THE EFFECT OF MIXED CROPPING AND SEEDLING AGE ON THE PERFORMANCE OF PEPPERS (*Capsicum* species)

BY

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D E D I C A T I O N

To the memory of my father, YUNANA LAURONJO,
who early in my education quietly inspired
me always to strive for the best.

THESIS CERTIFICATION

This thesis entitled *THE EFFECT OF MIXED CROPPING AND SEEDLING AGE ON THE PERFORMANCE OF PEPPERS (Capsicum species)* by RISTA YUNANA meets the regulations governing the degree of Master of Science (*Agronomy*) of Ahmadu Bello University and is approved for its contribution to scientific knowledge and literary presentation.

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ABSTRACT

Two experiments were designed to study crop mixtures involving maize and pepper. Seedling age treatments were also included. In 1980 at Dangora, pepper was mixed with maize and cowpea planted in the sequence maize-pepper-cowpea under rainfed condition. Three maize spacing treatments of 360, 270 and 180cm. were used. In 1981 at Samaru, pepper was intercropped with maize in the dry season under irrigation. Maize was spaced at 240, 180 and 120cm. Variability was great in both experiments. In 1980, mixed cropping had an adverse effect on chilli pepper yield and the relative yield totals (R Y Ts) were less than 1. In monetary value, however, mixing was better than sole pepper but not as good as sole maize. Transplanting at 6 weeks gave higher monetary return than at 8 and 10 weeks with no significance between 8 and 10. In 1981, sole pepper had higher monetary value than sole maize and most of the mixed treatments were intermediate. For treatments with pepper transplanted at 7 weeks old R Y T was about 1 but for the 94 weeks old transplants R Y T was 1.3, possibly indicating a benefit from mixing. The late transplanting time performed better in crop mixtures but not in sole pepper, though the interaction was not statistically significant. Leaf cover trends were similar in sole crop and mixtures but the mixtures generally had greater leaf cover than the mid-point between sole maize and sole pepper. Cropping pattern and seedling age had no effect on the proportion of flowers that set fruits. Maximum fruit set of 41 - 46% was from flowers opening 103 - 115 days from sowing of pepper.

CHAPTER 1

INTRODUCTION

1.1 Origin and Importance of Peppers

Peppers (*Capsicum* spp.) were domesticated in South America and have been distributed throughout Africa since the fifteenth century. They are a major vegetable crop for Nigerian farmers, particularly in the northern States and are produced all the year round, under irrigation in the dry season. Formerly, chillies or hot peppers were an important export crop and most of the export production came from the Funtua area of Kaduna State. However, the export has declined from 580 tonnes in 1970 (FAO, 1971). The Nigerian Groundnut Board set up a committee with the aim of reviving export of chillies (Anonymous, 1979). A report on samples evaluated at the Tropical Products Institute in London, states that some of the chillies were of suitable quality for the international market but the prices could not compete with those from other sources (Green, 1979). Nevertheless, peppers and especially chillies are an important crop for home consumption and in internal trade.

1.2 Objectives of the Study

Research on peppers at the Institute for Agricultural Research (IAR), Zaria, started in the 1960s, with the collection of some local types and concentrated on nutritional studies, the improvement of the local types and the introduction of some promising exotic lines (Olarewaju, 1977). In Nigeria the traditional system of growing peppers is in mixtures with other crops (p.15-19). The production of pepper in mixtures has not been thoroughly investigated. Examination of information available and observation of local practice suggest that peppers are often transplanted into established maize which was usually harvested as fresh cobs and then replaced with cowpea.

Furthermore, it has been observed that local farmers transplant peppers older than the age recommended by such standard texts as Purseglove (1977) and Greensill (1975). This could possibly be related to the practice of mixed cropping and therefore the effect of seedling age at transplanting was included in the study with a view to determining the optimal age for transplanting.

In summary, therefore, the objectives of this study were:

1. To compare the production of peppers in sole crop and mixtures with maize and cowpea.
2. To determine the effect of age of transplant of the peppers in both cropping systems.

CHAPTER 2

REVIEW OF LITERATURE

Capsicum spp. (C. annum L. and C. frutescens L.) have a long history of cultivation which led to the development of a large number of varieties differing in growth habit and especially in size, shape, colour and pungency of the fruits. They have the common name peppers and include such types as bird chilli, cayenne, paprika, red and sweet peppers (Purseglove, 1977).

2.1 Taxonomy and Terminology of Capsicum spp.

The classification of the genus is very confused. Many species and varieties have been suggested from time to time. Bailey (1948) recognized one species only, Capsicum frutescens (Syn. C. annum) and 5 varieties. Heiser and Smith (1953) recognized C. annum and C. frutescens as valid species and two other species of cultivated Capsicum: C. pubescens Ruiz & Pav. and C. pendulum Willd. Most authorities now recognize two main species, C. annum and C. frutescens (Purseglove, 1977).

C. annum, an annual, is probably the most important of the two species and its common names are chilli, red pepper and sweet pepper. There are many cultivars, identified by the shape, colour or position of fruits on

the shoot; fruits can be either erect or pendant. Sweet peppers belong to the species C. annum (Purseglove, 1977) but not all C. annum are sweet peppers, some varieties are pungent. The sweet peppers have the mildest flavour with little of the pungent substance, capsicin. Sweet peppers are harvested in the green state as a salad vegetable or in the red ripe state to produce mild condiments. They are used as flavouring or colouring material in cookery.

C. frutescens is a perennial plant often cultivated as an annual but with a longer growing season than C. annum. Commonly called bird chillies, the fruits are generally smaller, clustered, erect, usually red and more pungent than C. annum. They are used in the manufacture of sauces, curry powder and in the prepara- of pickles all of which are used for culinary purposes and for seasoning (Purseglove, 1977).

The very pungent types of C. annum and all forms of C. frutescens are commonly referred to as hot peppers while chillies are the dried ripe fruits of hot peppers (Purseglove, 1977) but especially the small, conical, very pungent peppers (Parry, 1969). Ridley (1912) used chillies for peppers used as a spice. In this review "chillies" is used as an alternative term for hot peppers.

Peppers are rich in vitamin A, C and E. In Nigeria, peppers are the most important spice, ground and used with tomato in soups and also on meats. The fruits are called by different local names such as 'Ata' (Yoruba), 'Ose' (Igbo) and 'Barkono' (Hausa).

