | 1.1 | |
| Error (c) | 84 | 67181.3 | 799.8 | | |
| Total | 126 | 361421.9 | 2868.4 | | |
| Grand total | 143 | 868225.3 | | | |
| Grand mean 254.8 | | | | | |
| Total number of observations | 144 | | | | |

NS = Not significant at the 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 83: Analysis of variance of number of panicles per $m^2$ in the direct-seeded lowland rice at Badeggi, 1986 wet season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Mainplot | | | | | |
| Replication | 2 | 299180 | 149590 | 20.83** | SIG. |
| Glyphosate | 2 | 197724 | 98862 | 6.77** | SIG. |
| Error (a) | 4 | 58384 | 14596 | 2.91 | |
| Total | 8 | 256107 | 32013.3 | 6.38 | |
| Sub-plot | | | | | |
| Oxadiazon | 1 | 17711 | 17711 | 1.96 | NS |
| Glyphosate x Oxadiazon | 2 | 62237 | 31169 | 3.45 | NS |
| Error (b) | 6 | 54178 | 9030 | 1.80 | |
| Total | 9 | 134226 | 14914 | 2.97 | |
| Sub-sub-plot | | | | | |
| Sub-sub treatments (Post emergence herbicide) | 7 | 908076 | 129725 | 25.87** | SIG. |
| Glyphosate x Sub-sub treatments (Post emergence) | 14 | 67882 | 4849 | 0.96 | NS |
| Oxadiazon x Sub-sub treatments (Post emergence) | 7 | 62034 | 8862 | 1.76 | NS |
| Glyphosate x Oxadiazon x Post emergence | 14 | 62702 | 4479 | 0.89 | NS |
| Error (c) | 184 | 621126 | 5013 | | |
| Total | 126 | 1521819 | 12078 | | |
| Grand total | 143 | 2221333 | | | |
| Grand mean 228.4 | | | | | |
| Total number of observations | 144 | | | | |

NS = Not significant at 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 84: Analysis of variance of number of panicles/$m^2$ in the direct seeded lowland rice at Badeggi, 1986-87 dry season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication | 2 | 993.0 | 496.5 | 0.85 | NS |
| Glyphosate | 2 | 377716.8 | 188858.4 | 1094.56** | SIG. |
| Error (a) | 4 | 690.2 | 172.5 | 0.296 | |
| Total | 8 | 378407.0 | 47300.87 | 81.16 | |
| Sub-plot | | | | | |
| Oxadiazon | 1 | 93[illegible].4 | 9344.4 | 12.93** | IG. |
| Glyphosate x Oxadiazon | 2 | 3847.3 | 1924.0 | 2.66 | |
| Error (b) | 6 | 4333.9 | 722.3 | 1.23 | |
| Total | 9 | 17526.2 | 1947 | 3.34 | |
| Sub-sub plot | | | | | |
| Sub-sub treatments (Post emergence) | 7 | 223550.1 | 31935.7 | 54.79** | SIG. |
| Glyphosate x Sub-sub treatments | 14 | 62459.9 | 4461.4 | 7.65** | SIG. |
| Oxadiazon x Sub-sub treatments | 7 | 3143.7 | 449.1 | 0.77 | NS |
| Glyphosate x Oxadiazon x Sub-sub treatments | 14 | 12062.3 | 861.6 | 1.47 | NS |
| Error (c) | 84 | 48757.6 | 582.8 | | |
| Total | 126 | 350173.5 | 2779.2 | | |
| Grand total | 143 | 747099.7 | | | |
| Grand mean 227.1 | | | | | |
| Total number of observations | | | | | |

NS = Not significant at the 0.05 *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 85: Analysis of variance of spikelets/panicle in the direct-seeded lowland rice at Badeggi, 1986-87 dry season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication | 2 | 1271.3 | 635.6 | 2.10 | NS |
| Glyphosate | 2 | 162331.2 | 81165.6 | 444.94** | SIG. |
| Error (a) | 4 | 729.7 | 182.4 | 0.60 | |
| Total | 8 | 163060.8 | 20382.6 | 67.67 | |
| Sub-plot | | | | | |
| Oxadiazon | 1 | 658.8 | 658.8 | 5.18** | SIG. |
| Glyphosate x Oxadiazon | 2 | 424.4 | 212.2 | 1.67 | NS |
| Error (b) | 6 | 762.5 | 127.1 | 0.43 | |
| Total | 9 | 1845.0 | 205.1 | 0.68 | |
| Sub-sub plot | | | | | |
| Sub-sub treatments (Post emergence) | 7 | 96614.3 | 13802.1 | 45.82** | SIG. |
| Glyphosate x Sub-sub treatments | 14 | 9524.3 | 680.3 | 2.25** | SIG. |
| Oxadiason Sub-sub treatments | 7 | 2251.8 | 321.7 | 1.06 | NS. |
| Glyphosate x Oxadiazon x Sub-sub treatments | 14 | 1684.4 | 120.3 | 0.31 | |
| Error (c) | 84 | 25301.3 | 301.2 | | |
| Total | 126 | 135376.3 | 1074.4 | | |
| Grand total | 143 | 301554.0 | | | |
| Grand mean 138.2 | | | | | |
| Total number of observations | 144 | | | | |

