EFFECTS OF PERIOD OF WEED INTERFERENCE AND CHEMICAL WEED CONTROL ON GROWTH AND YIELD OF GARLIC (*Allium sativum* L.)

BY

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A thesis submitted to the Post-Graduate School, Ahmadu Bello University, in Partial fulfilment of the requirement for the degree of master of science in Agronomy.

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DECLARATION

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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CERTIFICATION

This thesis entitled " EFFECTS OF PERIOD OF WEED INTERFERENCE AND CHEMICAL WEED CONTROL ON GROWTH AND YIELD OF GARLIC (Allium sativum L.)", by Mr. Peter Tunku meets the regulations governing the degree of master of science of Ahmadu Bello University, Zaria, and is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This work is dedicated to my mother, for her patience, support and love to me during the course of my study.

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ABSTRACT

Two sets of trials were conducted during the 1994 and 1995 dry seasons at Samaru in the Northern Guinea Savanna agro-ecological zone of Nigeria to study the effect of period of weed interference and chemical weed control on the growth and yield of garlic (Allium sativum L.).

In the weed interference trials, weed infestation initially for 3 WAP did not cause any significant depression in the growth and yield of garlic as reflected in crop viguor score, plant height and number of fully opened leaves per plant and bulb yield. Subsequent weed removal after initial infestation for 9 WAP did not ameliorate the depression in the growth and yield of garlic caused by weed interference compared with weed infestation until harvest.

Uncontrolled weeds throughout the crop life cycle caused 70% and 80% reduction in garlic yield in 1994 and 1995, respectively, compared with the maximum obtained with the crop kept weed-free throughout. The critical period of weed competition was observed to be between 5 and 6 WAP in both years.

In the weed control study, all the herbicide treatments effectively reduced weed infestation compared with the hand weeded control. In the two years, oxadiazon applied alone at lOOOg a.i/ha and 1500g a.i./ha, the mixture with chloroxuron at 750+1000g a.i./ha and 750+2000g a.i./ha and with prometryne at 750 +1000g a.i./ha and 750+l500g a.i./ha resulted in high garlic bulb yield that were comparable to that of the hoe-weeded control. The treatment effectively controlled weeds without phytotoxicity on the crop.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Production and Uses of Garlic

Garlic (Allium sativum L.), a bulb crop belonging to the family Alliaceae, is the second most widely used member of the cultivated Allium genus after onion (Allium cepa) (Henry and Mann, 1963). Garlic is an erect herb, which produces a bulb composed of smaller clove as storage organs arising from axillary buds between the foliage leaves. Two types of mature leaves are found in each cloves; the protective and storage leaf. The stem of leaves may be flattened or elongated, but dries up at maturity leaving only the swollen cloves.

Garlic is a minor crop and is usually grouped with onion or other vegetables in documented production data, therefore no clear picture of the world production is available. However, notes on its production in several countries, suggest its relative importance: Mexico is believed to be the largest producing country in the world. In 1958, about 7,000 tons was exported from mexico to the United States and to the Carribean countries (Henry and Mann 1963).

In Africa, Egypt is believed to be the largest garlic producer. Between 1957 and 1961, the annual production was about 52,153 metric tonnes from 5,280 hectares.

In Nigeria, the production of garlic is mainly carried out in the Northern Guinea and the Sudan savanna ecological zones. This is usually during dry season under irrigation in areas like Borno State (Maiduguri), Sokoto State (Wurno and Gusau, Kano State (Kofa,

Kiru, etc.) and part of Katsina State. However, there is no available Statistical data on garlic production and trade in Nigeria.

Garlic is an important Vegetable crop whose cloves contain approximately 63% water, 6.3% protein, 0.1% fats, 29% carbohydrate, 1.0% mineral matter, 0.8% fibre, 0.03% calcium, 0.31% phosphorus, 1.3% Iron, calorific value per 100 of 142gm, 13micro vitamin C, 0.4 micro Nicotinic acid, 10 micro Ascorbic acid, 0.08 micro,Riboflavin and 0.25 micro thiamine

Garlic contains pungent sulphur compound which makes it popular in many countries where it is used as condiments for flavouring other food items such as salad, salami and sausage. In Medieval Europe it was widely used for distiquishing the smell and flavour of salted meat and fish. In India and China it is often used in preparing curries, while in Phillipines, Eastern Asia and parts of the tropic, the green tops are used as well as the bulbs (Henry and Mann, 1963). Dehydrated form is replacing the fresh bulb for Industrial and home uses.

Garlic is used for medicinal purposes, garlic salt is currently used by hypertensive patients. Garlic is also used for the treatment of whooping cough, lung diseases, abdominal complications such as ulcer of intestine. It is also used for the treatment of sore eye. Garlic preparation were reported to have fungicidal and bactericidal properties. The activities of the production derived from garlic as investigated in-vitro was found to inhibit the growth of both Aspergillus niger, Camoida albican, C. tropicalis, Trichophyton muntagnophytes, Canoida glabrata and Trichosporous beingelli were strongly inhibited by these products,

but showed no anti-bacterial activities except against Staphlococus aureus bacterium (Yoshida et al., 1987).

Debkirtaniya et al .(1980) reported that an oil fraction and crude methanolic obtained from garlic cloves had Larvicidal effect against the larva of Spodoptera litura, Euproctis sp . and Culex sp. Lepikhov (1972) reported that the garlic extract increased seed germination, improved growth and development of carrot, cucumber and other crops when the seeds of the crops were steeped for 24 hours in solution of extract from onion, garlic, pine needle and Bind-cherry leaves and in Succinic acid before sowing. The leaf area of the crop and yield increased, while the disease incidence were decreased.

In Nigeria, garlic is popularly used as an ingredient in most diets and also for medicinal purposes either alone or in combination with other herbs. It is used for curing cold and hypertension. The crop is a good source of income to the farmers. It fetches about 50 to 60 Naira per kg of fresh clove compared with 20 to 30 naira per kg of Onion.

1.2 Effect of Weeds on Garlic.

In Nigeria, the low yield of garlic could be attributed to a number of production constraints which may include the inability of farmers to combat the problem of diseases, pests and weeds. Garlic bulb yields are enormously reduced by weeds if not timely controlled. In Nigeria, hoe weeding is the most common weeds control practice which apart form being expensive, high labour intensive, strenuous and limited to small scale production, it also causes mechanical damage to the shallowly placed roots and bulbs

with consequently yield reduction (Lagoke et al., 1986).

In Brazil, Warren (1975) reported that there was a loss of 89% in garlic yield when there was a competition between garlic and nutsedge (Cyperus rotundus). William (1975) reported that 70 to 80% of garlic production was lost due to weed competition.

In Nigeria, there are no available figures to show these losses, however, such losses range from drastic reduction to total crop failure in extreme cases. The need arises, therefore, for an alternative methods of weed control in garlic especially through the use of chemicals.

This study was, therefore, initiated with the following objectives:-

1. to evaluate the effect of period of weed interference on garlic.
2. to evaluate the performance of various herbicides for weed control in the crop.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Weed Competition in Garlic

2.1.1 Losses Due to Weed Competition

The impart of weeds on yield of crop varies with the characteristics of the crops, the weed species, weed density, the environment, the stage of growth and the duration of crop exposure to weed (Dowson and Robbert, 1973). Weeds constitute a major problem in vegetables production. In the absence of any weed control in vegetable crops, losses in yield ranged from 20 to 100%, depending on the weed species present and other growing conditions (Robert et al., 1976).

Garlic like many other vegetable crops is very sensitive to weed competition especially during the early stage of growth, and that the association of garlic with nutsedge at 3 to 13 weeks after sowing resulted in significant yield reduction of 70 to 80% (William, 1975). Warren (1975) also reported that there was a loss of 89% in garlic yield when the crop was allowed to compete with nutsedge for 5 to 7 weeks.

Henry and Mann (1963) observed that mulching can effectively control weed in garlic and consequently reduce losses due to weed competition in the crop. Duranti (1988) reported 50% loss of garlic cloves in an unweeded plots compared to weed free plots. Ahmed (1991) observed that the presence of weed, mostly annual broadleaved species resulted in bulb yield loss of 79 to 89%.

2.1.2 Critical period of weed competition in garlic

The greatest loss in a crop yield due to weed competition occur during the critical period of weed competition, the period of the crop growth when it is most susceptible to weed competition (Nieto et al., 1968; Lagoke 1978; Adigun, 1984). For most crops this period has been reported to be between 3 and 4 weeks after planting (WAP). For garlic, little work has been done to establish the critical period during which weed competition exerts a serious effect on yield. However, Aliudin (1989) reported that the critical period of weed competition in garlic is between 30 and 60 days after sowing, as such weed control during these periods will result in high yield of fresh garlic bulbs.

Warren (1975) reported a loss of 89% in garlic yield when there was competition between garlic and nutsedge 5 to 7 weeks. William (1975) reported that the critical periods of nutsedge competition with garlic occured between 3 and 13 weeks after sowing. He suggested that for optimum yield, the crop should be kept weed free during the identified critical period.

2.2 Chemical Weed Control in Garlic

Chemical weed control method is considered to show more promise than hoe weeding on the production of closely planted bulb vegetable like garlic, since it will reduce labour requirement and its attendant cost, increase profitability and also facilitate efficient weed control (Sinha et al., 1983).

Various chemicals that have been used singly or in mixture to control weed successfully in garlic in parts of the world include: oxadiazon, chloroxuron, prometryne (Deuber and Fornasier 1980;

Axerod and Rappaport, 1968; Janyska, 1966). These herbicides have also been used either singly or in mixture to control weeds in various crops in Nigeria, (Lagoke et al., 1982, Sinha et al., 1983, Adigun, 1984, Bakut, 1985, Bulus, 1986).

2.2.1 Oxadiazon

Oxadiazon(2-tert-butyl-4-(2,4-dichloro-5-Isoproxyphenyl)-D2-1,3,4-oxadiazolin-5-one) is a heterocylic compound used both as pre-emergence and post-emergence herbicide. It is usually formulated as an emulsifiable concentrate. The herbicide kills weed by contact with young shoots that may grow through the treated zones (Gary and Zoshney, 1974). The herbicide has a very low solubility in water and could remain on the soil surface where the herbicidal activity persist for several months (Chevrel and Tyrrell, 1974).

Deuber and Fornasier (1980) reported that the application of oxadiazon at 1 kg a.i./ha, as pre-emergence in garlic gave excellent selective control of both grasses and broad leaved weeds. He obtained the highest yield with oxadiazon and oxadiazon plus oxynil at 0.5 + 0.5 kg a.i./ha while oxynil plus oxadiazon at 0.75 + 0.25 kg a.i./ha failed to control grasses. Anon (1977) reported that high yield was obtained when oxadiazon at 3.5 kg a.i./ha and flu-orodifen at 2kg a.i./ha, both applied pre-emergence in irrigated onion and rainfed garlic. McIntyre (1978) observed that mixture of oxadiazon at 1 kg a.i./ha and fluorodifen at 2 kg a.i./ha applied pre-emergence gave good selective weed control and increased the garlic yield when compared with hand-weeded control.

Deuber and Fornasier (1980) also reported that pre-emergence

application of pendimethalin at 1.5kg a.i./ha, Linuron at 1kg a.i./ha all in mixture with oxadiazon at 1 kg a.i./ha on the day of planting, gave excellent selective weed control up to 115 days after sowing in garlic. Ahmed (1991) reported that application of oxadiazon at 0.5 to 1.5kg a.i./ha, applied pre-emergence effectively controlled weed in garlic.

2.2.2 Chloroxuron

Chloroxuron (N^1-4- (4-chlorophenoxy) phenyl-NN-dimethylurea) is a substituted urea herbicide, which is both soil and foliar active has been reported to be effective for selective control of broad-leaved and grass weeds in vegetable crops including garlic. In Israel, between 1963 and 1966, the results of trials at five localities representing different climatic region and soil types showed that chloroxuron applied pre-emergence at 250g a.i./ha gave adequate control of weeds for two months without any injury to garlic and produced yield equal to or higher than those from hand-weeded plots (Axelrod and Rappaport 1968).

Rappaport (1968) reported that second application of chloroxuron at 250g a.i./ha, 60 days after crop emergence, controlled weeds throughout the growing season. Dos (1966) observed that application of chloroxuron at 4 and 6 kg a.i./ha although controlled many weeds except Amaranthus hybridus, Bidens pilosa. Solomon (1967) reported that the application of chloroxuron at 3000g a.i./ha applied pre-emergence gave an effective control of weeds in autum-planted garlic. He further reported that chloroxuron at 3000g a.i./ha applied to garlic at 5-leaf stage gave good weed control.

2.2.3 Prometryne

Prometryne (4, 6 - bisisopropylamino -2- methylthio 1,3,5-triazine), a symmetrical triazine, is a white crystalline solid with a water solubility of 48 ppm at 20°C and is formulated either as a wettable powder or in liquid alone or in combination with other herbicides. Some workers have shown that prometryne is absorbed through both foliage and roots and translocated acropetally through xylem from roots and foliage accumulating in the epical meristem (Anon. 1958). Prometryne has been shown to selectively control broad leaved weeds and grasses when applied *pre-emergence and post-emergence in cotton, okra, potato, onion,* carrot, yam, soyabean, cowpea, groundnut, melon and maize (Hilton et al., 1974; Lagoke et al., 1982; Bulus, 1986; Sambo, 1986).

Janyska (1966) conducted an experiment for three years in which prometryne at rates of 2,3 and 5kg a.i./ha was applied pre-emergence and post-emergence to the spring planted garlic, and post-emergence to the autumn planted crop. The two lower rates of the herbicide gave satisfactory weed control and resulted in higher garlic yield than the hand weeded control. Prometryne applied in row at 2.0kg a.i./ha before garlic was planted was phytotoxic to the crop and reduced yield by 60% compared with the same rate applied after planting. Leiderman (1966) observed that application of prometryne at 1.5kg a.i./ha gave the best control of weed species.

Ramirez (1973) obtained higher commercial cloves yield than the hand weeded control when prometryne at 0.75kg a.i./ha was applied. Stoynov et al., (1973) reported that of the various herbicides tested for weed control in garlic, the best result was

obtained with prometryne at 2kg a.i./ha when applied pre-emergence. Armellina (1976) reported that pre-emergence application of prometryne at 2.8kg a.i./ha gave an excellent weed control.

Mascarenthas et al. (1980) reported that the application of prometryne at 0.96kg a.i./ha, Diuron at 0.8kg a.i./ha, Linuron at 2kg a.i./ha, bifenox at 1.68kg a.i./ha, all in mixture with glyhosate at 2kg a.i./ha controlled weeds without visible injury to garlic when applied pre-emergence. Janyska (1984) reported that 7.9 tons/ha of garlic was obtained when 3kg a.i./ha prometryne was applied.

2.2.4 CGA 152'005

CGA 152'005 is a crystalline, colourless, odourless herbicide with molecular weight of 419.4, melting point of 165.2°C, belonging to the chemical class-sulfonylurea. It provide selective pre-emergence and post-emergence control of broad spectrum of annual dicotyledonous weeds in maize, grain sorghum and sugarcane.

CGA 152'005 has foliar and soil activities and can be applied pre-emergence as well as post-emergence to weeds and to crops. As the soil activities of the compound is strongly subjected to environmental influences, such as moisture and other soil characteristics. Pre-emergence use of CGA 152'005 mainly aims at mixture with other residual herbicides for control of annual grasses and broad leaved weeds in maize and sorghum. After the application of CGA 152'005, growth of susceptible plant species stop rapidly while other symptoms appear shortly. The plant becomes yellowish or reddish and begins to die. The death of these species takes 1 to 3 weeks to occur (Dauda 1997).

The primary site of action of CGA 152'005 is the inhibition of the enzyme acetolactate synthase (ALS). Lower residual activity is observed under dry soil condition, especially to the late germinated or large seeded weeds and may indicate a reduced root uptake, which may be attributed to a decreased availability of CGA 152'005 in the soil solution. The rates require for adequate weed control is between 10 to 40g a.i./ha. CGA 152'005 is generally excellently tolerated by maize, sorghum and sugar cane if applied post-emergence. A pre-emergence application to date had been tested in maize and sorghum and offered somewhat less tolerance than a post-emergence treatment. The well tolerated rates when applied pre-emergence may be upto 20 to 30g a.i./ha. Some results showed an unacceptable maize injury caused by low rates of CGA 152'005. To date, high precipitation after application, stagnant water, or waterlogged on compacted soils are suspected to be the main reason for maize phytotoxicity by the compound (Dauda 1997).