2.2 Mixed Cropping Systems

2.2.1 Importance of Mixed Cropping.

The practice of growing crops in mixtures often referred to as mixed cropping or intercropping (see Appendix 1 page 116 for definitions) is to a large extent confined to the traditional agriculture of the under-developed areas of the world. Most observers testify to the large extent of crop mixtures in the tropics (Miracle, 1967; Webster and Wilson, 1966). It is, however, difficult to give figures of the extent to which it is practised, though the FAO (1973) made estimates for various countries. Some estimates of mixed cropping are probably guesses whilst others are based on detailed surveys taken over a very limited area (Kass, 1978). Kass (1978), citing Francis et. al. (1976) state that 98% of cowpea in Africa and more than 60% of maize and beans in Latin America are grown in crop mixtures. Baker and Norman (1975) summarised surveys which showed that 93% of the Sokoto area (353.1 ha. surveyed), 83% of the Zaria area (360.5 ha. surveyed) and

53% of the Omu-Arun area (84.3 ha. surveyed) in northern Nigeria were planted to crop mixtures. More recent data from the Funtua, Gusau and Gombe Agricultural Development Projects show that at least 90% of the adjusted area of millet and cowpea are to be found in mixed crop production systems (Fisher, 1980b). Sole crops of sorghum, groundnut and cotton were recorded more frequently. Such figures indicate that mixed crop production systems have proved to be much more persistent in the farming system than was supposed when agricultural research commenced in Northern Nigeria, in late 1920's (Fisher, 1980c; 1980b).

2.2.2 *The Development of Research in Mixed Cropping*

In spite of the obvious popularity of mixed cropping, relatively little coordinated research has been done, since development programmes have placed emphasis on sole crops. One reason for the neglect of research in mixed cropping is the perception that because such a system is usually associated with "subsistence" farmers it is not worthy of being a topic of serious research endeavour (Norman, 1975). Another frequently quoted justification for emphasis on sole cropping is that as agriculture develops, mixtures become increasingly difficult to manage, particularly when mechanization is introduced (Willey and Osiru, 1972). According to Fisher (1979a) "the result of

this assumption has been for research to concentrate on sole crops and for recommendations to carry the implications that the practices are to be applied to sole cropping of the crops concerned". This is seen in most of the recommendations and leaflets produced for extension purposes in the country. For example, the current 'Guide to the production of peppers' (AERLS 1979) and 'Recommended practices for the production of maize' (AERLS 1980) make no mention of mixed cropping. The recommended spacing for sole peppers is 60x60cm. or 60x30cm, 1 plant per stand and for sole maize is 90x60cm, 2 plants per stand or 90x30, 1 plant per stand.

With the establishment of international institutes of agricultural research in the 1960's, there has been widespread recognition that the ability to expand world food supplies would depend on increasing food production by small farmers in the tropics, most of whom are growing crop mixtures (Kass, 1978). In northern Nigeria, experimental studies with mixed crops started receiving attention only after Andrews' work in late 1960s which was published in 1972 (Andrews, 1972). Recent research has clearly shown real advantages for mixed crops. This has led to a much wider acceptance among scientists of the advantages of mixed cropping, the realisation that the choice of mixed

cropping system by the small farmer is rational and the acceptance of the system as an object for scientific research (Fisher, 1979a).

2.2.3 Findings of Research in Mixed Cropping

Evans (1960) found that intercropping maize or sorghum with groundnuts generally leads to a greater production per unit area than growing these crops in pure stands. Webster and Wilson (1966) concluded that in most experiments on mixed cropping in the tropics, more than one acre of pure stands was required to produce the yield of one acre of the mixed crop and that for the tropical small-scale farmer, there was no advantage to be gained by replacing the traditional practice of mixed cropping by sole cropping. They went further to say that this advantage is not necessarily confined to low-input farming of land of poor fertility but may also apply to more intensive, well managed farming.

Reports appearing since then have generally substantiated Webster and Wilson's conclusion. For instance, Willey and Osiru (1972) found that yield of mixtures of maize and beans were up to 38% greater than could be achieved from sole crop in Uganda and the advantages were even greater with mixtures of beans and sorghum (Osiru and Willey, 1972). Their results also showed that mixed

cropping is beneficial where improved varieties and additional inputs are used. Again, Andrews (1972) showed total yield advantages of up to 80% from mixtures of sorghum with millet or cowpea in northern Nigeria, also under improved conditions while Baker (1978, 1979a, 1979b) reported higher monetary output per hectare from various mixtures at Samaru, Nigeria. Both higher yields and economic return were obtained from mixed cropping systems in Mexico, by Hart (1975).

It must also be appreciated that there can be some disadvantages of mixed cropping. For example, Fisher (1977) reported negative yield results. In 3 out of 4 cropping seasons maize-bean mixtures were less productive than pure stands. This appeared to be due to deletorious competition between the maize and bean crop mixture during the low rainfall seasons at Kabete, Kenya. Willey (1979) reviewing intercropping experiments said that disadvantages of intercropping in the form of a yield decrease can result from adverse competitive effects, allelopathic effects and difficulties concerned with the practical management of intercropping.

2.2.4 Findings from Village Surveys

Farm surveys also show that mixed cropping gives greater productivity per unit land area than sole crops. Norman (1972) showed that in northern Nigeria labour was

more uniformly used throughout the season under the indigenous mixed cropping system whilst variability of return from different plots was less than with sole cropping. The average return per acre was almost 62% higher than for sole crops. The contrast of mixed cropping and sole cropping was, however, confounded by the fact that most of the sole crop was cotton, a crop often neglected by farmers. Mixtures also gave a higher return to labour during the peak period (June and July) (Norman, 1974; 1975).

2.2.5 Conclusion from Reviews on Mixed Cropping and the Mechanisms of Yield Advantages

For all the different aspects of mixed cropping reviewed by Kass (1978) (yield, plant constituents, economic return, pest and disease control, yield stability, long-term effects, and effects of cultural practices), experimental evidence suggested that mixed cropping is more beneficial than detrimental. Other beneficial results of mixed cropping are better control of weeds, one crop may provide physical support for another or a more continuous leaf cover may give better protection against erosion (Willey, 1979). The case for mixed cropping appears weakest with regard to the incidence of pests and diseases and the difficulty of the cultural practices it requires. For the literature on mixed cropping includes as many cases

of increased incidence of pests and diseases as it does decrease (Kass, 1978). However, some success with the partial mechanisation and use of fertilizers for crop mixtures has been reported (Kass, 1978 citing Andrews, 1972; Brown and Graffis, 1976; Crookston, 1976; Ogborn, 1977).

Mixed cropping has been shown to have higher optimum total plant populations than in sole crops (Willey and Osiru, 1972; Osiru and Willey, 1972). Webster and Wilson (1966) and Willey (1979) concluded that the major cause of yield advantages and the only one for which there is much evidence to date, is the more efficient use of such growth resources as light, water and nutrients by crop mixtures than the same crops grown sole. In other words, inter-species competition is less than intra-species competition. This comes about because of the differences between the competing crops in stature, canopy and root development and depth or on account of the differences in their growth periods. The productivity of mixed cropping depends primarily on the selection of crop combinations capable of achieving more efficient use of the environmental resources than pure stands and on planting the crops in proportions and at densities which will maximize the total yield while achieving the desired balance of production between the species (Webster and Wilson, 1966; Kass, 1978).