NS = Not significant at the 0.05 level, *, **, significant differences at the 0.05 and 0.01 level respectively.

Appendix 86: Analysis of variance of spikelets per panicle in the direct-seeded lowland rice at Badeggi 1986 wet season

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication | 2 | 28.8 | 14.4 | 0.05 | NS |
| Glyphosate | 2 | 32329.4 | 16164.7 | 31.05** | SIG. |
| Error (a) | 4 | 2082.4 | 520.6 | 2.10 | |
| Total | 8 | 34411.8 | 4301.47 | 17.36 | |
| Sub-plot | | | | | |
| Oxadiazon | 1 | 10033.4 | 10033.4 | 84.04** | SIG. |
| Glyphosate x Oxadiazon | 2 | 9225.3 | 4612.7 | 38.63** | SIG. |
| Error (b) | 6 | 716.3 | 119.4 | 0.48 | |
| Total | 9 | 19975.0 | 2219.4 | 8.95 | |
| Sub-sub plot | | | | | |
| Sub-sub treatments | 7 | 344737.8 | 49248.3 | 198.73** | SIG. |
| Glyphosate x Sub sub treatments | 14 | 19751.7 | 1410.8 | 5.6** | SIG. |
| Oxadiazon sub-sub treatment | 7 | 4542.6 | 648.9 | 2.61 | SIG. |
| Glyphosate x Oxadiazon x Sub-sub treatments | 14 | 4468.0 | 319.1 | 1.28 | |
| Error (c) | 84 | 20815.0 | 247.8 | | |
| Total | 126 | 394316.0 | 3129.5 | | |
| Grand Total | 143 | 448731.6 | | | |
| Grand mean 134.1 | | | | | |
| Total number of observations | 144 | | | | |

NS = Not significant at the 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 87: Analysis of variance of % unfilled grains in the direct-seeded lowland rice at Badeggi, 1986-87, dry season

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication | 2 | 0.60 | 0.30 | 0.01 | NS |
| Glyphosate | 2 | 8529.06 | 4264.53 | 185.86** | SIG. |
| Error (a) | 4 | 91.78 | 22.94 | 0.81 | |
| Total | 8 | 3620.83 | 452.60 | 16.15 | |
| Sub-plot | | | | | |
| Oxadiazon | 1 | 106.78 | 106.78 | 6.84** | SIG. |
| Glyphosate x Oxadiazon | 2 | 71.72 | 35.86 | 2.29 | |
| Error (b) | 6 | 93.63 | 15.60 | 0.55 | |
| Total | 9 | 272.13 | 30.24 | 1.07 | |
| Sub-sub plot | | | | | |
| Sub-sub treatments | 7 | 17676.19 | 2525.17 | 90.13** | SIG. |
| Glyphosate x Sub-sub treatments | 14 | 1168.39 | 83.46 | 2.97** | SIG. |
| Oxadiazon x Sub-sub treatments | 7 | 208.56 | 29.97 | 1.06 | NS |
| Glyphosate x Oxadiazon x Sub-sub treatments | 14 | 295.28 | 21.09 | 0.75 | NS |
| Error (c) | 84 | 2353.33 | 28.02 | | |
| Total | 126 | 21701.75 | | | |
| Grand total | 143 | 30515.31 | 100.00 | | |
| Grand mean 20.02 | | | | | |
| Total number of observations | 144 | | | | |