Inspite of the generally low injury level at late application, CGA 152'005 provided an excellent control of a wide spectrum of triazine sensitive and triazine resistant weeds at rate between 10 and 40g a.i./ha. Post-emergence control of a broad spectrum of annual dicotyledous weeds is provided in generally by 20 to 40g a.i./ha, depending on the species for which control is desired. The persistence of CGA 152'005 after post-emergence application was to be at least two months.

At Samaru, the results of some trials indicated that most of the treatments containing CGA 152'005 resulted in higher yield of maize than the recommended herbicide primagram at 2.5kg a.i./ha (Anon. 1994). In the trials, post-emergence application of CGA

152'005 plus Po 51 at 0.03 + 0.25kg a.i./ha, two weeks after sowing, effectively suppressed weeds and resulted in highest maize yield (Anon 1994). The mixture of CGA 152'005 at 0.02 and 0.03kg a.i./ha with Po 51 resulted in better crop performance than CGA 152'005 alone. However, no work with this herbicide on garlic has been done.

2.2.5 Cinosulfuron

Cinosulfuron (3-(4,6-dimethoxy -1, 3, 5 - triazin - 2 -yl) -1 -2 - (2 - methoxyethoxy) phenylsulfonylurea is a sulfonylurea herbicide used for broadspectrum weed control in transplanted and direct seeded rice in tropical and temperate countries.

Cinosulfuron is taken up mainly by roots and shoots after translocation via xylem and phloem. The herbicide inhibit the division in meristematic plant tissues. Achlderon et al., (1987) reported that in both direct seeded wet sown and transplanted rice the herbicide (cinosulfuron) gave good control of most major broadleaves and sedges of lowland rice. Application of 20g a.i./ha 3 to 15 days after sowing or transplanted is recommended for optimum efficiency of weeds control and for high yield in rice. Hare et al., (1987) reported the results of fourteen trials conducted in Malaysia on comparative efficiency of 350 to 450g a.i./ha pretfiachlor safene with fenclorim (sofit) and 10 to 20g a.i./ha cinosulfuron applied alone or together 4-days after sowing rice. Sofit and cinosulfuron alone provided 76 to 95% and 25 to 49% control of grasses, respectively 29 to 68% and 91 to 94% control broad-leaves respectively.

Burhan et al., (1989) reported that Cinosulfuron at 20g

a.i./ha resulted in more than 85% control of Monochoria vaginalis, marsilea crenata, Cyperus spp. and that weed control was superior than that provided with 2,4-D. They further observed that Setoff caused less damage to rice, about 0.03% when applied 3 to 9 days after transplanting compared with 11 to 12% obtained with 2,4-D applied at 6 to 12 days after transplanting. Guerra et al., (1989) reported that Cinosulfuron control broad range of weeds in rice without injury. The herbicide was effective when applied at 1 to 2 leaf stage of rice upto tillering. A rate of 80g a.i/ha provided adequate control of weeds. Zoschke et al., (1989) reported that when Cinosulfuron plus Duinclorac at the rates of 20 to 45g a.i./ha + 300g a.i./ha respectively applied 10 to 15 days after transplanting, the results indicated that the treatments did not caused more than 10% crop phytotoxicity and all the major weeds of South Korea were controlled with consequent increase in rice yield by approximately 20% by the treatments.

At Samaru, all the mixture containing cinosulfuron produced low millet grain yield. Terbuthylazine plus cinosulfuron at 0.75 + 0.01kg a.i./ha and prometryne plus cinosulfuron at 1.0 + 0.02kg a.i./ha however, resulted in the production of acceptable yield of all varieties of millet (Anon. 1994). However, no work have been done with this herbicide on garlic.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental Sites

Two sets of field experiments (weed interference and weed control) were conducted on the Irrigation Site of the farm of the Institute for Agricultural Research (I.A.R), Samaru (11°11¹N, 07°38¹ E 680m) in the Northern Guinea Savanna of Nigeria during the 1994 and 1995 dry seasons to determine the effect of period of weed interference and evaluate different herbicide treatments on garlic. The site for the two trials was cropped to tomato during the 1993 dry season. The soil of the site of the trials was sandy Loam. Details of the physico-chemical composition of the soil are presented in (Table 1). Detail of meteorological records of 1994 and 1995 at Samaru are shown in (Table 2). The most prevalent weed species observed at the site of the trials were mainly grasses and sedges at the early stage of the crop growth and broadleaved weeds at the later stage of crop growth. Detail of types of weed species and their level of occurrence at the site of the trials are contained in (Table 3).

3.2 Cultural Practices

3.2.1 Land Preparation

The experimental sites were ploughed, harrowed and marked out into paralled rows cf plots separated by 0.5m Irrigation channels and foot path. The plots consisted of levelled rectangular slightly sunken basins of Gross plot = 3m x 2m; net plot 2m x 1.5m sizes.

3.2.2 Fertilizer application

Single superphosphate at the rate of 45kg P_2O_5 /ha was incorporated into the basin as basal fertilizer before planting. Urea at the rate of 65kg N/ha was applied in two equal doses at 3 and 6 weeks after planting (WAP) using band placement between the rows.

3.2.3 Test-crop variety

A local variety of garlic "Ex-Kofa", popularly grown around Kofa village in Kano State was used. "Ex-Kofa" is one of the most popularly grown in Nigeria and it was used for the study because of its high yield potential. The mature bulb is globular in shape with white outer covering. The cloves have pink or light pink outer scales.

3.2.4 Preplanting and planting operations

Planting was carried out on 30th November and 1st November in 1994 and 1995, respectively. A day before planting, cloves were separated and soaked in water overnight. The field plots (basins) were also pre-irrigated the day before planting. Irrigation was supplied by surface flooding the basins at a 4 to 5 days interval. Planting was done manually on the prepared plots, with one clove per hole at a spacing of 20cm x 15cm between and within rows respectively. At one week after planting, gaps caused by non-emergence of cloves were replanted.

Table 1: Physico-chemical properties of the soil of the experimental sites at Samaru, 1994 and 1995 dry seasons.

Soil Compositon	Soil Depth (cm)			
	1994		1995	
	0-15	15-30	0-15	15-30
Particle size (%)				
Sand	35	30	40	30
Silt	43	44	36	30
Clay	22	26	24	40
Textural class	Loam	Loam	Loam	Clay-loam
Chemical properties				
PH in water	6.6	6.7	6.8	6.8
PH in $cacl_2$	6.0	5.9	6.4	6.5
Organic carbon (%)	0.54	0.84	0.62	0.96
Total Nitrogen (%)	0.098	0.056	0.084	0.112
Available prosphorus (ppm)	9.86	2.24	13.44	4.03
Exchangeable cation meq/ 100g soil				
Ca	1.40	0.70	1.40	1.60
Mg	0.88	0.70	1.02	1.38
K	0.46	0.32	0.37	0.42
Na	0.17	0.17	0.11	0.42
C.E.C	5.80	4.60	5.10	6.10

Table 2: Records of mean temperature and relative humidity at 10-days interval at Samaru, 1994/95 and 1995/96 dry seasons

	Temperature °C						Relative humidity (%)					
	1994		1995		1996		1994		1995		1996	
	Max.	Min	Max.	Min.	Max.	Min.	10am	4pm	10am	4pm	10am	4pm
January												
1-10	-	-	30.7	10.9	31.6	10.0	-	-	21.2	19.4	21.1	17.8
11-20			31.1	9.3	32.2	9.8	-		28.4	20.8	32.9	15.2
21-31	-		25.8	11.3	31.7	18.7	-		52.0	25.6	30.2	10.0
February												
1-10	-		28.1	11.4	32.9	11.5	-		35.2	27.5	22.3	15.4
11-20			31.1	13.8	34.1	19.4	-		19.6	14.4	22.6	19.4
21-28			26.3	12.1	32.6	18.4	-		25.1	13.2	20.8	14.0
March												
1-10			36.2	15.6	-	-	-		23.1	31.9	-	-
11-20	-		36.1	18.8	-	-	-		30.8	33.7	-	-
21-31			38.6	22.7	-	-	-		26.4	29.1	-	-
November												
1-10			27.6	17.2	-	-	-		64.1	53.8	-	-
11-20	-		29.4	14.9	-	-	-		39.5	40.8	-	-
21-30			28.3	14.3	-	-	-		27.4	19.2	-	-
December												
1-10	26.3	12.13	34.5	12.3	-	-	53.1	50.4	18.8	21.0	-	-
12-20	26.0	10.5	34.3	16.3	-	-	33.3	31.1	21.4	20.4	-	-
21-30	31.4	12.2	33.1	14.1	-	-	21.8	33.8	26.7	23.7	-	-

Table 3: List of common weed species present at the experimental sites and their levels of infestation

Types of Weeds	Level of Weed infestation 1994	1995
A) Grasses		
Chloris pilosa Schuncash.	**	**
Gynodon dactylon (L.) pers	***	***
Dactyloctenum aegyptium (L) Richt	***	***
Eleusine indica (L.)	**	**
Eragrostis tremula Hochst. ex steud	***	***
Pennisetum perdicellatum Trin	**	**
Rottboellia cochinchinensis (L) Roxb	**	**
B) Broad leaved weeds		
Acanthospermum hispidum DC)	**	**
Ageratum Conyzoides	***	***
Amaranthus spinosus (L)	*	*
Crotalaria retusa (L)	*	*
Cuscuta australis R. Br	*	-
Euphorbia heterophylla (L)	**	*
Euphorbia hirta (L)	**	**
Physalis angularis (L) Br	*	*
Solanum nigrum (L)	*	*
Vernonia galamensis (cass) L.	**	**
C) Sedges		
Cyperus rotundus (L)	***	***
Cyperus esculentus (L)	***	***

* = Low infestation

** = Moderate infestation

*** = Heavy infestation

- = Nil (Absent).

3.2.5 Herbicide Application

Herbicides were applied with a knapsack sprayer using deflector nozzle at a swath width of 75cm, a pressure of 2.1 kg/cm^2 and in a spray volume of 250L/ha. All the herbicides were applied after light irrigation at one day before planting garlic cloves.

3.3 Treatments and Experimental layout

The weed interference trial was laid out in a randomized complete block design and replicated four times. There were ten treatments in the weed interference trial (Table 4). In One set of the treatments, plot were kept weed-free initially for 3, 6, 9 and 12 WAP and subsequently left weed infested till harvest. In the other set of treatments, plots were initially weed infested for the corresponding periods indicated for the first set and subsequently kept weed-free till harvest. Two treatments in which the plots were either kept weed-free or weed-infested until harvest were included for comparison.

In the weed control study, eleven herbicides treatments were compared with hoe weeding at 3 and 6 WAP (control) and a weedy check in a randomized complete block design with three replicates. Detail of the treatments are contained in (Table 5)

The gross and net plot sizes in the two experiments were 6.00m^2 and 3.00m^2 respectively. Small hand hoes were used for weed removal both in the weed interference and herbicide evaluation trials according to treatments.

Table 4: Details of treatments for the weed interference trial in garlic at Samaru, 1994 and 1995 dry seasons

Treatments	Code
period of Weed interference	
Weed free for 3 WAP	*
Weed free for 6 "	*
Weed free for 9 "	*
Weed free for 12 "	*
Weed free until harvest	*
Weed-infested for 3 WAP	**
Weed-infested for 6 WAP	**
Weed-infested for 9 WAP	**
Weed-infested for 12 "	**
Weed-infested until harvest	**

WAP = weeks after planting
* = plots kept weed-free for various periods and subsequently allowed to be infested by weeds until harvest.
** = plots kept weed-infested for various periods and subsequently kept weed-free until harvest.

Table 5: Details of herbicide treatments for the weed control trial in Garlic at Saramu, 1994 and 1995 dry seasons

Treatments (Herbicides)	Rate g a.i./ha
Oxadiazon	750
Oxadiazon	1000
Oxadoazon	1500
Oxadiazon + Chloroxuron	750 + 1000
Oxadiazon + chloroxuron	750 + 2000
Oxadiazon + prometryne	750 + 1000
Oxadiazon + prometryne	750 + 1500
Oxadiazon + Cinosulfuron	750 + 10
Oxadiazon + Cinosulfuron	750 + 20
Oxadiazon + CGA 152'005	750 + 10
Oxadiazon + CGA 152'005	750 + 20
Hoe weeding at 3 and 6 WAP	
Weedy check.	

WAP = Weeks after planting

3.4 Data Collection

3.4.1 Weed cover score

Weed cover score in the two trials was taken at 3, 6, 9 and 12 WAP using a scale of 0 to 10, where 0 represent no weed cover and 10 represented complete weed cover.

3.4.2 Weed dry weight (kg/ha)

Weed samples were taken from 400cm^2 per plot before each weeding was done at 3,6,9 and 12 WAP. The samples were cleaned free of soil and oven-dried at 70°C for 48hrs to constant weight for dry matter determination. In the weed interference trial, weed weight was determined by adding the weight at the time of each weeding and at harvest.

3.5 Crop growth Parameters

3.5.1 Stand count

Stand count was taken at 3, 6, 9 and 12 WAP from the net plot inorder to assess the effect of the treatments on crop establishment.

3.5.2 Crop vigour score

Crop vigour score was taken at 3,6,9 and 12 WAP, using a scale of 0 to 10, where 0 was scored for a plot with completely dead plants and 10 for a plot with the most vigorous plants.

3.5.3 Plant height

Heights of 6 tagged plants were measured in each plot at 3, 6, 9 and 12 WAP from the base of the plant to the tip of the tallest formed leaf, using a metre-rule. The average height of the 6 plant samples were expressed in centimetre per plant.

3.5.4 Number of fully opened leaves

The number of fully opened leaves of the 6 tagged plants were taken at 3, 6, 9 and 12 WAP.

3.5.5 Leaf dry weight

The fresh leaves were placed in an oven se tat 70°C, to dry to a constant weight. The dry materials were weight and averaged expressed in grams per plant.

3.5.6 Crop injury score

Crop injury score was taken at 3, 6, 9 and 12WAS in herbicides treated plots. A scale of 0-10 was used, were 0 and 10 represented no injury and seriously injured plants plant respectively.

3.6 Yield and yield components

The following measurements were taken at harvest:

3.6.1 Fresh and dry weight of cloves

Cloves were separated from each of the 6 bulbs, samples per plot. The fresh cloves were weighed on the balance and expressed in grams. The fresh cloves after weighing were oven-dried at 70°C to a constant weight. The dry material was weighed and expressed in grams.

3.6.2 Bulb diameter

The diameter of 6 bulb sampled were measured using a venier calliper and the average bulb diameter expressed in millimetre.

3.6.3 Bulb yield per hectare

The total bulbs harvested from the net plot (2m x 1.5m) were weighed after 7 days of air-drying (curing). These plot yield were then expressed in kilograms.

3.7 Data Analysis

The data were subjected to analysis of variance for test of significance and treatment means were compared using Duncan multiple range test at five percent level of probabilities. Correlation coefficient and regression analysis were also done on appropriate parameters.

Predicted yields of garlic bulb as affected by periods of weed interference were estimated using the equation.

$$Y=a+b_2Z_2+b_3Z_3$$

Where Y = Yield/weed dry matter production and Z_2 and Z_3 are function of time of weeding period such that slope is zero at t=0 (time of sowing) and t=15 (time of harvesting) and a, b_2 and b_3 are regression coefficients. The reconstituted equation in cubic form is

$$Y= a+bt + b_2t^2 + b_3t^3$$

The equation given a relationship of yield/weed dry matter production and weeding time which has a zero slope at both t=0 and t=15 weeks.

In the weed control trial, bulb yield of different treatments as percentage of the untreated was obtained using the following equation.

$$D = \frac{A-B \times 100}{B}$$

Where A = Yield of the appropriate treatment, B= Yield of the untreated check and D=percent of the untreated check.

CHAPTER 4

4.0 RESULTS

4.1 Effect of Period of Weed Interference on Growth and Yield of Garlic

The effect of period of weed interference on various plant parameters viz: plant height, crop stand count, crop vigour score, number of fully opened leaves, leaf dry matter, bulb diameter, cloves fresh and dry weight, bulb yield and weed dry matter as well as weed cover score are contained in (Tables 6 to 12)

4.1.1 Plant height (cm)

The period of weed interference had a significant effect on the height of garlic plant at 9 and 12 WAP in both years while non-significant differences, amount treatment were observed at 6 WAP in both years (Table 6).

In both years, at 9 WAP, garlic plants of plots weed infested initially for the same 6 and 9 WAP indicated were significantly shorter than those of the plots kept weed-free for 6 and 9 WAP and those infested initially for 3 WAP only. In 1994, plants weed infested for 9 WAP had shorter plants than those infested for 6 WAP and those kept weed-free initially for 3 WAP only.