2.2.6 Persistence of Mixed Cropping in the Tropics

"Despite some negative results and disadvantages of mixed cropping, the advantages are so much greater in the tropics than in the temperate areas that they may well persist even with advanced technologies" (Fisher, 1979a). The reason for this difference may be that in most parts of the tropics, the growing season, measured in heat units, is longer than in the temperate areas. Thus there is much more scope in the tropics for combinations of crops which are able to utilise the growth factors available throughout the season more fully than would any single sole crop (Bradfield, 1972; Fisher, 1979a). Other arguments given by Fisher (1979a; 1979b) for the persistence of mixed cropping in the tropics are:

1. The increasing evidence from experiments that mixed cropping is more stable in output than sole crops (Norman, 1974; Abalu, 1976; Fisher, 1979c; Rao and Willey, 1979). Because the tropical farmer operates in an inherently more risk-prone physical environment, he will not so easily abandon the relative security of mixed cropping for the convenience of sole cropping.
2. Land preparation and weeding provide the major labour bottleneck for crop production in the

tropics. Both, however, may be more easily mechanised for mixed crops than the harvest operation which is critical in temperate climates where heavy winter rain may spoil unharvested crops.

2.3 Vegetables in Mixed Cropping

2.3.1 Importance of the Mixed Cropping System for Production of Vegetables

Traditionally most vegetables in the tropics are produced in mixed cropping systems. Although some large-scale, sole crop production of vegetables is developing in Nigeria, the small-scale growers are more important and likely to be so for a long time to come.

Terra (1966) writing on tropical vegetables said vegetables (egg plant (Solanum melongena), chillies) are often grown spaced between the field crops. Tindall (1978) stated that different kinds of vegetables have varying rates of growth, and advantage of this is taken in intensive cropping. For instance, short duration crops such as some okra varieties (Abelmoschus esculentus), lettuce (Lactuca sativa), radish, (Raphanus sativus), African spinach (Amaranthus hybridus) and certain beans can be planted at the same time with a long duration crop as tomato (Lycopersicon esculentum), onion (Allium cepa),

pepper and cabbage (Brassica oleracea var. capitata). Okigbo (1975) reported that in western Nigeria okra, tomato, "egusi" (Colocynthis citrullus L.) and "ewedu" (Corchorus olitorius), are mixed with major staple crops. Other vegetables were fluted pumpkin (Telfairia occidentalis), pumpkin (Cucurbita pepo) and white melon (Cucumeropsis vulgaris), grown as minor crops at wide spacing among field crops. Similarly, in market gardens close to urban centres, vegetables are grown either in pure stands or in mixtures on small adjacent beds (Okigbo, 1978). In the south-eastern states of Nigeria the dominant staples (yams, cassava, cocoyams, bananas and plantains and to some extent maize) are grown with a range of subsidiary crops such as okra, pumpkings, melons (Colocynthis vulgaris Syn. C. citrullus L. and Cucumeropsis species) and leafy vegetable (Amaranthus hybridus, Celosia argentea, Corchorus olitorius, Telfairia occidentalis, Solanum nigrum and so on) (Okigbo and Greenland, 1976). In the "middle belt area of Benue - Plateau" in Nigeria, early millet is often interplanted with sorghum, cowpeas, pumpkins, okra, maize and sorrel (Hibiscus sabdariffa) (Okigbo, 1978 citing Netting, 1968). Quinn (1975) reported that in the Northern Guinea zone of Nigeria there are many mixtures with vegetable crops

found among small-scale growers who produce most of the vegetables.

Okigbo (1978) citing Hailey (1968) reported that in several farms in southern Nigeria where yams are the staple food crop, it was found that 90% of the yam farms also carried peppers. In the Anloga area of Ghana there is an extensive shallot (Allium escalonicum) industry involving three crops of shallot in one year. Tomatoes, okra, maize and peppers are intercropped with the shallot especially the third crop and between the harvesting of one and planting of another shallot crop, vegetables are grown as sole crops or mixtures (Irvine, 1950; 1969; Grove, 1970). Okigbo (1978) citing Van Santen (1974) reported that in the Foya area of Upper Lofa, Liberia, upland rice planted May to July is usually intercropped with peppers and other crops. Similarly, Spencer (1973) observed that 19.7% of the upland rice in Sierra Leone, is intercropped with among other crops, pepper and okra.

Writing on perennial crops in the tropics, Webster and Wilson (1966) reported that intercropping with annuals is practicable for the first few years and is commonly practised by small-holders in order to provide food or cash return while waiting for the permanent crop

to bear. Young plantings of coconut, oil palm, cocoa and rubber are interplanted with a wide range of food crops including vegetables. This, they considered, must be practised cautiously to prevent adverse effects on the permanent crops by competition for light, nutrients and water and by deterioration in soil structure resulting from excessive or ill-timed tillage or exposure of bare soil. Similarly, Sahasranaman (1961) reported chillies as an intercrop for coconut plantation. To date, intercropping with short-term crops has not been reported to have any adverse effects on the yield or growth of coconut (Denamany et. al., 1979). In Ceylon, chillies are usually grown in mixed cultivations, being grown with betel pepper (Piper betle) or other crops (Ridley, 1912 citing Colombo (1905)).

A socio-economic survey of 3 villages near Zaria area of Nigeria (Norman, 1972) revealed that vegetables are usually grown in mixtures and seldom as a sole crop. The survey reported a total of 178 different crop mixtures of which 83 of the mixtures included vegetable crops and of these pepper was a component in 39 of the mixtures. The number of crops in the mixtures ranged from 2 to 6, with 2, 3 and 4 crop mixtures together constituting over 50% of the total number of vegetable crop mixtures. Pepper,

onion and okra were the three dominant vegetables in the mixtures. Norman's survey results (Table 2.1) show that 81% of the pepper was grown in mixtures. About 70% of the pepper in these mixtures was the small chillies known as Nigerian chillies (Gaide, 1980 Department of Agricultural Economics ABU, personal communication).

Table 2.1 Adjusted crop areas of pepper and other vegetables and the percentages grown in different crop combinations (April 1966 - March 1969) of three Zaria villages from Norman (1972)

Crop	Total adjusted hectares grown*	Percent of total adjusted hectares grown in each crop mixture class					
		Sole	Two	Three	Four	Five	Six
Okra	8.8	2.6	13.4	38.4	26.2	9.9	9.5
Onion	2.1	12.6	11.1	43.4	18.5	7.0	7.4
Pepper	5.7	19.4	28.2	34.1	7.6	7.6	3.2
Tomato	0.8	17.9	33.7	25.0	19.4	0	4.1

*In calculating the total adjusted areas of crops, each crop in the mixture was allocated an area calculated by dividing the area of the crop mixture by the number of crops in the mixture. For example, a 1 hectare pepper-onion mixture would be entered as ½ hectare pepper and ½ hectare onion.

Norman's data showed that pepper and cowpea are frequently grown together by small scale farmers around Zaria. In another survey by the Funtua Agricultural Development Project for the 1976/77 cropping season, 78% of the total area cropped with pepper was in crop mixtures (Slade, 1977). Quinn (1975) reported that the combination of wet season onions interplanted with pepper and cowpea and the furrow planted with pumpkin is a common mixture.