NS = Not significant at 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 88: Analysis of variance of % unfilled grains in the direct-seeded lowland rice at Badeggi, 1986 wet season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication | 2 | 320.9 | 160.4 | 1.21 | NS |
| Glyphosate | 2 | 890.1 | 445.0 | 68.83** | SIG. |
| Error (a) | 4 | 25.9 | 6.5 | 0.04 | |
| Total | 8 | 915.9 | 114.48 | 0.13 | |
| Sub-plot | | | | | |
| Oxadiazon | 1 | 961.0 | 961.0 | 7.04** | SIG. |
| Glyphosate x Oxadiazon | 2 | 480.2 | 240.1 | 1.76 | NS |
| Error (b) | 6 | 818.1 | 136.3 | 1 .03 | NS |
| Total | 9 | 2259.2 | 251.0 | 1.90 | |
| Sub-sub plot | | | | | |
| Sub-sub treatments (Post emergence herbicides) | 7 | 85634.4 | 12233.5 | 92.59** | SIG. |
| Glyphosate x Sub-sub treatments (Post emergence) | 14 | 6219.5 | 301.4 | 2.28** | SIG. |
| Oxadiazon x Sub-sub treatments (Post emergence) | 7 | 2029.4 | 289.9 | 2.19* | SIG. |
| Glyphosate x Oxadiazon x Post emergence | 14 | 2647.4 | 189.1 | 1.43 | NS |
| Error (c) | 84 | 11098.5 | 838.3 | | |
| Total | 126 | | | | |
| Grand total | 143 | | | | |
| Grand mean 29.07 | | | | | |
| Total number of observations | 144 | | | | |

NS = Not significant at the 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 89: Analysis of variance of grain yield in the direct-seeded lowland rice at Badeggi in 1985-86 dry season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication | 2 | 1.62 | 0.81 | 4.38 | NS |
| Glyphosate | 2 | 155.23 | 77.61 | 619.49** | SIG. |
| Error (a) | 4 | 0.501 | 0.125 | 0.67 | |
| Total | 8 | 155.74 | 19.46 | 108.15 | |
| Sub-plot | | | | | |
| Oxadiazon | 1 | 4.09 | 4.09 | 33.48** | SIG. |
| Glyphosate x Oxadiazon | 2 | 0.98 | 0.49 | 4.03 | NS |
| Error (b) | 6 | 0.73 | 0.12 | 0.66 | NS |
| Total | 9 | 5.80 | 0.64 | 3.49 | |
| Sub-sub plot | | | | | |
| Sub-sub treatments (Post emergence herbicides) | 7 | 87.96 | 12.56 | 57.99** | SIG. |
| Glyphosate x Sub-sub treatments (Post emergence) | 14 | 28.42 | 2.03 | 10.98** | SIG. |
| Oxadiazon x Sub-sub treatments (Post emergence) | 7 | 2.95 | 0.42 | 2.28** | SIG. |
| Glyphosate x Oxadiazon x Sub-sub treatments | 14 | 5.55 | 0.39 | 2.14** | SIG. |
| Error (c) | 84 | 15.52 | 0.18 | | |
| Total | 126 | 140.42 | | | |
| Grand total | 143 | 303.59 | | | |
| Grand mean 3.3 | | | | | |
| Total number of observations | 144 | | | | |

NS = Not significant at 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 90: Analysis of variance of grain yield in the direct-seeded lowland rice at Badeggi, 1986 wet season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication | 2 | 1.83 | 0.91 | 1.59 | NS |
| Glyphosate | 2 | 31.82 | 15.91 | 27.41 | SIG. |
| Error (a) | 4 | 2.32 | 0.58 | 1.0 | |
| Total | 8 | 34.14 | 4.26 | 7.48 | |
| Sub-plot | | | | | |
| Oxadiazon | 1 | 23.87 | 23.87 | 80.56** | SIG. |
| Glyphosate x Oxadiazon | 2 | 5.80 | 2.90 | 9.78** | SIG. |
| Error (b) | 6 | 1.77 | 0.29 | 0.51 | |
| Total | 9 | 31.45 | 3.49 | 0.18 | |
| Sub-sub plot | | | | | |
| Sub-sub treatments (Post emergence herbicides) | 7 | 342.03 | 48.86 | 85.06** | SIG. |
| Glyphosate x Sub-sub treatments (Post emergence) | 14 | 16.57 | 1.18 | 2.06** | SIG. |
| Oxadiazon x Sub-sub treatments (Post emergence) | 7 | 10.70 | 1.52 | 2.66* | SIG. |
| Glyphosate x Oxadiazon x Post emergence | 14 | 7.91 | 0.56 | 0.98 | NS |
| Error (c) | 84 | 48.24 | 0.57 | | |
| Total | 126 | 428.48 | 3.37 | | |
| Grand total | 143 | 492.91 | | | |
| Grand mean 3.5 | | | | | |
| Total number of observations | 144 | | | | |