At 12 WAP, garlic plants kept weed-free for the indicated periods were significantly taller than those weed infested for 9 and 12 WAP in both years. In 1994, garlic plants height increased significantly with weed- free period and decreased with infestation periods. No difference was observed in the height of the plants

weed-infested for 9 and 12 WAP in 1994. In 1995, garlic plants weed-infested for 9 and 12 WAP were also shorter than those kept weed-free initially for the same period.

4.1.2 Crop stand count

Stand count was significantly affected by the period of weed interference in the two trials (Table 7.) In 1994, plots kept weed-free initially for 3 WAP only had significantly lower stand count than the appropriately maxima at 6, 9 and 12 WAP in 1994 and at 12 WAP in 1995. In 1994, at 9 and 12 WAP, stand count decreased with increasing period of weed infestation, although, the difference between infestation periods of 9 and 12 WAP was not significant.

In 1995, plots kept weed-free for 3 WAP only and those infested for 9 and 12 WAP had significantly lower stand count than the other periods of weed interference.

4.1.3 Crop vigour score

Periods of weed-interference had significant effect on crop vigour score at 9 and 12 WAP in the two trials and also at 6 WAP in 1994 (Table 8). Garlic plants of the plots weed infested for 6 WAP and more and those kept weed-free initially for 3 WAP only had significantly lower vigour at 9 and 12 WAP than the appropriate maxima in the two years.

In 1994, weed-infestation for 6 WAP also depressed the vigour of garlic plants. In both years, crop vigour score significantly decreased with period of weed-infestation and increased with weed - free periods upto 9WAP.

Table 6: Effect of period of weed interference on plant height of garlic at Samaru, 1994 and 1995 dry seasons.

Period of weed interference	Plant height (cm) 1994 6WAP[1]	1994 9WAP	1994 12WAP	1995 6WAP	1995 9WAP	1995 12WAP
Weed-free for 3 WAP	22.92a	23.98b[2]	19.30d	28.97a	31.41ab	26.00abc
Weed-free for 6 WAP	23.48a	26.28ab	21.75c	26.90a	37.52a	40.00ab
Weed-free for 9 WAP	-[3]	26.63a	27.40b	-	39.10a	45.61a
Weed-free for 12 WAP	-	-	30.92a	-	-	45.50a
Weed-free until harvest	-	-	-	-	-	-
weed-infested for 3 WAP	22.10a	26.15ab	31.42a	26.56a	40.14a	45.40a
Weed-infested for 6 WAP	21.20a	24.83ab	26.58b	26.55a	29.97ab	34.11abc
Weed-infested for 9 WAP	-	14.98c	12.55e	-	21.56b	23.00bc
Weed-infested for 12 WAP	-	-	10.90e	-	-	21.10c
Weed-infested until harvest	-	-	-	-	-	-
$SE_{\pm}$	0.61	0.54	0.47	1.37	2.65	3.36

1 = Weeks after planting
2 = Treatments had not been applied at the time of observation
3 = means followed by the same letter(s) within a column are not significantly different at 5% level using Duncan's multiple Range Test (DMRT)

Table 7: Effect of period of weed interference on crop stand count of garlic at Samaru, 1994 and 1995 dry seasons

	Crop stand Count/3.00[2]					
	1994			1995		
	6WAP	9WAP	12WAP	6WAP	9WAP	12WAP
Period of weed interference						
Weed-free for 3 WAP[1]	47.00b[3]	38.75b	38.50b	50.00	50.00a	45.00b
Weed-free for 6 WAP	49.75a	49.25a	49.25a	50.00	50.00a	49.75a
Weed-free for 9 WAP	- [2]	49.75a	49.75a	-	50.00a	50.00a
Weed-free for 12 WAP	-	-	49.75a	-	-	50.00a
Weed-free until harvest	-	-	-	-	-	-
Weed-infested for 3 WAP	49.50a	49.50a	49.50a	50.00	50.00a	50.00a
Weed-infested for 6 WAP	49.25a	39.25b	39.25b	50.00	50.00a	50.00a
Weed-infested for 9 WAP	-	29.25c	28.50c	-	41.75b	39.00c
Weed-infested for 12WAP	-	-	27.75c	-	-	29.00d
Weed-infested until harvest	-	-	-	-	-	-
SE±	0.25	0.34	0.39	0.51	0.52	0.68

1. Weeks after planting
2. Treatments had not been applied at the time of observation.
3. Means followed by the same letter(s) within a treatment are not significantly difference at 5% level using Duncan multiple Range Test (DMRT)

Table 8: Effect of period of weed interference on crop vigour score of garlic at Samaru, 1994 and 1995 dry seasons

	Crop Vigour score[3]					
	1994			1995		
	6WAP	9WAP	12WAP	6WAP	9WAP	12WAP
period of weed interference						
Weed-free for 3 WAP	10.00a[4]	4.00c	3.25d	10.00	6.25c	4.75c
Weed-free for 6 WAP	10.00a	9.75a	8.25c	10.00	10.00a	9.25ab
Weed-free for 9 WAP	-[2]	10.00a	9.75ab	-	10.00a	10.00a
Weed-free for 12WAP	-	-	10.00a	-	-	10.00a
Weed-free until harvest	-	-	-	-	-	-
Weed-infested for 3 WAP	10.00a	10.00a	10.00a	10.00	10.00a	10.00a
Weed-infested for 6 WAP	9.25b	8.75b	9.00bc	10.00	8.75b	8.50b
Weed-infested for 9 WAP	-	3.50c	3.00d	-	3.50d	3.25d
Weed-infested for 12WAP	-	-	2.50d	-	-	2.75d
Weed-infested until harvest	-	-	-	-	-	-
SE±	0.08	0.15	0.22		0.20	0.23

1 = Weeks after planting
2 = Treatments had not been applied at the time of observation
3 = Crop vigour score using scale (0-10); where o = completely killed plants and 10 = most vigorous plants.
4 = Means followed by same letter(s) within a treatment are not significantly different at 5% using Duncan multiple Range Test (DMRT)

4.1.4 Number of fully opened leaves

The number of fully opened leaves per plant was significantly affected by periods of weed interference at 9 and 12WAP in both years and at 6WAP in 1995 (Table 9). In both years except at 12WAP in 1994, plants weeds infested for 6WAP and more had significantly lower number of opened leaves at 6,9 and 12WAP than the appropriate maxima. Similarly, garlic plants kept weed-free for 3WAP only had lower leaf count at 9 and 12WAP than the appropriate maxima in both years.

In 1995, plots kept weed-free for 6WAP only also had lower opened leaf number at 12WAP than the maximum.

4.1.5 Leaf Dry Weight per plant

The period of weed interference had significant effect on leaf dry weight of garlic at 9 and 12WAP (Table 10). In 1994, plant weed infested for various periods and those kept weed-free for 3WAP only had lower leaf dry matter production at 9WAP than those kept weed-free for 9WAP. At 12WAP, those infested for 6WAP and more and those kept weed-free for 3 and 6WAP were however lower in leaf dry matter. Generally, leaf dry matter decreased with infestation period.

In 1995, garlic leaf dry matter of plants weed infested for 9WAP and more and those kept weed-free for 3WAP only were lower than those of the plots kept weed-free initially for 6WAP and more periods.

Table 9: Effect of period of weed interference on number of fully opened leaves of garlic at Samaru, 1994 and 1995 dry

	Number of fully opened leaves/plant					
	1994			1995		
	6WAP	9WAP	12WAP	6WAP	9WAP	12WAP
Period of weed interference						
Weed-free for 3 WAP[1]	4.25	6.94bc[3]	7.87bc	3.78a	7.25c	6.58d
Weed-free for 6 WAP	4.44	9.31ab	12.59abc	3.43ab	9.70ab	10.45c
Weed-free for 9 WAP	-[2]	11.78a	16.19a	-	10.80a	14.13a
Weed-free for 12 WAP	-	-	16.02a	-	-	14.18a
Weed-free until harvest	-	-	-	-	-	-
Weed-infested for 3 WAP	4.00	11.69a	18.19a	3.45ab	10.50ab	13.80a
Weed-infested for 6 WAP	3.18	7.81bc	14.47ab	3.28c	6.23d	11.75b
Weed-infested for 9 WAP	-	5.73c	6.10c	-	4.23e	3.03e
Weed-infested for 12WAP	-	-	6.25c	-	-	3.05e
Weed-infested until harvest	-	-	-	-	-	-
SE±	0.17	0.71	1.56	0.09	0.22	0.27
	NS					

1 = Weeks after planting
2 = Treatments had not been applied at the time of observation
3 = Means followed by the same letter(s) within a treatment are not significant difference at 5% level using Duncan multiple Range Test (DMRT)
NS = Not significant

Table 10: Effect of period weed interference on leaf dry weight and Bulb diameter of garlic at Samaru, 1994 and 1995 dry seasons.

	1994				1995			
	leaf dry weight /plant (g)			Bulb diameter (mm)	Leaf dry weight /plant (g)			Bulb diameter (mm)
Period of weed interference	6WAP	9WAP[1]	12WAP	Maturity	6WAP	9WAP	12WAP	Maturity
Weed-free for 3WAP	1.50	2.80c[3]	2.45c	1.74ab	1.79	2.89b	2.65b	2.15cd
Weed-free for 6WAP	1.48	3.95ab	4.23b	2.26ab	1.83	5.77a	4.73a	3.11bc
Weed-free for 9WAP	-[2]	4.05a	6.68a	3.11ab	-	5.81a	4.67a	3.45ab
Weed-free for 12WAP	-	-	6.89a	3.54ab	-	-	4.75a	4.27a
Weed-free until harvest	-	-	-	3.86a	-	-	-	4.51a
Weed-infested for 3 WAP	1.02	3.45b	6.68a	3.85a	1.80	5.64a	4.66a	4.48a
Weed-infested for 6 WAP	1.01	2.69c	3.80b	2.80ab	1.71	4.38ab	4.29a	3.01bc
Weed-infested for 9 WAP	-	1.88d	1.95c	1.55ab	-	2.90b	1.88bc	1.37de
Weed-infested for 12 WAP	-	-	1.90c	1.50b	-	-	1.10c	1.2de
Weed-infested until harvest	-	-	-	1.57ab	-	-	-	0.97e
SE±	0.40 NS	0.12	0.18	0.51	0.20 NS	0.49	0.29	0.25

1 = Weeks after planting
2 = Treatments has not been applied at the time of observation
3 = Means followed by same letter(s) within a treatment are not significantly different at 5% level using Duncan multiple Range Test (DMRT)
NS = Non significant

4.1.6 Bulb diameter

Period of weed interference significantly affect bulb diameter at maturity in the two trials (Table 10). Although it only followed a discernible trend in 1995. In 1995, bulb diameter generally decreased with increasing period of weed infestation and increased with weed-free period. Specifically, garlic plants kept weed-free for 3 and 6WAP and those infested for 6WAP and more had smaller bulb diameter than those kept weed-free for 9WAP and more in both years.

4.1.7 Cloves fresh and dry weight

The effect of periods of weed interference was significant on cloves fresh and dry weight in both years (Table 11). In both years, garlic plants weed infested initially for 9WAP and beyond and plants kept weed free for 3 WAP had significantly lower cloves fresh weight compared with plots kept weed-free throughout and those infested initially for 3WAP only. In 1994 garlic plants weed infested for 9 WAP and beyond produced significantly lower cloves dry matter compared with plots kept weed-free upto 6 WAP and till harvest and weed-infested initially for 3 WAP only. In 1995, cloves dry weight of plants kept weed-free for 3WAP initially was also lower than that of the plant kept weed-free throughout and corresponding weed infested plants.

4.1.8 Bulb yield

Periods of weed interference had significant effect on garlic bulb yield in both years (Table 11). In both years, plants weed-infested for 9 WAP and more and weed free initially for 3 WAP had

Table 11: Effect of period of weed interference on cloves fresh weight, cloves dry matter and Bulbs yield of garlic at Samaru, 1994 and 1995 dry seasons.

	1994			1995		
Period of weed interference	Cloves fresh weight (g)/plot	Cloves dry matter (g)/plot	Bulbs yield (kg/ha)	Cloves fresh weight g/plot	Cloves dry matter g/plot	Bulbs yield (kg/ha)
Weed-free for 3 WAP[1]	10.9c[2]	3.2ab	135bc	10.6a-d	2.8bc	601ab
Weed-free for 6 WAP	12.3a	3.7ab	290ab	14.3ab	4.3ab	1131a
Weed-free for 9 WAP	14.1a	4.7a	384a	14.9a	4.6ab	1234a
Weed-free for 12 WAP	14.6a	5.1a	323a	15.5a	5.2a	1217a
Weed-free until harvest	18.3a	6.5a	363a	15.8a	5.1a	1249a
Weed-infested for 3 WAP	17.6a	6.3a	358a	14.9a	4.6ab	1197a
Weed-infested for 6 WAP	12.2b	3.1ab	246a-c	13.2a-c	4.0ab	984ab
Weed-infested for 9 WAP	8.5c	2.2b	154bc	9.1b-d	1.8c	286b
Weed-infested for 12WAP	6.8c	1.6b	107c	7.6cd	1.3c	288b
Weed-infested until harvest	7.5c	1.6b	104c	6.9d	1.3c	227b
$SE_{\pm}$	1.77	0.81	32.32	1.26	0.41	162.78
LSD (0.05)	3.63	1.66	66.32	2.59	0.84	333.98

1 = Weeks after planting
2 = Mean followed by the same letter(s) with a treatment are not significantly different at 5% levels using Duncan mulptiple Range Test (DMRT)

significantly lower bulb yield than those kept weed-free initially for 6 WAP till harvest and those infested initially for 6 WAP only. The bulb yield in 1995 was generally 2 to 3 times higher than that of 1994.

4.1.9 Weed cover score

The period of weed interference had a significant effect on the weed cover score at 9 and 12WAP (Table 12). In both years, at 9WAP plants weed-infested initially had significantly higher weed cover score than those kept weed-free initially for 6 and 9WAP and those infested initially for 3WAP only. At 12WAP, plant weed infested for 12 WAP had significant higher weed cover than those kept weed-free until 12WAP in both years.

In 1995, plants weed infested for 9WAP were also higher in weed cover than those weed infested for 6 WAP and those kept weed-free initially for 3 WAP only.

4.1.10 Weed dry matter production

Period of weed interference had significant effect on weed dry matter production in both years (Table 12). In both years, plots weed infested for 6 WAP and more had high weed dry matter than those plots kept weed-free initially for 6 WAP and more and those infested initially for 3 WAP only.

Weed dry matter increased with weed infestation and decreased with weed-free period in both years. In 1995, difference between infestation periods of 9 WAP and more was not significant.

Table 12: Effect of period of weed inteference on weed cover score, weed dry weight of garlic at Samaru, 1994 and 1995 dry seasons.

Period of weed interference	Weed cover score[4]						Cumulative weed dry weight at harvest (kg/ha)	
	1994			1995			1994	1995
	6WAP	9WAP	12WAP	6WAP	9WAP	12WAP		
Weed-free for 3WAP[1]	1.25b[3]	8.25b	8.75b	1.25b	7.75b	8.75b	92.3d	61.4b
Weed-free for 6WAP	1.00b	2.50c	6.00c	1.00b	2.00c	4.75c	63.9e	47.3c
Weed-free for 9WAP	-[2]	1.00d	2.00d	-	1.00d	1.75d	31.2f	22.7d
Weed-free for 12WAP	-	-	1.00e	-	-	1.00d	8.8fg	7.6e
Weed-free until harvest	-	-	-	-	-	-	7.8g	5.8e
Weed-infested for 3 WAP	1.00b	1.00d	0.75e	1.00b	1.00d	1.00d	9.1fg	6.1e
Weed-infested for 6 WAP	2.25a	1.00d	0.25e	2.25a	1.00d	1.00d	84.0de	55.9bc
Weed-infested for 9 WAP	-	9.75a	0.25e	-	9.75a	1.00	107.8bc	82.5a
Weed-infested for 12WAP	-	-	10.00a	-	-	9.75a	11.8ab	91.9a
Weed-infested until harvest	-	-	-	-	-	-	137.8a	92.9a
$SE_{\pm}$	0.11	0.14	0.20	0.11	0.11	0.16	5.17	3.01

1 = Weeks after planting
2 = Treatments had not been applied at the time of observation
3 = Means followed by the same letter(s) within a treatment are not significant different at 5% Level using Duncan multiple Range Test (DMRT)
4 = Weed cover score where 0 represented no weed cover, and 10 represented complete weed cover.