2.3.2 Experimental Studies of Mixtures with Vegetables

The International Institute for Tropical Agriculture (IITA), in southern Nigeria has studied mixtures involving vegetables with roots, tubers or cereals. Intercropping maize-melon-cassava showed no significant difference in grain yield of maize. The melon crop suffered adversely from competition with maize and cassava, especially because of shading. To obtain satisfactory melon yields maize has to be reduced below 50,000 pl/ha. (IITA, 1975; 1976). Bradfield (1970; 1972) in the Phillipines reported that the annual sequence of rice-sweet potato-soyabean (mature)-sweet corn (fresh)-soyabean (fresh) in a multiple cropping/intercropping system resulted in increase production and the gross income of about ₱3,000/ha/year (compared with the average annual income of ₱500 from rice monoculture system of the southeast Asian small-holders).

Wilson and Adeniran (1976) at IITA reported intercropping of cassava with three vegetables in the sequence: tomato, okra and french bean (Phaseolus vulgaris). The highest total yields were produced when cassava rows were 2m. apart. The cassava had no apparent effect on the performance of the tomato, but suppressed the yields of okra and bean. The land equivalent ratios (LERs) showed that the cassava-vegetable mixture was more efficient than sole cropping of cassava alone or any of the vegetables. Cassava yields of up to 20t/ha were obtained (compared with 28t/ha for sole crop cassava), with total fresh weights of vegetables between 10 and 15t/ha. Randhawa (1975) reported that vegetables were suitable intercrops in sugarcane in India. Suggested intercrops were egg-plants, tomatoes, capsicums and onions. All combinations gave a much higher net income than sugarcane alone and of the intercrops compared onion was the most profitable.

Intercropping of chilli, cocoyam (Colocasia spp.), cucumber (Cucumis sativus), french bean, ginger (Zingiber officinale), groundunt, okra, long bean (Vigna sesquipedalis), maize and tomato with pineapple was investigated in Malaysia. All except cocoyam, french bean and maize were potentially profitable (Lee, 1972). Denamany et. al. (1979) also in

Malaysia studied the possibility of intercropping coconut with chilli, maize, cabbage, cauliflower (Brassica oleracea var. botrylis), tomato and shallots as compared to the crops already used by farmers. Though the vegetables gave much better gross income than banana, pineapple, coffee and cocoa, they were much more labour intensive. In areas where farm sizes were small, vegetables were recommended as intercrops in coconuts so that land and labour utilization could be maximized.

The effect of mulching with maize stalks and intercropping with horse bean (Vicia faba) on yield and quality of sweet pepper in Egypt was increased number of sweet pepper plants surviving after frost for both treatments. Mulching increased the yield by 293% and the presence of bean crop increased yield by 91% (Motaz et. al., 1972)

In concluding this section, it is evident that production of vegetables in crop mixtures is widespread in the tropics and that generally where mixed production has been compared with sole crops, it has performed favourably.

2.4 Effect of Seedling Age on Peppers

Most reports from the tropics have defined optimum transplanting time using the chronological age and there is much variation in the optimum suggested (Table 2.2). Nevertheless, many recommendations or studies have indicated an optimum between 3 and 6 weeks of age including Bunting and Milsum (1930), Lim and Wong (1975), Koay et. al. (1977) in Malaysia, Holman and Sagoe-Nkansah (1970), Sinnadurai (1971) and Norman (1977) in Ghana and Purseglove (1977) and Greensill (1975) writing for the tropics in general. In contrast Anonymous (1955) in South Africa and Saunders (1940) have suggested 6 - 8 weeks.

Because differences in growing temperature may be responsible for large differences in growth stage at a given chronological age, the stage of development or height of seedling might be better criteria for making a recommendation than age of seedling, but only a few reports have in fact given this information. Terra (1966) and Korodi (1966) considered 2 - 4 leaves to be the optimum stage but Spaldon and Gromora (1966) suggested 6 - 8 leaves, Erdei (1964) gave 8 - 10 leaves and Nicklow (1964) even suggested the seedling could have unopened flower buds when transplanted. Greensill (1975) and the extension leaflet of the Institute for Agricultural Research, Zaria

suggested a height of 2 - 3 inches (5 - 7.5cm.) whereas Hemy (1961), Anonymous (1955) and Purseglove suggested 4 - 6 inches (10 - 15cm).

Lim and Wong (1975) in Malaysia showed that chilli transplanted 3 - 4 weeks after sowing were more vigorous in vegetative growth, and flowered and fruited earlier than those transplanted at 5, 6 and 7 weeks after sowing. Total yield of fruits of the younger transplant was also higher than that of older transplants. Koay et. al. (1977) also in Malaysia obtained similar results. They found that transplanting chilli at 3, 4 and 5 weeks after sowing produced more vigorous plants than transplanting at 6, 7 and 8 weeks. Yields from plants transplanted at 3, 4, 5, 6, 7 and 8 weeks after sowing were 16.5, 11.4, 10.0, 7.9, 6.3 and 4.8t/ha; respectively. The presence of flower buds at transplanting (in the 7 weeks transplant) increased the earliness of flowering but depressed the total yield of fruit. Similarly, Norman (1977) in Ghana obtained better plant growth and higher yield from hot pepper transplanted 5 - 6 weeks after pricking out than those transplanted 7 weeks after pricking out. Flowering, fruiting and harvesting were delayed by the late transplanting.

Among the authors who presented experimental results, Nicklow (1964), Korodi (1966), Holman and Sagoe-Nkansah (1970),

Lim and Wong (1975), Norman (1977) and Koay et. al. (1977) favoured a transplanting treatment early in the range of treatment covered in their experiments whereas Erdei (1964) and Spaldon and Gromora (1966) favour a transplanting treatment fairly late in the range.

Many but not all of the recommended transplanting treatments fall in the range of 3 - 6 weeks, 3 - 5 leaves and 10 - 15cm. height. Exceptions might be for colder climates, for instance in highland, sub-tropical S. Africa, where seedlings would take longer to reach a given growth stage or height. Generally, transplanting later than the suggested time has been more deleterious than transplanting earlier.

Table 2.2 A Summary of Optimum Age, Stage of Growth or Height for Transplanting of Pepper Seedlings

Author	Country	Optimum Transplanting Time		
		Age (weeks)	Stage of Growth	Height (cm)
Bunting and Milsum (1930)*	Malaysia	6	ni	ni
Saunders (1940)*	Tropics	6-8	ni	ni
Anonymous (1955)*	S. Africa	6-8	ni	10-15
Hemy (1961)*	Tanzania	ni	ni	10-15
Erdei (1964)	Hungary	ni	8-10 leaves	ni
Nicklow (1964)	U.S.A.	ni	without flower or with only unopened buds	ni
Korodi (1966)	Hungary	ni	with cotyledons only and with 2 leaves	ni
Terra (1966)*	Tropics	ni	2-4 leaves	ni
Spaldon and Gromora (1966)		ni	6-8 leaves	ni
Holman and Sagoe-Nkansah (1970)	Ghana	6	ni	ni
Sinnadurai (1971)*	Ghana	4	ni	ni
Greensill (1975)*	Tropics	4	ni	5-7.5
Lim and Wong (1975)	Malaysia	3-4	ni	ni
Norman (1977)	Ghana	5-6	ni	ni

Table 2.2 (contd)

Author	Country	Optimum Transplanting Time		
		Age (week)	Stage of Growth	Height (cm)
Koay et. al. (1977)	Malaysia	3-5	ni	ni
Purseglove (1977)*	Tropics	4-5	ni	15
AERLS (1979)*	Tropics	ni	ni	7.5

*Suggested transplanting time apparently not directly based on experimental data.

ni = not indicated.