NS = Not significant at the 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 91: Analysis of variance of grain yield in the direct-seeded lowland rice at Badeggi, 1986-87 dry season.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F | Significance |
|---|---|---|---|---|---|
| Main-plot | | | | | |
| Replication | 2 | 0.17 | 0.085 | 0.74 | NS |
| Glyphosate | 2 | 171.95 | 85.97 | 1887.75** | SIG. |
| Error (a) | 4 | 0.18 | 0.04 | 0.39 | |
| Total | 8 | 172.13 | 21.51 | 195.54 | |
| Sub-plot | | | | | |
| Oxadiazon | 1 | 1.19 | 1.19 | 15.43** | SIG. |
| Glyphosate x Oxadiazon | 2 | 0.40 | 0.20 | 2.62 | |
| Error (b) | 6 | 0.46 | 0.08 | 0.68 | |
| Total | 9 | 2.07 | 0.23 | 2.01 | |
| Sub-sub plot | | | | | |
| Sub-sub treatments (Post emergence) | 7 | 73.79 | 10.54 | 92.40** | SIG. |
| Glyphosate x Sub-sub treatments | 14 | 12.36 | 0.88 | 7.74** | SIG. |
| Oxadiazon x Sub-sub treatments | 7 | 1.84 | 0.26 | 2.30** | SIG. |
| Glyphosate x Oxadiazon x Sub-sub treatment | 14 | 1.06 | 0.07 | 0.57 | |
| Error (c) | 84 | 9.56 | 0.11 | | |
| Total | 126 | 18.65 | 0.78 | | |
| Grand total | 143 | 273.03 | | | |
| Grand mean 3.35 | | | | | |
| Total number of observations | 144 | | | | |

NS = Not significant at the 0.05 level, *, **, significant differences at the 0.05 and 0.01 levels respectively.

Appendix 92: Common and chemical names of herbicides mentioned in the text.

| Common name | Chemical name |
|---|---|
| Benthiocarb | S-(4-chlorophenyl) methyl diethyl carbomothicate. |
| Bentazon | 3-isoprophyl-1H-2,1,3-benzo thiadiazin-4 (3H)-one 2, 2-dioxide. |
| Butachlor | N-(butoxymethyl)-2-chloro-2',6'diethyl acetanilide. |
| Delapon | 2-2-dichloropropionic acid |
| Dimethametryne | 4-(1,2-dimethyl-n-propylamino)-2-thylamino-6-methyl-thio-5-triazine |
| Fluoridifen | P-nitrophenyl (x-x-x-trifluoro-2-nitro-P-toyl) urea. |
| Glyphosate | N-(phosphonomethyl) glycine. |
| Molinate | S-ethyl hexahydro-IH-azepine-1-carbothioate. |
| Oxadiazon | 2-tert-butyl-4(2,4-dichloro-S-isopropocyphenyl) $D^2$ 1,3,4-oxadiaxolin-5-one. |
| Paraquat | 1,1-dimethyl-4,4 bipyridinium ion. |
| Propanil | 3' 4'-dichloropropionanilide. |
| Silvex | 2-(2,4,5-trichlorophenoxy) propionic acid. |

Appendix 93: BIOGRAPHY: PETER OSE IMEOKPARIA

Ma,e: P. O. Imeokparia

Date of Birth: 6th April, 1950

Business Address: National Cereals Research Institute, Badeggi, P. M. B. 8, Bida, Niger State, Nigeria.

Home Address: Chief Imeokparia's Quarters, c/o Apostolic School, Ewoyi, P. O. Box 44, Uromi, Bendel State.

| Institutions Attended: | From | To | Cert./Dip./Degree |
|---|---|---|---|
| Apostolic School, Ewoyi Uromi, | 1957 | 1962 | Pri. Sch. Leaving Cert. Grd. A |
| Ishan Grammar School Uromi | 1963 | 1967 | West African Sch. Cert. Division 2. |
| Federal Govt. College Warri | 1968 | 1969 | Higher School Certificate |
| University of Ibadan, Ibadan | 1970 | 1973 | B.Sc. Forestry. |
| University of Florida, Gainesville | 1978 | 1980 | M. Agricuture (Weed Science). |

Posts Held since Award of First Degree

| Organisation | From | To | Position |
|---|---|---|---|
| Ministry of Agric. and Natural Resources, Bendel State, Nigeria | 1974 | 1975 | Forestry Officer |
| Nigerian Sugar Company Bacita. | 1976 | 1980 | Agronomist (Weed Science) |
| National Cereals Res. Institute, Badeggi Bida | 1981 | to date | Agronomist (Weed Science). |

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