4.1.11 Predicted Garlic bulb yield in response to periods of weed interference

Figures 1 and 2 are curves of predicted values of total garlic bulb yield in response to period of weed interference using a cubic regression of various equation. The equation give a relationship of yield and weeding time which has a zero slope at t=0 and t=15 weeks.

In 1994, it was estimated that keeping the crop weed-free initially for 38 and 49 days after sowing resulted in 25 and 10% loss in total bulb yield, respectively. Similarly, once the plants were infested for 27, 40 and 91 days after sowing, it was estimated that 10, 25 and 70% reduction in total bulb yield of garlic would occur (Fig.1). In 1995, inorder to obtained 20 and 10% yield reduction the crop should be kept weed-free for 35 and 42 days after sowing, respectively. Similarly, crop infested for 38, 54 and 79 days after sowing, it was estimated that 20, 50 and 80% reduction in total yield would occur (Fig 2). Garlic (Ex. Kofa') was critically affected by weeds between 5 and 6 WAP. With this variety, it was required to keep the crop weed-free for 6 to 9 weeks of the life-cycle inorder to obtain maximum yield.

4.1.12 Predicted weed dry matter production in reponse to periods of Weed infestation

In 1994, initial weed-infestation for 94, 84 56 and 38 days after sowing resulted in 10, 20, 30 and 50% reduction in weed dry matter, respectively. Inorder to obtain 50% reduction in weed dry matter production, it was required to keep the plots weed-free for 40 days after planting (Fig 3).

In 1995, initial weed-infestation for 84, 63, 53 and 38 days after sowing, resulted in 10, 20, 30 and 50% reduction in weed dry matter, respectively. Inorder to obtain 50% reduction in weed dry matter, it was required to keep the plots weed free for 40 days after planting (Fig 4).

o- - -o Initially weed-free

o——o Initially weed-infested

$Y_1 = -226 + 177t - 16.5t^2 + 0.477t^3$

$Y_2 = 486 - 43.1t + 0.039t^2 + 0.0760t^3$

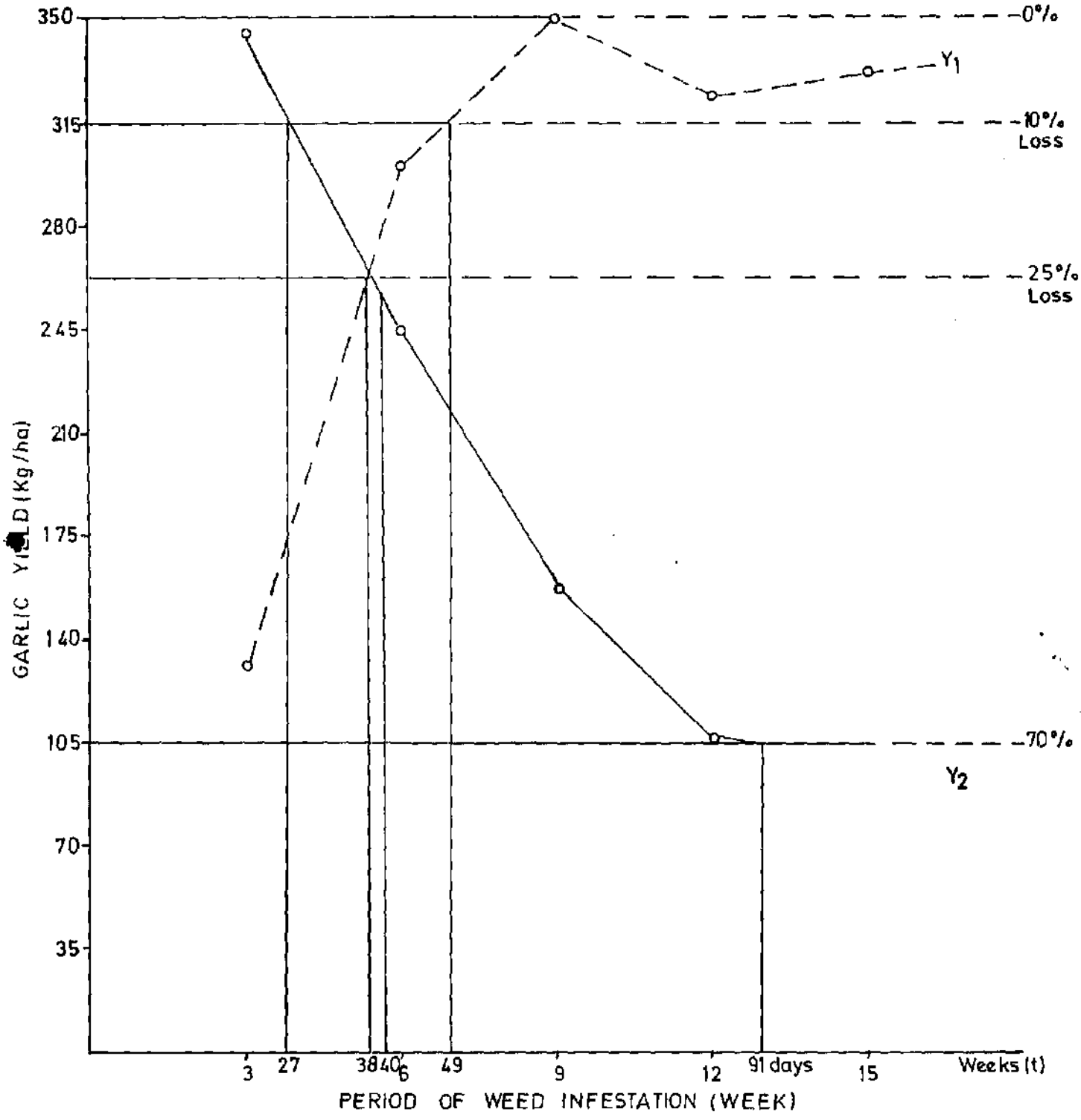


Fig.1. Regression values of total Garlic yields as affected by period of weed interference, Samaru, 1994

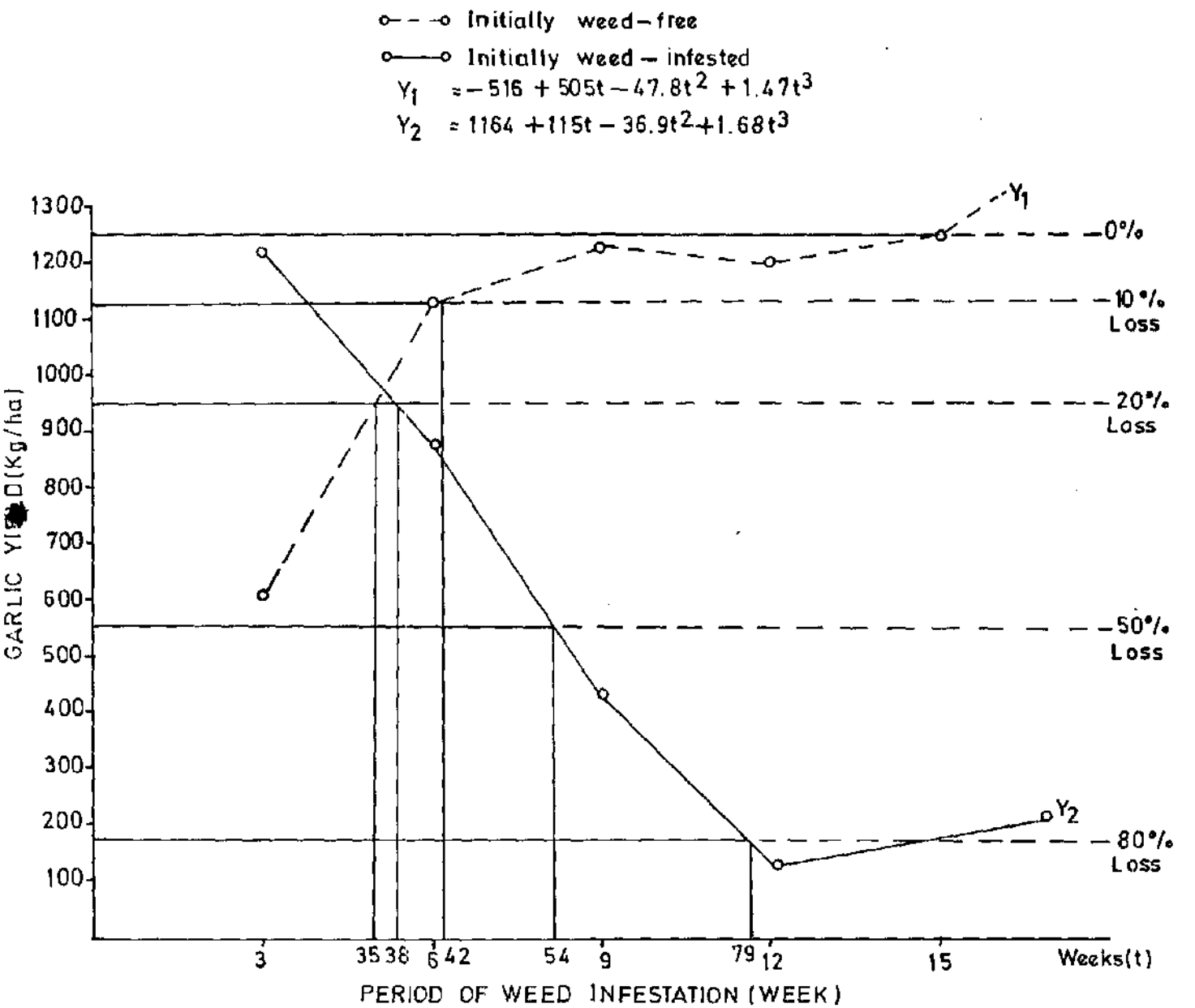


Fig.2. Regression values of total Garlic yields as affected by period of weed interference, Samaru, 1995

o — o Initially weed-free = Y_1

o — o Initially weed - infested = Y_2

$Y_1 = 104 + 0.129t - 1.63t^2 + 0.0795t^3$

$Y_2 = -143 + 67.3t - 6.06t^2 + 0.188t^3$

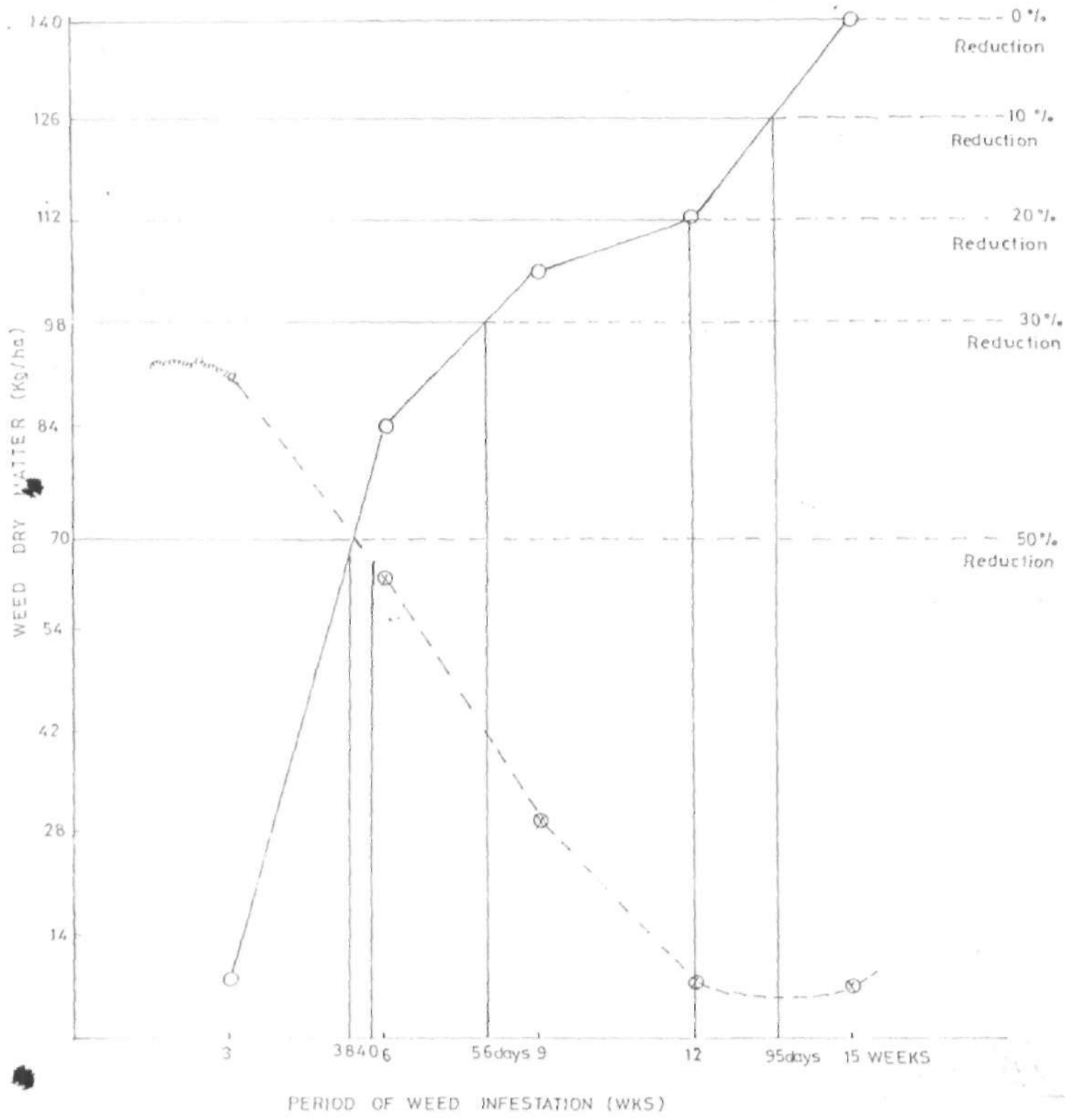


Fig. 3. Regression values of total weed dry matter production as affected by period of weed interference at Samaru, 1994.

o--o Initially weed free

o—o Initially weed infested

$Y_1 = 58.2 + 5.59t - 1.70t^2 + 0.0727t^3$

$Y_2 = -75.2 + 33.1t - 2.15t^2 + 0.0458t^3$

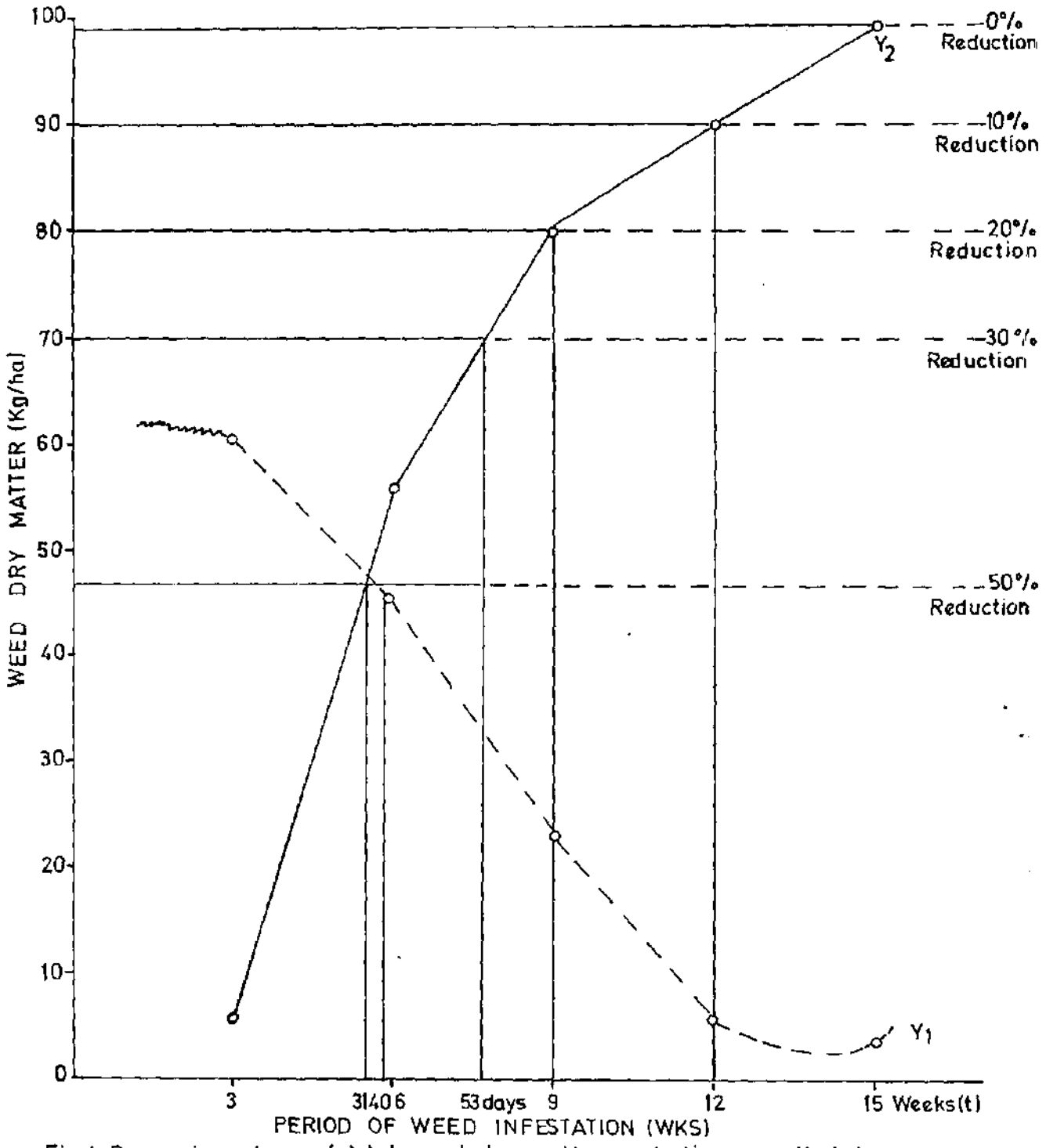


Fig.4. Regression values of total weed dry matter production as affected by period of weed interference at Samaru, 1995.