CHAPTER 3

MATERIALS AND METHODS

The original intention was to have two identical rainfed experiments during the wet season of 1980, one at Samaru on which detailed records were to be kept and one at Dangora, in a different ecological zone which would provide only yield data. However, the Samaru experiment had to be repeated during the dry season under irrigation and because of the constraint of irrigable land available, the number of treatments had to be reduced and other modifications made. The two experiments for which data are available therefore consist of one rainfed experiment located at Dangora between June and December 1980 and one irrigated experiment at Samaru between January and June 1981. Yield data only are available from Dangora but additional information is available for Samaru.

3.1 Experimental Sites

There were two experimental locations. One at Dangora and the other at Samaru.

(a) The Dangora location is in Kano State at latitude 11° 35'N and longitude 8° 11'E and falls within the Sudan Savanna ecological zone. The soil on the Ministry of Agriculture Farm Centre is a sandy clay loam. The field used for the experiment had been left fallow for 4 years and the

surface was rather uneven giving rise to poor drainage in some plots. Rainfall during the experimental period and other weather records are shown for Kadawa, about 30km from Dangora in Appendix Table 1 (p.119). This is the nearest meteorological station to the site.

(b) The Samaru location is at latitude 11^{o} 11'N and longitude 7^{o} 38'E within the Northern Guinea ecological zone. The experiment was located in the Irrigation Site which had been cropped with maize during the preceeding wet season. The soil is a sandy loam, light colour and moderately well drained. Analytical results for samples taken prior to laying out the experiment are given in Table 3.1. Weather records are given in Appendix Table 2 (p.120).

Table 3.1 Soil conditions of experimental site prior to layout of experiment, Samaru 1981

pH (in water, 1:1)	5.90
Total N (Sulphuric acid digestion and micro distillation method)	0.07%
Available P (Olsen method)	7.00ppm
Available K (In Ammonium Acetate extraction and read with flame photometer)	0.17meq/100g soil
Organic Carbon (Walky and Black method)	0.39%

3.2 Treatments

At Dangora in 1980 the experiment consisted of all combinations of 3 maize spacings (180, 270 and 360cm) with 2 plants/stand and 3 pepper seedling ages (6, 8 and 10 weeks) with the pepper interplanted at 45cm apart and 1 plant/stand. The maize spacings cover the range observed among farmers who grow maize - vegetable mixture. This gave 9 mixed crop treatments which were compared with 3 sole crop pepper treatments also transplanted 45cm apart at 6, 8 and 10 weeks old and 1 sole crop maize sown at 90cm with 2 plants/stand but duplicated to give 2 plots in each replicate. Cowpea was sown at 180, 270 and 360cm in the mixed crop treatments, 4 weeks before the maize was harvested to replace the maize in the mixtures. The treatments were coded A, B, . . .to N (Table 3.2, 3.3 and Figure 3.1).

Table 3.2 Treatments at Dangora in 1980, rainfed experiment

Treatment Code	Maize Spacing ((cm), 2 plants/ stand) (intra)	Pepper Spacing ((cm), 1 plant/ stand) (intra)	Cowpea Spacing ((cm), 2 plants/ stand) (intra)	Pepper Seedling Age (weeks)
A	-	45	-	6
B	-	45	-	8
C	-	45	-	10
D	360	45	360	6
E	360	45	360	8
F	360	45	360	10
G	270	45	270	6
H	270	45	270	8
I	270	45	270	10
J	180	45	180	6
K	180	45	180	8
L	180	45	180	10
M	90		-	-
N	90		-	-

Table 3.3 Intended plant populations at Dangora in 1980, rainfed experiment

Maize Spacing (cm)	Intended population/ha			
	Maize	Pepper	Cowpea	Maize + Pepper
-	-	25,720	-	25,720
360	8,230	21,605	8,230	29,835
270	10,288	20,576	10,288	30,864
180	14,403	18,519	14,403	32,922
90	26,749	-	-	26,749

Treatments:

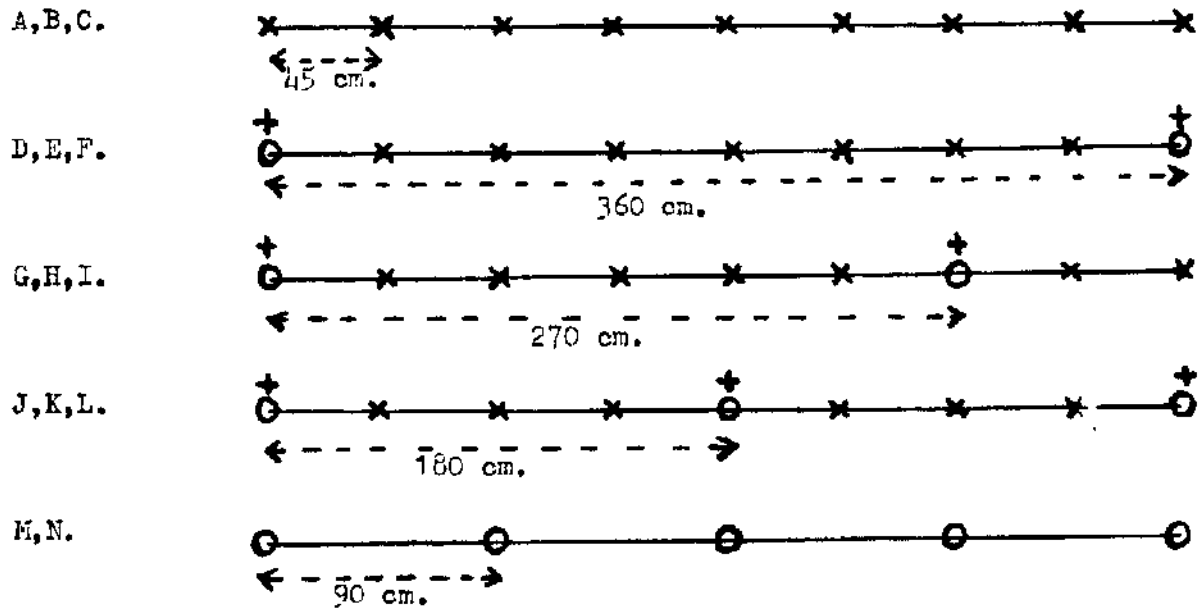


Figure 3.1. Spatial arrangement on ridge at Dangora 1980

Key:

✖ Pepper

O Maize-two plants

✚ Cowpea-two plants

At Samaru in 1981 the experiment took place during the dry season under irrigation. This called for a number of modifications in the treatments. Because land was limiting the total area available for the experiment was very small, therefore, the plot size and treatment number were reduced. Cowpea was excluded because of the problems attached to its cultivation under irrigation and because its harvest would have fallen in the wet season. A sweet pepper variety was planted instead of C. frutescens because of its shorter growth period. The treatments consisted of all combinations of 3 maize spacings (120, 180 and 240cm) with 2 plants/stand and 2 pepper seedling ages (7½ and 9½ weeks) with pepper interplanted at 40, 36 and 34.3cm apart in the 120, 180 and 240cm maize spacings respectively. This gave 6 mixed crop treatments which were compared with 2 sole crop pepper treatments transplanted 30cm apart at 7½ and 9½ weeks old and 1 sole crop maize sown at 60cm with two plants/stand but duplicated to give 2 plots in each replicate. This gave total of 10 treatments per replicate. The treatments were coded A, B, ... to J (Tables 3.4, 3.5 and Figure.3.2).

Table 3.4 Treatments at Samaru in 1981, irrigated experiment

Treatment Code	Maize Spacing ((cm) 2 plants/ stand)	Pepper Spacing ((cm) 1 plant/ stand)	Pepper Seedling Age (weeks)
A	-	30	7½
B	-	30	9½
C	120	40	7½
D	180	36	7½
E	240	34.3	7½
F	120	40	9½
G	180	36	9½
H	240	34.3	9½
I	60	-	-
J	60	-	-

Table 3.5 Intended plant populations at Samaru in 1981, irrigated experiment

Maize Spacing (cm)	Intended population/ha		
	Maize	Pepper	Maize + Pepper
-	-	57,870	57,870
240	18,518	41,667	60,185
180	23,148	37,037	60,185
120	32,407	27,778	60,185
60	60,185	-	10,185

Treatments:

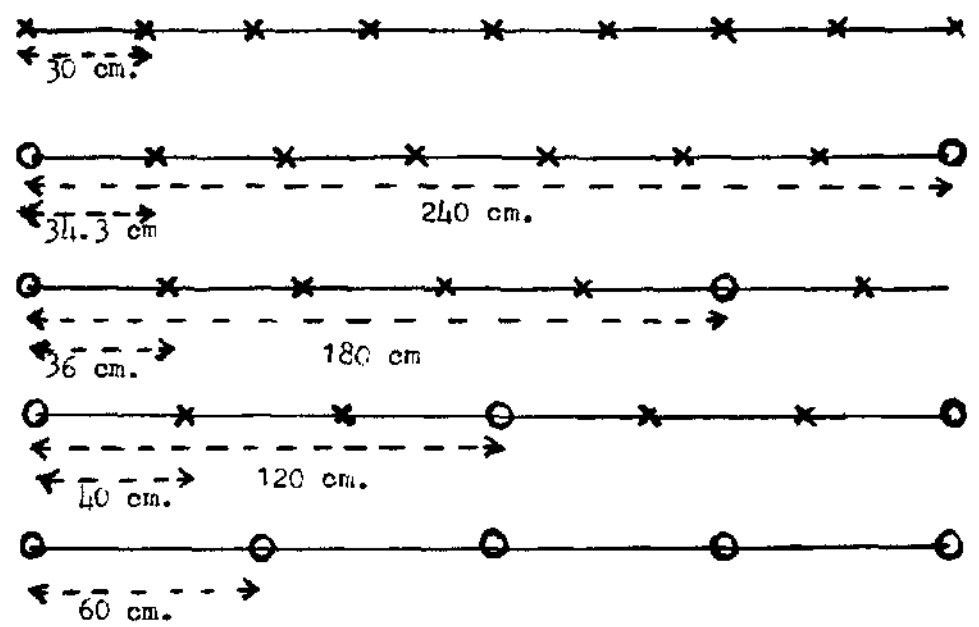


Figure 3.2. Spatial arrangement on ridge at Samaru in 1981.

Key:

× Pepper

O Maize-two plants

In 1980 at Dangora under rainfed the mixed treatments had the same total population being slightly higher than sole crop pepper and maize both of which had the same population. At Samaru in 1981 under irrigation all the treatments had similar populations.

3.3 Experimental Design and Layout

A randomized complete block design was used for both experiments. At Dangora in 1980, treatments were in 4 replicates. A replicate consisted of 14 plots and a plot had 6 ridges of 90cm apart which for pepper was later reduced to 4 ridges due to seedling shortage.

Gross Plot:

Width = 4 ridges x 90cm = 3.6m

Length = 10.8m

Area = 10.8m x 3.6m = $38.88m^2$

Net Plot:

Width = 2 ridges x 90cm = 1.8

Length = 10.8m

Area = 10.8m x 1.8m = $19.44m^2$

At Samaru in 1981 under irrigation treatments were in 5 replicates. A replicate consisted of 10 plots and a plot had 4 ridges of 60cm apart.

Gross Plot:

Width = 4 ridges x 60cm = 2.4

Length = 7.2m

Area = 7.2m x 2.4m = 17.28m^2

Net Plot:

Width = 2 ridges x 60cm = 1.2m

Lenght = 7.2m

Area = 7.2m x 1.2m = 8.64m^2

3.4 Varieties Used

Pepper, the Nigerian chilli cultivar, Kashin Burgu, supplied by the Horticultural Section of the Institute for Agricultural Research, Zaria, was used at Dangora in 1980. The evaluation report from Tropical Products Institute (Green 1979) states that it is one of the "good marketable chillies" and has "nice appearance but tends towards loose seeds". At Samaru in 1981 Line 5972/2 of sweet pepper was used on the recommendation of the Plant Pathology Section of I.A.R. who considered it less susceptible to leaf curl virus disease. The chilli pepper used at Dangora was not planted because its long growth cycle and fruiting period makes it unsuitable for the limited irrigation period.

Maize, NCB (Nigerian Composite B) variety was sown at Dangora in 1980. It is one of the first maize composites developed in Nigeria. The components are material from Kenya, South Africa, Central Africa and Nigeria. It has mixed yellow and white dent grains. The ears are small and usually borne singly on small-sized plants. It is classed as medium in maturity, 120 days. In 1981 at Samaru Bomo Local, a selection made at Zaria, was planted. It is an improved local variety with a yield potential of up to 4000kg/ha and popular with the local farmers especially for fresh cob consumption.

Cowpea, Line 1696, selected in Nigeria was used at Dangora in 1980. It is one of the advance release varieties under zonal trial and was chosen for this experiment because of its late maturity to allow for more competition period with the chillies after maize was harvested. It is photosensitive (short day) with large white seeds and short pods.