4.1.13 Relationship between various parameters and garlic bulb yield in the weed-interference studies

As shown in Tables 13 and 14, in both years, bulb yield of garlic was positively correlated with crop vigour score, bulb diameter, clove dry weight and number of fully opened leaves per plant at 9 WAS (r=0.41, 0.62, 0.64, 0.36 in 1994 and 0.37, 0.81, 0.71, 0.35 in 1995, respectively). Bulb yield was also positively correlated with crop stand count at 12 WAP in 1994 (Table 13). Weed cover score at 9 WAP, weed dry matter at 12 WAP number of cloves per bulb were however, negatively correlated with bulb yields in both years.

Table 13: Correlation of Bulb yield of garlic with various parameters in the weed interference studies at Samaru, 1994 dry season.

	1	2	3	4	5	6	6	7	8	9	10	12	13	14
1.	1.00													
2.	0.25	1.00												
3.	0.34*	0.67**	1.00											
4.	0.01	0.63**	0.37*	1.0										
5	-0.36*	0.36*	0.12	0.13	1.00									
6.	0.41**	0.93**	0.68**	0.57**	0.01	1.00								
7.	0.33*	0.97**	0.68**	0.53**	0.31	0.97**	1.00							
8.	0.36*	0.96**	0.69**	0.48**	0.25	0.95**	0.97**	1.00						
9.	-0.40**	0.05	0.02	0.15	0.32*	-0.06	-0.0	-0.02	1.00					
10.	-0.16	0.48**	0.33*	0.31	0.52**	0.22	0.33*	0.43*	0.19	1.00				
11.	0.62**	0.06	0.16	0.03	-0.35*	0.18	0.09	0.13	-0.26	-0.18	1.00			
12.	0.64**	0.12	0.71	-0.01	-0.23	0.19	0.13	0.20	-0.19	-0.05	0.52**	1.00		
13.	0.31	0.63**	0.68**	0.52**	0.30	0.95**	0.98**	-0.01	0.45**	0.07	0.07	0.13	1.00	
14.	0.35*	0.64**	0.98**	0.39*	0.06	0.68**	0.66**	0.65**	-0.00	0.210	0.2	0.217	0.65**	1.00

* significant at 5% level of probability(r^2=0.312)
** significant at 1% level of probability (r^2=0.403)
1. Bulb yield
2. Plant height at 9 WAP
3. Crop stand count at 12 WAP
4. Weed cover score at 6 WAP
5. Weed cover score at 9 WAP
6. Crop vigour score at 9 WAP
7. Leaf fresh weight at 9 WAP
8. Number of fully opened leaves per plant at 9 WAP
9. Number of cloves per bulb
10. Weed dry matter at 12 WAP
11. Bulb diameter
12. Cloves dry weight at maturity
13. Leaf dry matter at 9 WAP
14. Bulb dry matter at 12 WAP

Table 14: Correlation of Bulb yield of garlic with various parameters in the weed interference studies at Samaru, 1995 dry season.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1.	1.00													
2.	0.29	1.00												
3.	0.30	0.69**	1.00											
4.	0.17	0.55**	0.47**	1.00										
5.	-0.33*	0.32*	0.25	0.09	1.00									
6.	0.37*	0.94**	0.70**	0.61**	0.15	1.00								
7.	0.28	0.91**	0.68**	0.51**	0.26	0.95**	1.00							
8.	0.35	0.94**	0.68**	0.46**	0.24	0.95**	0.92**	1.00						
9.	-0.36*	-0.03	0.00	0.06	0.43**	-0.05	-0.04	-0.00	1.00					
10.	-0.38*	0.21	0.17	-0.00	0.97**	0.04	0.17	0.13	0.41**	1.00				
11.	0.81**	0.22	0.24	0.09	-0.36**	0.28	0.19	0.25	-0.52	-0.39*	1.00			
12.	0.79**	0.27	0.31	0.21	-0.33	0.33**	0.27	0.30	-0.51*	-0.37*	0.79**	1.00		
13.	0.30	0.90**	0.66**	0.50**	0.18	0.94**	0.99**	0.90**	-0.05	0.12	0.21	0.28	1.00	
14.	0.39*	0.64**	0.95**	0.38*	0.05	0.65**	0.62**	-0.62**	-0.16	-0.01	0.34**	0.44**	0.60	1.00

* significant at 5% level of probability (r^2 0.312)
** significant at 1% level of probability (r^2 0.403)
1. Bulb yield
2. Plant height at 9 WAP
3. Crop stand count at 12 WAP
4. Weed cover score at 6 WAP
5. Weed cover score at 9 WAP
6. Crop vigour score at 9 WAP
7. Leaf fresh weight at 9 WAP
8. Number of fully opened leaves per plant at 9 WAP
9. Number of cloves per bulb
10. Weed dry matter at 12 WAP
11. Bulb diameter
12. Cloves dry weight at maturity
13. Leaf dry matter at 9 WAP
14. Bulb dry matter at 12 WAP

4.2 Evaluation of Herbicides for Weed Control in Garlic

The results of the effects of weed control treatments on various parameters viz:- weed cover score, weed dry matter plant height, crop stand count, crop vigour score, number of fully opened leaves, crop injury score, leaf dry weight, fresh and dry weight of cloves per plot, the diameter and yield of garlic bulbs, are contained in Tables 15 to 23.

4.2.1 Weed cover score

The herbicide and hoe weeded treatments significantly reduced weed cover score at 6, 9 and 12 WAP compared with the weedy check in the two years (Table 15).

At 6 and 9 WAP in both years, oxadiazon alone at 1000 and 1500g a.i./ha and the mixture at 750g a.i./ha with chloroxuron at both rates, prometryne at 750 + 1500g a.i./ha and CGA 152'005 at 750 + 20g a.i./ha resulted in lower weed cover than oxadiazon plus cinosulfuron at 750 + 10g a.i./ha. In 1995, the herbicides and hoe-weeded treatments caused similar reduction in weed-cover scores at 6 WAS. At 6 and 9 WAP in 1994, and 12 WAS in 1995, oxadiazon at 750g a.i/ha also resulted in lower cover score than oxadiazon plus cinosulfuron at 750 + 10g a.i./ha. Oxadiazon at 1500g a.i/ha and the mixture at 750g a.i/ha with chloroxuron at both rates also resulted in significantly lower score at 9 and 12 WAP compared with oxadiazon plus prometryne at 750 + 1000g a.i/ha in both years. In 1995, at 12 WAP, oxadiazon plus CGA 152'005 at 750 + 20g a.i/ha also caused lower weed cover score than oxadiazon plus prometryne at 750 + 1000g a.i/ha. At sampling date, oxadiazon at 1000, 1500g a.i/ha resulted in lower weed cover than the lowest rate of 750g a.i/ha

Table 15: Effect of weed control treatments on weed cover and weed dry matter of garlic at Samaru, 1994 and 1995

Treatment	Rate (g a.i./ha)	Weed cover score[1] 1994 6WAP[2]	1994 9WAP	1994 12WAP	1995 6WAP	1995 9WAP	1995 12WAP	weed dry matter 1994	weed dry matter 1995
Oxadiazon	750	0.67cd	2.33cd	3.33b-e	1.05b	2.33bc	3.33cd	13.3b	12.8bc
Oxadiazon	1000	0.33cd	1.67d	2.33de	0.56b	1.67c-e	2.67de	13.6b	12.1bc
Oxadiazon	1500	0.80d	1.00d	2.33de	0.56b	1.00e	1.33e	10.2b	1.0d
Oxadiazon+chloroxuron	750+1000	0.00d	1.00d	2.00e	0.56b	1.00e	1.33e	9.7b	1.0d
Oxadiazon+chloroxuron	750+2000	0.67cd	1.67d	2.33de	0.81b	1.33de	2.33de	8.3b	9.8bc
Oxadiazon+Prometryne	750+1000	1.67bc	3.33c	4.33bc	1.05b	2.67b	4.33bc	10.7b	12.8bc
Oxadiazon+Prometryne	750+1500	0.33cd	1.00d	3.00cde	0.56b	1.00e	1.33e	8.8b	12.9bc
Oxadiazon+Cinosulfuron	750+10	2.67b	4.67b	4.67b	1.18b	2.67b	5.33b	16.6b	22.7b
Oxadiazon+Cinosulfuron	750+20	1.67bc	3.67bc	4.00bc	1.05b	2.00bc	3.67cd	8.3b	16.0bc
Oxadiazon+CGA 152'005	750+10	1.33bcd	3.67bc	3.80bcd	1.18b	2.00bcd	3.33cd	13.8b	8.5cd
Oxadiazon+CGA 152'005	750+20	0.33cd	1.33d	2.00e	0.81b	1.00e	2.33de	10.8b	6.2cd
Hoe weeded at 3 & 6WAP		0.33cd	4.76b	4.86b	1.05b	2.00bcd	4.33bc	22.5b	16.0bc
Weedy check		5.67a	7.67a	9.33a	2.09a	8.00a	9.67a	41.6a	39.9a
SE±		0.30	0.29	0.33	0.17	0.20	0.31	4.04	2.78

1. Weed cover using scale (0-10); 0=no weeds, 10=complete weed cover
2. WAP weeks after planting
3. Means followed by same letters within treatment are not significantly different at 5% level of significant using Duncan Multiple Range Test (DMRT).

4.2.2 Weed dry matter production

The effect of weed control treatments was significant on weed dry matter production in both years (Table 15). In both years, all the herbicide and hoe-weeded treatments resulted in significantly lower weeds dry matter production than the weedy check. In 1995, oxadiazon alone at 1500g a.i./ha and the mixture with chloroxuron at 750 + 1000g a.i./ha and CGA 152'005 at both rates resulted in significantly lower weed dry matter production than oxadiazon plus cinosulfuron at 750+ 10g a.i./ha. In the same year, hoe weeding caused higher weed dry matter production than oxadiazon alone at 1500g a.i./ha and the mixture with chloroxuron at 750 + 1000g a.i./ha.

4.2.3 Plant height

At all sampling dates in both years, plant height was depressed by oxadiazon plus cinosulfuron at 750 + 20g a.i./ha and oxadiazon plus CGA 152'005 at both rates compared with the hoe-weeded control (Table 16). In 1994, oxadiazon plus cinosulfuron at 750 + 10g a.i./ha and the weedy check also resulted in significantly shorter plants at 12 WAP compared with the tallest plant of garlic of the plots treated with oxadiazon plus chloroxuron at 750 + 1000g a.i./ha. In all cases, oxadiazon plus cinosulfuron at 750 + 20g a.i./ha caused the production of shorter garlic plant than the mixture containing a lower rate of cinosulfuron.

Table 16: Effect of weed control treatments on plant height of garlic at Samaru, 1994 and 1995 dry seasons.

Treatment	Rate (g a.i/ha)	Plant height (cm)							
		1994				1995			
		3 WAP	6 WAP[1]	9 WAP	12 WAP	3 WAP	6 WAP	9 WAP	12 WAP
Oxadiazon	750	20.57a	27.43a	35.20a	46.80ab	20.33ab	31.42a-d	35.84	40.03ab
Oxadiazon	1000	21.20a	28.03a	34.90a	46.90ab	19.97ab	37.50ab	43.17a	45.94ab
Oxadiazon	1500	21.27a	29.00a	37.00a	53.60a	22.13a	40.42a[2]	43.85a	47.62a
Oxadiazon+Chloroxuron	750+1000	20.73a	29.10a	38.60a	55.10a	23.73a	40.15a	43.25a	46.66a
Oxadiazon+Chloroxuron	750+2000	20.27a	29.03a	36.10a	46.57ab	20.33ab	34.92a-c	37.33ab	41.52ab
Oxadiazon+Prometryne	750+1000	20.67a	28.83a	32.40a	44.40ab	21.11a	36.67ab	39.39ab	40.30ab
Oxadiazon+Prometryne	750+1500	20.00a	28.30a	33.00a	53.43a	16.87bc	29.67bcd	35.92ab	38.55ab
Oxadiazon+Cinoeulfuron	750+10	17.47a	23.63a	27.70a	33.67b	13.07d	26.75cd	31.11b	33.38b
Oxadiazon+Cinosulfuron	750+20	7.93ab	7.70b	6.30b	1.90c	5.93e	7.50e	6.53d	5.47cd
CGA 152'00	750+10	6.35b	6.03b	5.60b	3.67c	6.33e	5.54e	4.51d	3.80d
Oxadiazon+ CGA 152'005	750+20	4.15b	3.73b	4.40b	2.23c	3.63e	5.54e	4.51d	3.80d
Hoe weeded at 3 & 6 WAP		20.43a	28.80a	35.90a	36.87a	21.73a	36.83ab	39.84ab	39.63ab
Weedy check		20.21a	23.33a	20.40ab	13.43c	15.50cd	23.00d	21.84c	16.71c
SE±		1.41	2.10	4.00	3.33	0.82	1.98	2.15	2.86

1. WAP= weeks after sowing
2. Mean followed by the same letter(s) within treatment are not significantly different at 5% level using Duncan multiple Range Test (DMRT)

4.2.4 Crop Injury

In the two years, weed control treatments had significant effect on crop injury score of garlic (Table 17). In all the observations, except at 3 WAP in 1995, mixtures of oxadiazon with the two sulphonylurea herbicides, each at both rates significantly caused severe injury to garlic than oxadiazon alone at all rates as well as hoe weeding and the weedy check. In 1994, oxadiazon plus prometryne at both rates also caused higher injury score than oxadiazon alone. In 1995, oxadiazon plus cinosulfuron at 750 + 10g a.i./ha resulted in injury score comparable to those of oxadiazon alone at 3 WAP. At both years, oxidiazon plus CGA 152005 at 750 + 20g a.i./ha caused the most injury to garlic.

4.2.5 Stand count

Garlic stand count was significantly affected by weed control treatments throughout 1994 and 1995 (Table 18). Uncontrolled weed throughout the crops life- cycle reduced garlic stand count significantly at 9 and 12 WAP in 1994, and at 12 WAP only in 1995 compared with the hoe weeded control. Similarly, in both years, oxadiazon plus cinosulfuron at 750 + 20g a.i./ha and oxadiazon plus CGA 152'005 at both rates reduced stand count of garlic significantly compared with the appropriate maxima. Oxadiazon plus sulphonylurea herbicides at higher rates had lower stand than the lower rates in both years, although not significant.

Table 17: Phytotoxicity of weed control treatment on garlic at Samaru, 1994 and 1995 dry seasons

Treatment	Rate (g a.i./ha)	Crop injury score of garlic[1] 1994 3WAP	6WAP[2]	9WAP	12WAP	1995 3WAP	6WAP	9WAP	12WAP
Oxadiazon	750	0.00d[3]	0.00e	0.00e	0.00d	0.00b	0.00d	0.00d	0.00d
Oxadiazon	1000	0.00d	0.00e	0.00e	0.00d	0.00b	0.00d	0.00d	0.00d
Oxadiazon	1500	0.00d	0.00e	0.00e	0.00d	0.00b	0.00d	0.00d	0.00d
Oxadiazon+chloroxuron	750+1000	0.00d	0.00e	0.00e	0.00d	0.00b	0.00d	0.00d	0.00d
Oxadiazon+chloroxuron	750+2000	0.00d	0.00e	0.00e	0.00d	0.00b	0.00d	0.00d	0.00d
Oxadiazon+Prometryne	750+1000	0.33d	0.67de	0.33de	1.00cd	0.66b	1.00c	0.67d	0.00d
Oxadiazon+Prometryne	750+1500	1.67c	1.67c	1.00cd	1.66bc	0.33b	1.33c	1.67c	2.00c
Oxadiazon+Cinosulfuron	750+10	2.00c	1.33cd	1.33c	2.33b	7.33a	7.33b	8.33a	9.00b
Oxadiazon+cinosulfuron	750+20	7.00b	7.33b	8.00b	9.67a	7.67a	8.00ab	8.67a	9.00b
Oxadiazon+CGA 152'005	750+10	7.33b	8.33a	8.67ab	8.67a	8.00a	8.67a	9.00a	9.67a
Oxadiazon+CGA 152'005	750+20	8.33a	9.00a	9.00a	9.67a	0.00b	0.00d	0.00d	0.00d
Hoe weeded at 3 & 6WAP		0.00d	0.00e	0.00e	0.00d	0.00b	0.00d	0.00d	0.00d
Weedy check		0.00d	0.00e	0.00e	0.00d	0.00b	0.00d	0.00d	0.00d
SE±		0.18	0.19	0.19	0.23	0.17	0.15	0.19	0.10

1. Crop injury score (using a scale of 0-10); 0 = No injury, 10 = dead crop
2. WAP= weeks after planting
3. Mean followed by the same letter(s) within treatment are not significantly different at 5% level using Duncan multiple Range Test (DMRT)

Table 18: Effect of weed control treatments on crop stand count of garlic at Samaru, 1994 and 1995 dry seasons.

Treatment	Rate (g a.i./ha)	stand count/net plot							
		1994				1995			
		3WAP[1]	6WAP	9WAP	12WAP	3WAP	6WAP	9WAP	12WAP
Oxadiazon	750	50.00a	50.00a	50.00a	49.00a	50.00a	50.00a	50.00a	50.00a
Oxadiazon	1000	50.00a	50.00a	50.00a	49.67a	50.00a	50.00a	50.00a	50.00a
Oxadiazon	1500	50.00a	50.00a	50.00a	50.00a	50.00a	50.00a	50.00a	50.00a
Oxadiazon+chloroxuron	750+1000	50.00a	50.00a	50.00a	49.33a	50.00a	50.00a	50.00a[2]	50.00a
Oxadiazon+chloroxuron	750+2000	50.00a	50.00a	50.00a	48.33a	50.00a	50.00a	50.00a	50.00a
Oxadiazon+Prometryne	750+1000	49.67a	49.33a	48.00a	48.00a	50.00a	50.00a	50.00a	50.00a
Oxadiazon+Prometryne	750+1500	48.67a	48.00a	47.00a	47.00a	50.00a	48.67a	48.67ab	48.67a
Oxadiazon+Cinosulfuron	750+10	49.67a	49.67a	49.67a	46.00a	50.00a	49.67a	49.67a	49.00a
Oxadiazon+Cinosulfuron	750+20	41.00b	39.00b	36.67b	27.00d	42.67b	45.00a	40.33b	30.00c
Oxadiazon+CGA 152'005	750+10	38.67b	39.00b	34.33b	32.33c	44.33b	36.33b	22.67c	18.00d
Oxadiazon+CGA 152'005	750+20	28.00c	24.33c	24.33c	23.00d	33.33c	31.33b	13.67d	4.33e
Hoe weeded at 3 & 6WAP		50.00a	50.00a	49.67a	49.00a	50.00a	50.00a	50.00a	50.00a
Weedy check		50.00a	50.00a	37.67b	37.00b	50.00a	50.00a	43.00ab	39.67b
$SE\pm$		0.55	0.85	1.05	1.34	1.07	1.68	1.74	1.37

1. WAP = Week after planting
2. Means followed by the same letter(s) are not significant using Duncan multiple Range Test (DMRT)

4.2.6 Crop vigour score

In both years, oxadiazon plus cinosulfuron at 750 + 20g a.i./ha and oxadiazon plus CGA 152'005 at both rates resulted in significantly lower crop vigour scores than the state the treatments at 3 to 12 WAP (Table 19). Oxadiazon mixtures with prometryne at 750 + 1500g a.i./ha and cinosulfuron at 750 + 10g a.i./ha also reduced crop vigour score at 6, 9 and 12 WAP in 1994 and 6 WAP in 1995 compared with the appropriate maxima. In 1995, oxadiazon plus cinosulfuron at 750 + 10g a.i./ha also reduced crop vigour score significantly at 12 WAP (Table 19). Uncontrolled weeds throughout crop life caused significant reduction in crop vigour score of garlic plant at 6, 9, and 12 WAP in 1994 and 9 and 12 WAP in 1995. Garlic plants of the hoe weeded plots had depressed vigour compared with the maximum at 12 WAP in 1994.

4.2.7 Number of fully opened leaves

Oxadiazon plus cinosulfuron at 750 + 20g a.i./ha and oxadiazon plus CGA 152'005 at both rates resulted in lower number of opened leaves at 6 to 12 WAP in 1994 and 3 to 12 WAP in 1995 compared with the appropriate maxima (Table 20). The treatments also resulted in significantly lower number of opened leaves than the weedy check at 3 to 12 WAP in both years. At 3 WAP, in 1994, only oxadiazon plus CGA 152'005 at both rates, reduced the number of opened leaves significantly compared with the appropriate maxima. Mixture of oxadiazon with cinosulfuron at 750 + 10g a.i./ha and prometryne at 750 + 1500g a.i./ha reduced the number of opened leaves of garlic

Table 19: Effect of weed control treatments on viguor of garlic crop at Samaru, 1994 and 1995 dry seasons

Treatment	Rate (g a.i./ha)	Crop viguor score[2]							
		1994				1995			
		3WAP	6WAP	9WAP	12WAP	3WAP	6WAP	9WAP	12WAP
Oxadiazon	750	10.00a[3]	9.67ab	9.67ab	9.33ab	10.00a	10.00a	10.00a	10.00a
Oxadiazon	1000	10.00a	10.00a	10.00a	9.42ab	10.00a	10.00a	10.00a	10.00a
Oxadiazon	1500	10.00a	10.00a	10.00a	9.67ab	10.00a	10.00a	10.00a	10.00a
Oxadiazon+chloroxuron	750+1000	10.00a	10.00a	10.00a	10.00a	10.00a	10.00a	10.00a	10.00a
Oxadiazon+chloroxuron	750+2000	10.00a	9.67ab	10.00a	9.33ab	10.00a	10.00a	10.00a	10.00a
Oxadiazon+Prometryne	750+1000	9.67a	9.33abc	9.00ab	10.00a	10.00a	10.00a	10.00a	10.00a
Oxadiazon+Prometryne	750+1500	9.33a	8.33c	8.33bc	8.33b	10.00a	8.67b	9.33a	9.33a
Oxadiazon+Cinosulfuron	750+10	9.00a	8.67bc	8.33bc	8.33b	9.67a	8.33b	9.33a	8.33b
Oxadiazon+Cinosulfuron	750+20	4.33b	4.00d	2.27d	2.33de	7.00b	3.00c	2.33c	2.33d
Oxadiazon+CGA 152'005	750+10	4.00bc	4.00d	2.33d	2.67d	6.67b	2.33cd	1.33d	1.11e
Oxadiazon+CGA 152'005	750+20	3.33c	3.33d	1.33d	1.00e	6.67b	2.00d	1.00d	1.00e
Hoe weeded at 3 & 6WAP		10.00a	10.00a	9.67ab	6.33c	10.00a	10.00a	10.00a	9.67a
Weedy check		10.00a	8.33c	7.00c	5.33c	10.00a	9.67a	7.33b	4.67c
SE±		0.18	0.24	0.30	0.34	0.16	0.17	0.21	0.26

1. WAP = weeks after planting
2. Crop viguor score, where 0= represented dead plant and 10= represented the most vigorous plant.
3. Means followed by the same letter(s) within treatments are not significantly different at 5% using Duncan Multiple Range Test (DMRT)

Table 20: Effect of weed control treatment on the number of fully opened leaves of garlic at Samaru, 1994 and 1995 dry seasons.

Treatment	Rate (g a.i/ha)	Number of opened leaves/plant							
		1994				1995			
		3 WAP[1]	6 WAP	9 WAP	12 WAP	3 WAP	6 WAP	9 WAP	12 WAP
Oxadiazon	750	2.57abc[2]	4.63abc	8.27a	12.64cd	3.03abc	4.36b	6.00abc	7.25abc
Oxadiazon	1000	3.00abc	4.50abc	9.40a	15.00a	3.10abc	5.08abb	7.80ab	10.92a
Oxadiazon	1500	3.87a	5.77a	9.97a	14.62ab	3.20ab	5.25ab	7.50ab	11.17a
Oxadiazon+Chloroxuron	750+1000	3.47ab	6.23a	9.87a	14.99a	3.43ab	5.42ab	8.18a	11.78a
Oxadiazon+Chloroxuron	750+2000	2.83abc	5.57a	8.27a	13.86ab	3.53ab	5.25ab	7.67ab	10.42ab
Oxadiazon+Prometryne	750+1000	2.47abc	4.77abc	8.20a	13.03bcd	3.27ab	4.92abb	7.41ab	8.87ab
Oxadiazon+Prometryne	750+1500	2.47abc	4.10abc	6.57ab	12.60cd	2.87bc	4.42ab	6.75ab	9.42cd
Oxadiazon+Cinosulfuron	750+10	2.50abc	5.00ab	6.63ab	11.77de	2.43cd	4.42abd	6.77ab	9.08cd
Oxadiazon+Cinosulfuron	750+20	1.80abc	1.93bc	3.00bc	2.67g	1.93de	2.50c	3.25cde	2.25d
Oxadiazon+CGA 152'00	750+10	1.53bc	1.90bc	3.00bc	2.67g	1.87e	1.83c	2.25de	2.42cd
Oxadiazon+ CGA 152'005	750+20	1.07c	1.70c	1.67c	1.67g	1.37e	1.33c	1.42e	1.08d
Hoe weeded at 3 & 6 WAP	20.43a	3.50ab	5.63a	10.17a	10.67a	3.67a	5.58a	7.50ab	10.33a
Weedy check		2.47abc	4.60abc	6.47ab	5.11f	2.97abc	4.33b	5.12bcd	4.83bcd
SE±		0.45	0.71	1.00	0.41	0.17	0.26	0.66	1.14

1. WAP= weeks after sowing
2. Mean followed by the same letter(s) within treatment are not significantly different at 5% level using Duncan multiple Range Test (DMRT)

significantly at 12 WAP in both years, and 3 WAS only in 1995. The mixture with prometryne at 750 + 1000g a.i./ha also reduced the number of opened leaves at 12 WAP in 1995, compared with the appropriate maxima (Table 20). Unchecked weed significantly reduced number of opened leaves at 12 WAP in 1994 and 6 and 12 WAP in 1995 compared with the hoe weeded. In both years, at 12 WAP, Oxadiazon plus chloroxuron at 250 + 1000g a.i./ha produced the highest number of leaves per plant.

4.2.8 Leaf dry matter

In both years, oxadiazon plus cinosulfuron at 750 + 20g a.i./ha and oxadiazon plus CGA 152'005 at both rates resulted in significantly lower shoot dry matter than the appropriate maxima at 3 to 12 WAP (Table 21). Mixtures of oxadiazon with prometryne at 750+ 1500 and cinosulfuron at 750 + 10g a.i./ha caused significant reduction in shoot dry weight of garlic at 9 and 12 WAP in 1994 and at 6 and 9 WAP in 1995. In 1995, Oxadiazon plus chloroxuron at 750 + 2000g a.i./ha similarly reduced shoot dry weight significantly at 9 WAP (Table 21). Unchecked weed growth significantly reduced shoot dry weight of garlic at 12 WAP in 1994 and 6, 9 and 12 WAP in 1995 compared with the hoe weeded control. Similarly, shoot dry matter was also depressed by hoe weeding at 12 WAP in 1994. In both years oxadiazon plus chloroxuron at 750 + 1000 g a.i./ha produced the highest shoot dry weight.

Table 21: Effect of weed control treatment on Leaf/shoot dry matter production of garlic at Samaru, 1994 and 1995 dry seasons

Treatment	Rate (g a.i/ha)	Dry weight of shoot/plot					
		1994			1995		
		6 WAP	9 WAP	12 WAP	6 WAP	9 WAP	12 WAP
Oxadiazon	750	2.19a[2]	3.15abc	0.67bcd	1.86cd	2.06b	5.31a
Oxadiazon	1000	2.33a	3.57a	1.41abc	2.37bc	2.09b	4.71a
Oxadiazon	1500	2.31a	3.27ab	0.76a-d	3.66a	2.51ab	5.32a
Oxadiazon+Chloroxuron	750+1000	2.33a	3.28ab	1.63a	3.00abc	3.27a	5.47a
Oxadiazon+Chloroxuron	750+2000	2.23a	3.16abc	0.65bcd	2.62abc	1.91bc	4.88a
Oxadiazon+Prometryne	750+1000	1.74a	2.25bcd	1.52ab	2.45bc	2.24ab	5.06a
Oxadiazon+Prometryne	750+1500	1.94ab	1.39def	0.70bcd	2.03bcd	1.72bc	4.84a
Oxadiazon+Cinosulfuron	750+10	1.17ab	1.39def	0.69bcd	2.03bcd	1.67bc	4.24a
Oxadiazon+Cinosulfuron	750+20	0.07b	0.61ef	0.17d	0.06e	0.21d	0.03b
Oxadiazon+CGA 152'00	750+10	0.04b	0.11f	0.22d	0.33e	0.14d	0.01b
Oxadiazon+ CGA 152'005	750+20	0.03b	0.10f	0.09d	0.02e	0.03d	0.01b
Hoe weeded at 3 & 6 WAP	20.43a	2.21a	2.90abc	0.54cd	3.13ab	2.67ab	5.18a
Weedy check		1.28ab	0.33fb	0.30d	1.16de	0.98cd	0.12b
SE±		0.32	0.28	0.20	0.26	0.23	0.39

1. WAP= weeks after sowing
2. Mean followed by the same letter(s) within treatment are not significantly different at 5% level using Duncan multiple Range Test (DMRT)

4.3 Effect of weed control treatments on garlic yield and yield attributes

4.3.1 Fresh and dry weight of cloves

In both years, oxadiazon plus cinosulfuron at 750 + 20g a.i./ha, Oxadiazon plus CGA 152'005 at both rates and weedy check resulted in significantly lower fresh and dry weight of cloves than the appropriate maxima (Table 22). In 1994, oxadiazon alone at all rates, oxadiazon plus prometryne at 750 + 1500g a.i./ha, the hoe weeding treatment as well as the weedy checks resulted in significantly lower clove weight than the appropriate maxima. Oxadiazon plus chloroxuron at 750 + 2000g a.i./ha also caused reduction in clove fresh weight in the year.

In 1995, unchecked weeds throughout crop life-cycle caused significant reduction in cloves weight than the maxima. Oxadiazon plus cinosulfuron at 750 + 10g a.i./ha also depressed cloves dry weight. Oxadiazon plus chloroxuron at 750 + 1000g a.i./ha produced the highest cloves fresh and dry weight both years.

4.3.2 Bulb diameter

Bulb diameter was significantly affected by the weed control treatments in both years (Table 23). In the two years, mixtures of oxadiazon with cinosulfuron at 750 + 20g a.i./ha and CGA 152'005 at both rates as well as weedy checks resulted in significantly lower bulbs diameter than the appropriate maxima. In 1994, oxadiazon plus prometryne at 750 + 1500g a.i./ha also reduced bulb diameter significantly compared with the maximum obtained with oxadiazon plus chloroxuron at 750 + 1000g a.i./ha (Table 23). In both years oxadiazon plus chloroxuron at 750 + 1000g a.i./ha produced the highest bulb diameter compared to the hoe weeded control.

Table 22: Effect of weed control treatments on cloves fresh weight and cloves dry matter of garlic at maturity, at Samaru, 1994 and 1995 dry seasons.