3.5 Nursery Management

The pepper seedlings transplanted at Dangora were raised at Samaru, Zaria. The seed-bed was 120cm. wide and 500cm. long. Nemagon 20 (Nematicide) was applied to the seed-bed 3 weeks before sowing at the rate of 8.5g/sq.m. The granules were spread on the soil and

forked into a depth of 15 - 20cms, and the soil compacted to prevent loss of fumigant. Three weeks after Nemagon application superphosphate was applied at the rate of 21 gm/sq.m. The soil was dug and worked to a fine tilth. It was then raked to remove stones and straw and made the surface level. Seeds were sown thinly in drills about 10cm apart and ½cm deep, and covered lightly with soil, on 6 June 1980. The bed was mulched with dry grass and watered when necessary. The mulch was removed when seedlings emerged and weeding was by hand pulling when necessary. Nitrogen feeding was given to increase the growth rate of seedlings: 21.5g of calcium ammonium nitrate (CAN) in 9.2 litres of water applied at the rate of 4 litres per square metre.

For the Samaru experiment in 1981 seed-beds were sited at the field and sunken to facilitate watering. All the operations were carried out as for the Dangora experiment in 1980 except for the application of Nemagon. Seedlings were raised entirely under irrigation and beds were irrigated every two days.

3.6 Field Management

3.6.1 Land Preparation, Basal Fertilizers and Irrigation

At Dangora in 1980 the preparatory tillage operations consisted of ploughing, harrowing and ridging at 90cm in July. Basal dressing of calcium ammonium nitrate (CAN) and single superphosphate at the rate of 154 and 222 kg/ha respectively were applied just before ridging. The quantities given are based on the recommendation for sole crop pepper and meet the basal requirement of maize of 40kgN/ha and 40kg P_2O_5/ha.

In 1981 at Samaru tillage operations were carried out as at Dangora, October - November 1980. The rates used for basal dressing were as for Dangora and were applied in slits along the leeward side of the ridge just before sowing the maize in February 1981. The CAN and superphosphate were mixed before application into the slits at the base of the ridges.

Irrigation was done by application water in the furrow with an initial schedule of 2 irrigations per week and later irrigated after every 5 days. The rains started in April, from then till June irrigation was given only to supplement rainfall when necessary.

3.6.2 Planting and Thinning of Maize and Cowpea

Maize seeds were treated with seed dressing of thiram and aldrin (Aldrex -T) at the rate of 3kg seed/ 1 packet of Aldrex -T (about 9g) and sown on 2 July 1980 at Dangora. Four grains were planted per stand at the specified treatment spacings of the plots. Plants were thinned to 2 plants per stand 2 weeks after germination. Gaps were supplied immediately after germination.

Cowpea was sown on 2 September 1980, 2 weeks after the very late transplanted pepper (10 weeks old transplants) and 9 weeks after maize sowing. The seeds were sown at the base of maize stands 4 weeks before maize harvest and only in treatments having both pepper and maize. Three seeds were planted per stand and later thinned to 2 plants per stand. Missing stands were supplied after germination.

At Samaru maize seeds were treated and sown as at Dangora but sown on 3 February 1981 and thinned 3 weeks after sowing. Seeds were sown on the leeward side of the ridges just above the band of fertilizer applied. This was to allow irrigation water reach the plant roots easily and prevent close contact of seeds with fertilizer.

3.6.3 Transplanting of Pepper

For Dangora 1980, seedlings were removed and transported from Samaru very early in the morning and transplanting was done on 3 dates for the 3 ages of 6, 8 and 10 weeks. Seedlings were planted 1 per stand at a spacing of 45cm within row for all pepper treatments.

In 1981 at Samaru seedlings were transplanted on 26 February and 12 March 1981 for the transplant age treatments of 7½ and 9½ weeks respectively. The size and stage of seedlings at transplanting were 5.3cm high with 5 true leaves and 9.3cm with 6 leaves for the 7½ and 9½ weeks old seedlings respectively. The field and seed-beds were irrigated a few hours before transplanting. Transplanting was done in the evenings, 1 seedling per stand with the seedlings planted on the leeward side of the ridge.

3.6.4 Side Dressing of Maize and Pepper

At Dangora maize was side dressed at 4 weeks after planting. Side dressings were metered by means of a scoop which contained 9g of CAN (2.34 gN) when level-full. One and half (1½) scoop was supplied per

stand of maize which gave 181kg/ha of CAN in the sole crop (Table 3.6).

Table 3.6 Rate of Nitrogen Fertilizer Applied at Dangora in 1980, Rainfed Experiment

Cropping Pattern	Basal Dressing (kg/ha CAN)	Side Dressing		Total CAN (kg/ha)	Total Nitrogen (kg/ha)
		Pepper (kg/ha CAN)	Maize (kg/ha CAN)		
Sole Maize	154		181	335	87
180cm Maize Spacing	154	167	97	418	109
270cm Maize Spacing	154	185	69	408	106
360cm Maize Spacing	154	194	56	404	105
Sole Pepper	154	231		385	100

Side dressing of pepper treatments were split at 3 weeks after transplanting and at first fruit set except that the very late pepper treatments (10 weeks old transplants) did not receive the second side dressing because the rains stopped early. Half a scoop was given per stand of pepper at each side dressing equivalent to 231kg/ha of CAN in the sole crop. Overall, the mixtures received slightly more CAN per ha than the sole crops (Table 3.6).

At Samaru maize and pepper received side dressing as for Dangora except that one scoop of CAN per stand of maize was given (Table 3.7). Total CAN applied to mixtures was intermediate between that of sole maize and sole pepper.

Table 3.7 Rate of Nitrogen Fertilizer Applied at Samaru in 1981, Irrigated Experiment

Cropping Pattern	Basal Dressing (kg/ha CAN)	Side Dressing		Total CAN (kg/ha)	Total Nitrogen (kg/ha)
		Pepper (kg/ha CAN)	Maize (kg/ha CAN)		
Sole Maize	154		269	423	110
120cm Maize Spacing	154	250	146	550	143
180cm Maize Spacing	154	333	104	591	154
240cm Maize Spacing	154	375	83	612	159
Sole Pepper	154	520		674	175

3.6.5 Crop Protection

Both experiments were weeded and the ridges remoulded as necessary. No chemical control of pests and diseases was practised at Dangora.

At Samaru birds were scared until maize seedlings were established. The maize was sprayed against stemborers with carbaryl (Vetox 85) and later with carbaryl

in combination with menazon (Sayfos). Six sprayings were given at a weekly interval.

3.7 Drainage Score, Dangora Experiment

Scoring of plots for drainage was undertaken at Dangora on 3 occasions in the month of August and September 1980 (Appendix Table 37 p.137). A 0 - 6 scale was used to visually score:

0 = very bad drainage, water logged.

1 = bad, water standing at base of furrow.

2 = below satisfactory drainage.

3 = satisfactory drainage.

4 = fairly good.

5 = good.

6 = very good drainage.

3.8 Observations

All the observations described below were only recorded for the 1981 Samaru experiment except the stand count at harvest, this was recorded for both experiments.

3.8.1 Height and Number of Leaves at Transplanting of Sweet Pepper, Samaru Experiment

The height and number of true leaves were recorded from 100 randomly sampled seedlings from the seed-bed on the dates of transplanting of the 7½ and 9½ weeks old seedlings. From these the average height and number of leaves at transplanting was calculated.