Treatment	Rate (g a.i./ha)	1994	1995	1994	1995
		Cloves fresh weight (g/plot)	Cloves dry Matter (g/plot)	Cloves fresh weight (g/plot)	Cloves dry matter (g/plot)
Oxadiazon	750	6.84d	2.58bc	9.72a	4.96a
Oxadiazon	1000	10.72b	3.57b	12.28a	6.01a
Oxadiazon	1500	10.34b	3.48b	15.19a	7.52a
Oxadiazon+ chloroxuron	750+1000	12.69a	5.83a	15.25a	7.26a
Oxadiazon+ chloroxuron	750+2000	8.49c	3.96ab	13.74a	6.55a
Oxadiazon+ Prometryne	750+1000	13.39a	5.61a	12.63a	5.98a
Oxadiazon+ Prometryne	750+1500	6.58d	2.10bcd	12.83a	5.86a
Oxadiazon+ Cinosulfuron	750+10	8.46c	3.18b	9.74a	4.16b
Oxadiazon+ Cinosulfuron	750+20	1.99e	0.27de	1.90b	0.87c
Oxadiazon+ CGA 152'005	750+10	1.16e	0.27de	1.13b	0.35c
Oxadiazon+ CGA 152'005	750+20	0.99e	0.07e	0.95b	0.09c
Hoe weeded at 3 & 6WAP		5.74d	0.85cde	10.48a	5.67a
Weedy check		1.23e	0.38de	3.85b	1.77bc
SE±		0.29	0.43	1.26	0.57

Means followed by the same letter(s) are not statistically different from each other at 5% level using Duncan multiple Range Test (DMRT)

Table 23: Effect of weed control treatments on Bulb diameter and Bulbs yield of garlic at Samaru, 1994 and 1995 dry seasons

Treatments	Rate (g a.i./ha)	1994		1995	
		Bulb diameter (mm)	Bulb yield (kg/ha)	Bulb diameter (mm)	Bulb yield (kg/ha)
Oxadiazon	750	1.7abcd	226bc	2.8a	549bcd
Oxadiazon	1000	2.0ab	303ab	2.8a	932abcd
Oxadiazon	1500	2.1ab	356ab	3.2a	1586ab
Oxadiazon+chloroxuron	750+1000	2.2a	368a	3.2a	1890a
Oxadiazon+chloroxuron	750+2000	2.0ab	332ab	2.7a	1153abc
Oxadiazon+Prometryne	750+1000	2.1ab	273abc	2.6a	1356ab
Oxadiazon+Prometryne	750+1500	1.4b-f	321ab	2.7a	1373ab
Oxadiazon+Cinosulfuron	750+10	1.8abc	242abc	1.9ab	748bcd
Oxadiazon+Cinosulfuron	750+20	0.8ef	37d	0.4c	17d
Oxadiazon+CGA 152'005	750+10	1.0def	27d	0.3c	5d
Oxadiazon+CGA 152'005	750+20	0.8f	15e	0.3c	3d
Hoe weeded at 3 & 6WAP		1.6a-e	349ab	2.2ab	765bcd
Weedy check		1.1c-f	154cd	1.0bc	214cd
SE±		0.16	43.63	0.29	354.55

Means followed by the same letter(s) are not statistically different from each other at 5% Level using Duncan multiple range Test (DMRT)

4.3.3 Bulb yield

Garlic bulb yields obtained with oxadiazon alone at 750g a.i./ha and the mixtures with cinosulfuron at 750 + 20g a.i./ha and CGA 152'005 at both rates as well as the weedy check were significantly lower than the maximum obtained with oxadiazon plus chloroxuron at 750 + 1000g a.i./ha in both years (Table 23). In 1995, hoe weeding and oxadiazon plus cinosulfuron at 750 + 10g a.i./ha also resulted in lower bulb yield than the maximum. Mixtures of oxadiazon with cinosulfuron at 750 + 10g a.i./ha however resulted in higher yields than other two rates in 1994. In Figures 5 and 6 shows garlic yield as per cent of untreated control obtained with different herbicides. Oxadiazon at 750g a.i./ha resulted to about 46% and 157% increase in bulb yield in 1994 and 1995, respectively compared to the unweeded control. Mixture of oxadiazon plus chloroxuron at 750 + 1000g a.i./ha resulted in about 138% and 785% increase in bulb yields in 1994 and 1995, respectively compared to the unweeded control. Oaxadiazon plus prometryne at 750 + 1500g a.i./ha resulted to about 105% and 610% increase bulb yield in 1994 and 1995, respectively, compared to the unweeded control. With oaxdiazon plus cinosulfuron at 750 + 10g a.i./ha also resulted into about 60% and 220% increase in bulb yield in 1994 and 1995, respectively, compared to the unweeded control.

4.3.4 Relationship between various parameters and garlic Bulbs yield in the weed control studies

In both years, Bulbs yield of garlic was positively correlated with plant height at 9 WAP, crop vigour score at 9 WAP, number of

opened leaves per plant at 9 WAP and leaf dry matter at 9 WAP (r= 0.775,0.856, 0.716 and 0.733, respectively in 1994) and (r=0.725, 0.62, 0.690 and 0.744, respectively in 1995) (Tables 24 and 25). Bulbs yield was also positively correlated with crop stand count at 12 WAS in 1994, (r=0.840) (Table 24), and bulb diameter in 1995, r=0.316 (Table 25). Bulbs yield was however negatively correlated with Crop injury score at 3 and 6 WAP in both years and weed dry matter at 12 WAP, number of cloves per bulb and crop stand count in 1995 (r=-0.639, -0.327 and -0.567, respectively).

Table 24: Correlation of various parameters and garlic Bulb yield in the weed control studies at Samaru, 1994 dry season.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	1.00													
2	0.78**	1.00												
3	0.86**	0.90**	1.00											
4	-0.28	-0.27	-0.16	1.00										
5	0.72**	0.80**	0.84**	-0.13	1.00									
6	0.73**	0.85**	0.84**	-0.46**	0.78**	1.00								
7	0.74**	0.74**	0.80**	-0.38*	0.63**	0.76**	1.00							
8	0.21	0.28	0.33*	0.60**	0.25	0.02	0.24	1.00						
9	0.71**	0.83**	0.82**	-0.32*	0.73**	0.79**	0.79**	0.30	1.00					
10	-0.05	-0.07	0.03	0.74**	0.01	-0.26	-0.25	0.53**	-0.20	1.00				
11	0.84**	0.87**	0.94**	-0.21	0.79**	0.81**	0.83**	0.27	0.80**	-0.09	1.00			
12	-0.80**	-0.85**	-0.96**	-0.02	-0.82**	-0.75**	-0.71**	-0.43**	-0.73**	-0.23	0.89**	1.00		
13	-0.81**	-0.85**	-0.96**	-0.03	-0.82**	-0.74**	-0.71**	-0.45**	-0.73**	-0.22	-0.89**	0.99**	1.00	
14	0.59**	0.74**	0.67**	-0.29	0.74**	0.67**	0.52**	0.06	0.60**	0.03	0.63**	-0.62**	-0.61**	1.00

* Significant at 5% level of probability (r^2=0.317)
** Significant at 1% level of probability (r^2=0.408)
1 = Bulb yield
2 = Plant height at 9WAP
3 = Crop viguor score at 9WAP
4 = Weed cover score at 9WAP
5 = Number of opened leaves per plant at 9WAP
6 = Leaves dry weight at 9WAP
7 = Leaves fresh weight at 12WAP
8 = Bulb diameter at maturity
9 = Weed dry matter at 12 WAP
10 = Number of cloves per Bulb at maturity
11 = Crop stand count at 12 WAP
12 = Crop injuries score at 3 WAP
13 = Crop injuries score at 6 WAP
14 = Bulb dry weight at 6 WAP

Table 25: Correlation of various parameters and garlic Bulb yield in the weed control studies at Samaru, 1995 dry season.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	1.00													
2	0.73**	1.00												
3	0.62**	0.95**	1.00											
4	-0.34*	-0.18	-0.01	1.00										
5	0.70*	0.90**	0.88**	-0.13	1.00									
6	0.74**	0.90**	0.87**	-0.22	0.87**	1.00								
7	0.58**	0.93**	0.93**	-0.25	0.83**	0.87**	1.00							
8	0.32*	0.63**	0.70**	0.22	0.59**	0.56**	0.63**	1.00						
9	-0.64**	0.86**	0.87**	-0.27	0.72**	0.80**	0.89**	0.59**	1.00					
10	-0.33**	-0.18	-0.02	0.86**	-0.07	-0.20	-0.24	0.20	-0.35	1.00				
11	0.57**	0.89**	0.95**	0.02	0.87**	0.81**	0.88**	0.67**	0.82**	0.03	1.00			
12	-0.56**	-0.91**	-0.97**	-0.18	-0.83**	-0.81**	-0.86**	-0.71**	-0.80**	-0.14	-0.92	1.00		
13	-0.55**	-0.91**	-0.97**	-0.19**	-0.84**	-0.82**	-0.86**	-0.72**	-0.81**	-0.13	-0.92**	0.99**	1.00	
14	0.68**	0.89**	0.87**	-0.22	0.82**	0.93**	0.87**	0.54**	0.78**	-0.21	0.81**	-0.81**	-0.82**	1.00

* Significant at 5% level of probability (r^2=0.317)
** Significant at 1% level of probability (r^2=0.408)

1 = Bulb yield
2 = Plant height at 9WAP
3 = Crop viguor score at 9WAP
4 = Weed cover score at 9WAP
5 = Number of opened leaves per plant at 9WAP
6 = Leaves dry weight at 9WAP
7 = Leaves fresh weight at 12WAP
8 = Bulb diameter at maturity
9 = Weed dry matter at 12 WAP
10 = Number of cloves per Bulb at maturity
11 = Crop stand count at 12 WAP
12 = Crop injuries score at 3 WAP
13 = Crop injuries score at 6 WAP
14 = Bulb dry weight at 6 WAP

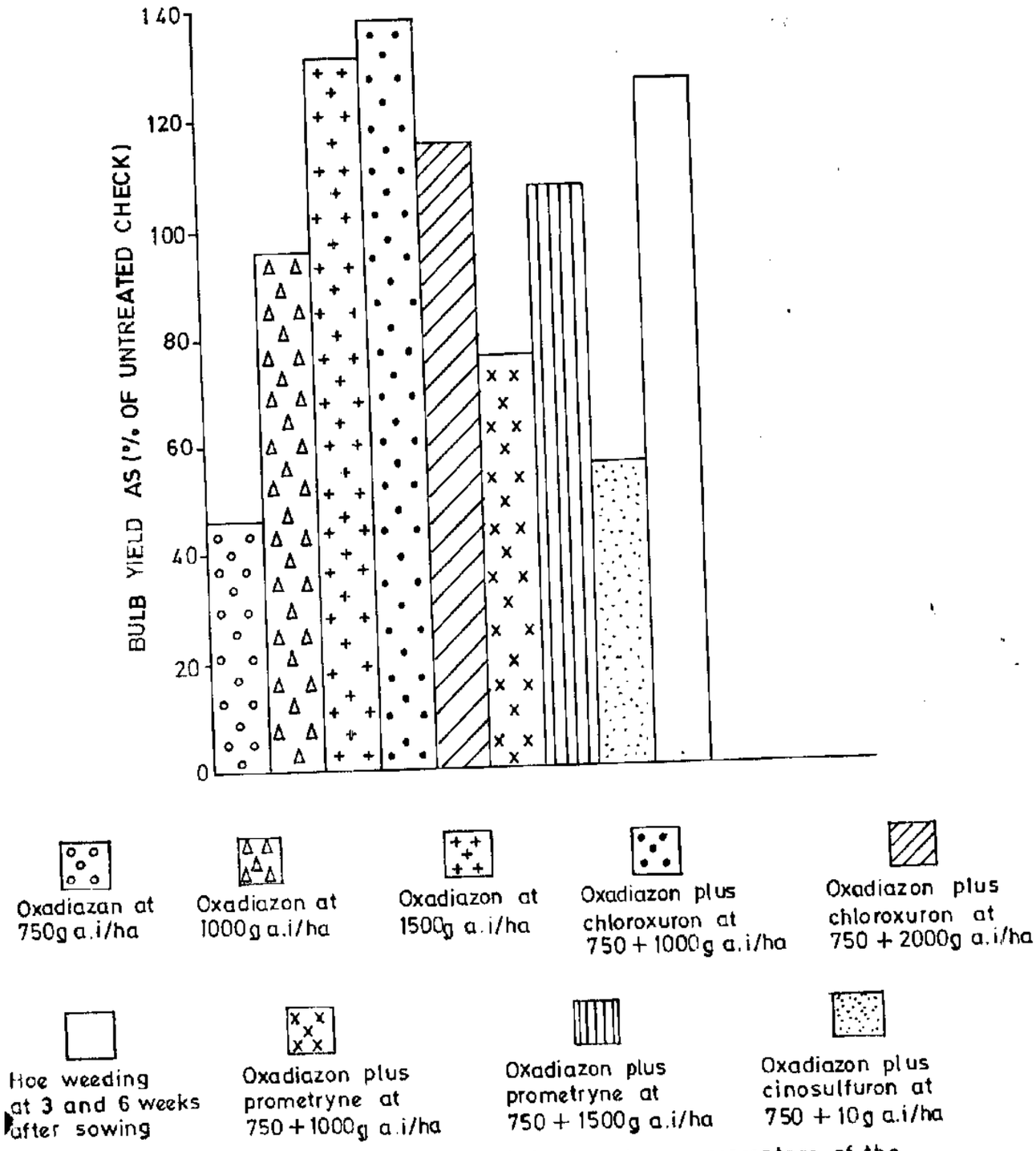


Fig. 5: Garlic bulb yield of weed control treatments as percentage of the untreated check (1994)

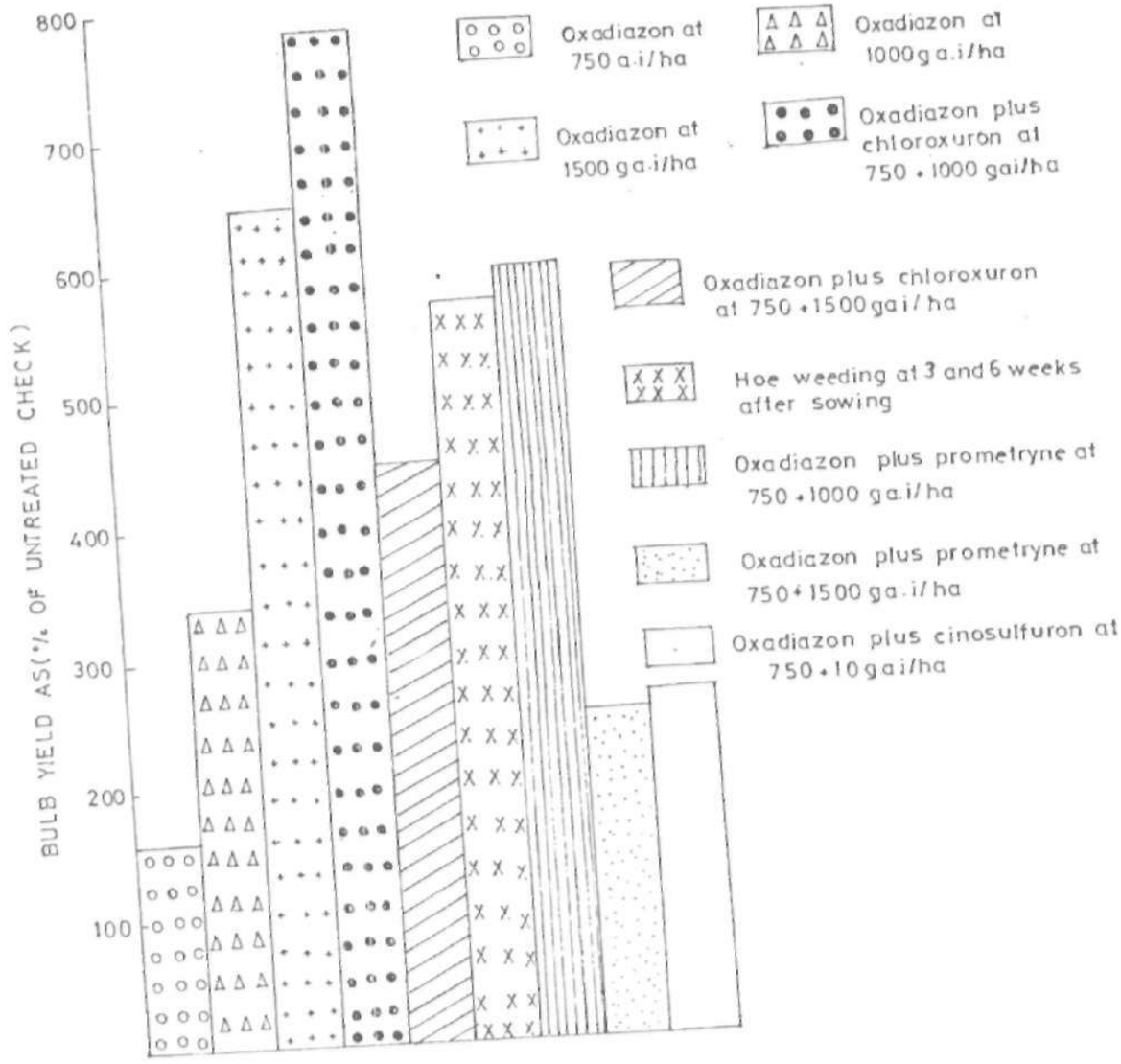


Fig. 6: Garlic bulb yield of weed control treatment as percentage of untreated check. (1995)

CHAPTER FIVE

5.0 DISCUSSION

The maximum bulb yield of 1890kg/ha obtained in 1995 with garlic in the weed control trial during the study compares favourably with the range of 1 to 3.5 ton/ha reported earlier by other workers (Furman and Blyshchik 1989; Tindall, 1983). It is however, worth noting that inspite of the limited water supply and coupled with environmental effects, the maximum yield obtained in the weed control trials was still comparable to those previously reported by other workers (Tindall, 1983; Blyshick, 1989). This confirm the fact that once appropriate cultural practices such as adequate fertilizer rates, use of adapted variety, adequate population are combined with effective weed control, good water supply until bulb formation stage of the crop would result in good yield.

However, despite the presence of plots kept weed-free throughout the crop life-cycle in the weed interference trials the highest bulbs yield in 1995 was 1249kg/ha which was less than that obtained from the weed control trials. This yield cannot be regarded as being too far from those reported by other workers (Tindall 1983, Blyshchik 1989). The lower yield from hand weeding, compared with herbicide treatments could be attributed to frequent disturbances of the crop during the manual weeding Olorukonba (1987) reported similar findings with ginger. Magani (1990) who obtained similar results with maize, observed that

elimination of weeds competition from the time of planting through the use of pre-emergence herbicides in the weed control trials, compared with effective control after initial infestation might have been responsible for higher yield observed with the former situation.

In 1994, the bulb yield of garlic in both weed control and weed interference were extremely low, compared with the yield of 1995, probably due to the inconsistency in water supply during the period, coupled with delayed planting and excessive heat that does not favour vegetative growth of the crop during the earlier stage as earlier reported by Chang and Parka, (1989) and Bravo and Duimovic (1981). The authors further reported that the enumerated problems resulted in lower number of cloves per bulb, low bulb weight and subsequently poor garlic yield.

5.1 Effect of period of weed interference on garlic

The garlic plant growth and yield parameters were not significantly affected by weed infestation during the first 3 weeks of crop growth. This was probably because weeds had not established well enough to compete seriously with the crop at this stage. This agrees with the findings of Adigun (1984) in pepper, Bakut (1985) in maize- pepper mixture and Bulus (1986) in potato. They reported that provided weeds were subsequently removed, infestation for the first 3 WAP did not have adverse effect on the growth and yield of the crop.

In both years, weed infestation until 6 WAP and more

depressed the growth parameters and the bulb yield and yield components of garlic as reflected in crop vigour score, crop height, bulb dry matter production and yield of garlic at harvest compared with the highest. Similarly, weed infestation with the crop until 9 WAP resulted in significantly lower crop vigour score, plant height, bulb dry matter and yield of garlic at harvest compared with infestation until 3 WAP only. This results agrees with those obtained by Warren (1975) and Aliudin (1989) who have similarly reported significant reduction in garlic bulb yield when weeds were associated with the crop for 7 and 9 WAP.

In both years, once the crop was weed-infested for 9 WAP, subsequent removal of the weeds did not obviate growth and yield depression of the crop comparable to the crop weed infested till harvest. However, only the weed dry matter production on the plots weed-infested for 12 WAP did not differ significantly from that of the crop infested until harvest. This could be attributed to additional stress caused by the pulling of established weeds on plots weed-infested initially until 9 WAP coupled with the fact that the competition with weeds was too late to be ameliorated. Similar observation has been reported by Lagoke (1978) in maize and Bakut (1985) in maize-pepper mixtures. On the other hand, although significant reduction in crop yield was also caused by weed infestation for 6 WAP, compared with the weed free treatment, subsequent weeds removal after 6 WAP resulted in higher yield than the crop kept weed-infested throughout and those kept weed-free for 3 WAP only.

In these studies, except in the case of the crop kept weed-free for 3 WAP only in 1994, no significant differences were observed in the bulb yield of garlic kept weed-free for various periods. In these trials uncontrolled weeds throughout the crop life-cycle caused between 70 and 80% reduction in garlic yield in 1994 and 1995; respectively compared to the maximum obtained with crop weed-free throughout. These results agrees with earlier reports by some workers who obtained between 70 to 89% loss in garlic yield as a result of weed competition (Warren, 1975 William, 1975). However in order to obtained maximum yield the crop should be kept weed-free throughout its life-cycle. The period between 5 and 6 weeks after planting represents the period of maximum weed growth and critical period of competition with the crop in the trial. This result agrees with that of Warren (1975) who reported that the critical period of weed competition in garlic was between 5 and 7 WAP and Aliudin (1989) who similarly reported that the critical period of weed competition occurs between 30 to 60 days after sowing. This result is very important in the designing of a weed control strategy for garlic especially if pre-emergence herbicides will be used. Any treatment that can effectively control weeds during this period will be desirable

5.2. Effect of weed control treatments on garlic

In both years, all the weed control treatments effectively reduced weed infestation until 12 WAP compared with the untreated

control. In both years, the herbicide treatments, oxadiazon plus prometryne at 750 + 1000g a.i./ha and cinosulfuron at 750 + 10g a.i/ha were less effective on weeds than most of the other herbicide treatments evaluated. In these trials, mixture of oxadiazon plus chloroxuron at 750 + 1000g a.i./ha was outstanding, since it resulted in higher bulb yield than the weedy check, in both years. Plots treated with oxadiazon alone at 1000, 1500g a.i./ha and mixture with chloroxuron at 750 + 2000g a.i/ha, prometryne at 750 + 1500g a.i./ha produced significantly higher garlic bulb yield that was comparable to the highest obtained with oxadiazon plus chlorozuron at 750 + 1000g a.i./ha. This result is in line with the report of Deuber (1980) who reported that application of oxadiazon at 1kg a.i/ha (1000g a.i/ha) as pre-emergence in garlic gave an excellent selective control of both grasses and broad leaved weeds and that high garlic bulb yield was obtained. Orkwor (1981), Sinha et al. (1983) and Lagoke et al. (1986) obtained a similar results with onion. They reported that the application of pre-transplant oxadiazon at 1.5kg a.i./ha (1500g a.i/ha) and 2.0kg a.i./ha (2000g a.i/ha) significantly produced larger marketable bulb yield compared to the hoe weeded control.

In both years, despite an effective weed control, oxadiazon plus cinosulfuron at 750 + 20g a.i./ha and with CGA 152'005 at both rates caused significant depression in crop growth parameters viz: crop vigour score, plant height, plant stand count, leaf dry weight, number of leaves per plant and

consequently bulb yield of garlic. In 1995, oxadiazon plus prometryne at 750 + 1500g a.i./ha and oxadiazon plus cinosulfuron at 750 +10g a.i./ha also depressed plant height at the early stage of crop growth at 3 and 6 WAP. Sulphonylurea herbicides generally have a narrow range of selectivity in desired plants and high level of efficacy on weeds. Anon (1994) similarly observed at Samaru, that all the mixtures containing cinosulfuron produced lower millet yield as a result of phytotoxicity. Phytotoxic symptoms such as growth depression and burning of leaf tips were observed on garlic plants treated with oxadiazon plus prometryne at 750 + 1500g a.i./ha, but apparently later recovered which agrees with the report of Janyska (1966). The treatments containing prometryne produced higher garlic bulb yields that were comparable to the hoe-weeded treatment. These results agrees with the reports of Ramirez (1973), Armellina, (1976) and Mascarenthas, et al. (1980). In this trial hoe-weeding did not only resulted in slightly but significantly higher yield than the weedy check. Low weed challenge during the dry season coupled with large variability among plots and the extremes of injury caused by the sulphonylurea herbicides might have been responsible for the non significance of the yield.

Uncontrolled weeds throughout the crop life-cycle depressed various crop growth parameters and yield attributes of garlic. William (1975) and Warren (1975) have reported significant reduction of crop growth parameter and yield as a result of weed infestation. Garlic bulb yield reduction due to the uncontrolled

check was 70% in 1994 and 80% in 1995 compared with the maximum obtained in the trials.

Oxadiazon at 750g a.i./ha had bulb yield of about 46% higher in 1994 and about 157% in 1995 than the untreated control (Fig. 5 & 6). Oxadiazon at 1000g a.i./ha, the bulb yield was about 96% higher in 1994 and 336% in 1995, than untreated control. Mixture of oxadiazon with chloroxuron at 750 + 1000g a.i./ha resulted in about 138% in 1994 and 785% in 1995 bulb yield than the untreated control. Similar increased in bulb yield was obtained in plots treated with oxadiazon plus prometryne at various rates. Mixtures of oxadiazon with cinosulfuron at 750 + 20g a.i./ha and with CGA 152'005 at both rates did not improved garlic bulb yield, as a result of phytotoxicity.

5.3 Relationships between various parameters and yield of garlic in the weed interference and control studies

The significant positive correlation between garlic bulb yield and growth characters such as crop vigour, plant height, number of leaves per plant and leaf dry weight may be attributed to the fact that these parameters determined the bulb yield. The highly significant and positive correlation between yield attributes viz: plant higher, crop vigour score and leaves dry weight bulb yield revealed this as an important yield component and critical determinant of garlic bulb yield. These results agrees with the findings of Tindall (1983), who reported that the number of leaves per plant, crop stand count and plant height determine the bulb yield of garlic. Garlic bulb yield was however negatively correlated with weed dry matter production.

CHAPTER 6

6.0 SUMMARY AND CONCLUSIONS

Two sets of trials were conducted during the 1994 and 1995 dry seasons at Samaru (11° 11'N, 07° 38'E) in the Northern Guinea Savanna of Nigeria to study the effect of period of weed interference and chemical weed control on growth and yield of garlic (Allium sativum L).

In the weed interference trials, ten periods of weed interference were laid out in a randomized complete block design in four replicates. In one set of treatments plots of garlic were kept weed-free initially for 3,6,9 and 12 weeks after planting and subsequently allowed to be weed-infested till harvest. In the other set, plots of garlic were allowed to be infested by weeds initially for 3,6,9 and 12 Weeks after planting and subsequently kept weed-free till harvest. Two treatments in which the plots of garlic were either kept weed-free or weed-infested until harvest were included for comparison.

In the weed control study, eleven herbicides treatments were compared with two hoe weedings at 3 and 6 WAP and weedy check in a randomized complete block design with three replicates. The eight herbicide treatments consisted of oxadiazon alone at three rates 750, 1000 and 1500g a.i/ha and mixtures with chloroxuron, a substituted urea, prometryne a symmetrical triazine and cinosulfuron and CGA 152'005 both sulphonylurea herbicides each at two rates. The herbicides were all applied pre-planting.

In the weed interference trials, weed infestation initially for 3 WAP did not caused any significant depression in garlic bulb yield and various crop growth parameters as reflected in crop vigour score, plant height and number of fully opened leaves per plant. Similarly, no significant weed dry matter production occurred during the first 3 weeks of growth as reflected in the result of cumulative weed dry matter at harvest. Crop growth parameters, yield and yield attributes of garlic were depressed by weed infestation from 6 WAP. Cumulative weed dry matter production of plots weed infested for 6 WAP and more, were significantly higher than the least obtained with those kept weed-free for 6 WAP and more and those weed infested for 3 WAS only. Subsequently, weed removal after initial infestation for 9 WAP did not ameliorate weed infestation and the depression in the growth and yield of garlic compared with weed infestation till harvest. Keeping the crop weed free throughout the crop life resulted in the highest bulb yield.

It was apparent that garlic crop was critically affected by weed competition between 5 and 6 WAP in both years. Any treatment that can effectively control weeds during this period will therefore be desirable, while yield comparable to the maximum can be obtained by keeping the crop weed-free for 6 weeks initially.

In the weed control experiment, oxadiazon plus chloroxuron at 750 + 1000g a.i./ha was outstanding since it resulted in vigorous garlic growth and significantly higher garlic yield than

the same herbicide applied at 750g a.i./ha and the weedy check in both years. Oxadiazon at 1500g a.i./ha also resulted in significantly higher bulb yield than the weedy check in 1994. The other herbicide mixtures with the exception of oxadiazon plus cinosulfuron at 750 + 20g a.i./ha and oxadiazon plus CGA 152'005 at both rates also resulted in higher bulb yield than weedy check. Uncontrolled weed-growth throughout the crop life-cycle resulted in significant depression of crop growth parameters such as crop vigour score, plant height, number of leaf per plant and garlic bulb yield reduction of 70% and 80% in 1994 and 1995, respectively .

In conclusion, it was apparent that

1. Garlic crop was sensitive to early weed infestation in the study
2. Pre-sowing herbicides at the rates at which they were applied were effective in weeds control in garlic crop. Based on the results obtained from this study, the application of Oxadiazon plus Chloroxuron at 750 + 1000 g a.i./ha is suggested for maximum bulb yield of garlic.

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APPENDIX

Appendix 1: Common and chemical names of the herbicides mentioned in the text

Common Name	Chemical Name
Oxadiazon	2-tert-butyl-4-(2,4-dichloro-5-Isoproxyphenyl) - D^2 -1,3,4-Oxadiazolin -5-one)
Chloroxuron	N^1-4-(4-chlorophenoxy) phyenyl-NN-dimethylurea
Prometryne	4,6-bisisopropylamino-2-methylthio-1,3,5-triazine
Cinosulfuron	3-(4,6-dimethoxy-1, 3,5-triazin-2-yl) -1-2-(2-methoxyethoxy)phenylsulfonylurea

Appendix 2: Means squares from analysis of variance for plant height as affected by period of weed interference at Samaru, 1994 and 1995 seasons

Source of variation	Degree of freedom	Plant height					
		1994			1995		
		6 WAP	9 WAP	12 WAP	6 WAP	9 WAP	12 WAP
Replication	3	1.28	1.78	1.65	0.18	0.19	0.15
Treatment	9	363.93**	563.967**	624.98**	105.29**	46.21**	122.31**
Residual	27	-	-				
Total	39	-	-				

Appendix 3: Means squares from analysis of variance for crop vigour score as affected by period of weed interference at Samaru, 1994 and 1995 seasons

Source of variation	Degree of freedom	Cover givour score					
		1994			1995		
		6 WAP	9 WAP	12 WAP	6 WAP	9 WAP	12 WAP
Replication	3	1.00	0.78	0.50	0.68	0.64	0.82
Treatment	9	4115.67**	982.30**	383.83**	470.20**	550.30**	340.96**
Residual	27	-	-	-			
Total	39	-	-	-			

** = F value significant at 1% level of probability

WAP = Weeks after planting

Appendix 4: Means squares from analysis of variance for bulbs diameter, cloves dry matter abd bulb yield as affected by period of weed interference at Samaru, 1994 and 1995 seasons

Source of variation	Degree of freedom	Bulb diamter at maturity		Cloves dry matter		Bulb yield at harvest	
		1994	1995	1994	1995	1994	1995
Replication	3	2.16	5.77	2.59	1.19	0.74	1.39
Treatment	9	3.67**	29.73**	5.04**	14.12**	12.10**	7.60**
Residual	27						
Total	39						

** = F value significant at 1% level of probability

Appendix 5: Means squares from analysis of variance for plant height as affected weed control treatment at Samaru, 1994 and 1995 dry seasons

Source of variation	Degree of freedom	Plant height					
		1994			1995		
		6 WAP	9 WAP	12 WAP	6 WAP	9 WAP	12 WAP
Replication	3	0.31	0.08	0.23	1.07	1.97	0.13
Treatment	9	21.70**	10.62**	37.63**	29.82**	49.80**	35.82**
Residual	24						
Total	38						

** = F value significant at 1% level of probability

WAP = Weeks after planting

Appendix 6: Means squares from analysis of variance for weed dry matter as affected by weed control treatment at Samaru, 1994 and 1995 dry seasons

Source of variation	Degree of freedom	Weed dry matter					
		1994			1995		
		6 WAP	9 WAP	12 WAP	6 WAP	9 WAP	12 WAP
Replication	2	1.13	1.73	0.05	1.47	3.35	1.34
Treatment	9	436.28**	58.17**	27.80**	7.67**	21.26**	10.05**
Residual	24						
Total	38						

** = F value significant at 1% level of probability

WAP = Weeks after planting

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