3.8.2 First Flower Opening of Sweet Pepper, Samaru Experiment

The date of appearance of first opened flower was recorded.

3.8.3 Leaf Cover of Maize and Sweet Pepper, Samaru Experiment

Baumer and de Wit's (1968) optical point quadrat apparatus, locally constructed was used for measuring green leaf cover of maize and pepper in the mixture. The instrument is basically a simple viewer which consists of a tube with a crosswire attached to the open end of the tube. The camera obscura principle enables the observer to see object and crosswire with equal sharpness. Any object, either plant species or bare soil, which is covered by the crosswire can be identified. A scale, connected with the tube indicates the angle of inclination of the tube at the time of observation. The pointer is kept in position by gravity. This instrument estimates the interception of radiation at known angle of incidence on each crop in the mixture.

Observation was taken by fixing the position of the observer and aiming at various points in the canopy in a semi-circle. The viewer was moved at regular and small intervals with the tube maintained at an angle of inclination of 45^{o}. By looking through the instrument in

this manner, the relative frequency of the green leaves of pepper, maize and bare ground that were seen were recorded for each plot. From these frequencies the cover contributed by each crop was estimated as a percentage.

This measurement started 7½ weeks after planting maize, 4 weeks and 2 weeks after transplanting the 7½ and 9½ weeks old pepper respectively. It was done at weekly intervals until maize harvest and one further measurement made after 2 weeks.

3.8.4 Flower Tagging of Sweet Pepper, Samaru Experiment

Ten pepper plants were selected at random from the innermost ridges of each plot and labelled with tags 1 to 10. At an interval of 3 days, all newly opened flowers on the 10 selected plants were tagged. Tagging started at first appearance of flower and continued for 6 weeks. Records of dates and number of flowers were maintained. Different colours of thread were used for tagging at the different dates.

3.8.5 Plant Height of Sweet Pepper, Samaru Experiment

Measurements of height were taken fortnightly on five occasions between 2 April and 28 May 1981 using the 10 selected plants used for flower tagging. Measurement was from the ground level to the uppermost shoot tip.

3.8.6 50% Silking of Maize, Samaru Experiment

The dates of 50% silking of the net plot of maize treatments were recorded for each plot.

3.8.7 50% Flowering of Sweet Pepper, Samaru Experiment

A plot was said to have 50% flowering when 50% of its net plot pepper population have at least one flower and for some plots where 5 of the 10 selected plants have at least one flower.

3.8.8 50% Fruit Set of Sweet Pepper, Samaru Experiment

Dates at which 50% of the net plot pepper population set at least one fruit were recorded and the number of days from sowing to 50% fruit set calculated.

3.8.9 Percentage Fruit Set from Tagged Flowers of Sweet Pepper, Samaru Experiment

Fruits of the tagged plants were picked separately into labelled bags. Fruits were picked along with the thread used in tagging the flower. Counts and records were maintained of the number of fruits per thread colour which coded the date or period of flower tagging. From these records, the percentage of flowers that set fruit was calculated for each flower tagging interval and also the total percentage of flowers that set fruit.

3.8.10 Pepper Leaf Curl Score, Samaru Experiment

Scoring of plots for pepper leaf curl disease was done after second picking of fruits on 27 May 1981. All plants on the net rows of each plot were scored. A 0 - 4 scale was used to visually score.

0 = no leaf curl symptons

1 = top few leaves showing curling and puckering

2 = many leaves infected showing curling

3 = leaf curl involving entire plant and slight stunting of plant

4 = leaf curl involving entire plant and proliferation of plant.

3.8.11 Stand Count of Maize, Peppers and Cowpea

In 1980 at Dangora stand counts of maize, pepper and cowpea were recorded for net plots at harvest. At Samaru pepper stand counts were taken when Thielavia wilt disease appeared about 20 April 1981, 15 weeks after sowing. Final stands of maize and pepper were counted at harvest. All the data were expressed as number of plants per hectare (Appendix Table 38 - 39 p.138 - 139).

3.9 Harvesting and Yield of Maize, Peppers and Cowpea

At Dangora maize was harvested first as fresh cobs on 30 September 1980, 3 months after sowing and about 4 weeks before pepper picking started. The maturity of fresh cobs was determined by the silks turning brown as a result of their drying up. At Samaru harvest was on 21 May 1981, 3½ months after sowing except for replicate 3 which was harvested 2 weeks later. The late maturity of this replicate resulted from the slow development of the plants because the plots were water logged. Maize harvest was delayed until 4 of the 5 replicates were mature. Maize yields were expressed as marketable fresh cobs and total fresh cobs/ha. The number of marketable fresh cobs/ha was recorded only at Samaru. Maize stems were removed immediately after harvest.

The chillies at Dangora were picked red ripe. Picking started on 28 October, 1980, 4½ months after sowing, and continued at fortnightly intervals until most plants dried up due to the early cessation of rainfall. Chilli fruits were sun-dried at Samaru and yields expressed as air-dry weights per ha. At Samaru sweet pepper picking started a week before maize harvest, on 14 May 1981, 4 months after sowing. Only matured

green fruits were picked. The skin of mature green pepper is shiny, waxy and fairly firm and crisp. Picking was at weekly intervals. A total of 5 pickings completed the harvest with the early transplants (7½ weeks) having only 4 pickings. Sweet pepper yields were expressed as marketable and total fresh weight per ha. Also recorded were the number of fruits per plant from the 10 randomly selected and tagged plants and the number of fruits per ha.

Cowpea at Dangora was harvested at a single harvest when pods were completely dry, on 25 November 1980, 3 months after sowing, 6 weeks after maize harvest and 4 weeks after pepper picking started. Cowpea yield was expressed as seed yield per ha.

3.10 Statistical Analysis

At Dangora the yield data were analysed for covariance with drainage score. Pepper and cowpea yields were subjected to logarithmic transformation to improve homogeneity of treatment variances.

At Samaru all the data collected from observations, except maize stand count and total percentage fruit set were analysed. Pepper yield data except number of fruits per plant were subjected to logarithmic transformation before analysis.

The yield data of both experiments were further analysed by the bivariate analysis method of Pearce and Gilliver (1978) details of which are given in chapter 4.

CHAPTER 4

RESULTS AND DISCUSSION

In 1980 at Dangora sowing of maize and transplanting of pepper were carried out late. Because of this, and the unusually early cessation of rain in 1980 (Appendix Table 1 p.119), the overall performances of the crops were poor and yields were very low. There was a problem of water logging on some plots which resulted in zero yield of maize and pepper on a few plots. In 1981, at Samaru, good crop stands were initially obtained for both pepper and maize although germination was slow due to the cold weather. A later attack of maize by stemborers caused some stand losses of maize in spite of spraying and an attack of sweet pepper by Thielavia wilt resulted in serious stand losses of pepper (Table 4.1).

In both experiments variances of pepper and cowpea yields were found to be non-homogeneous with treatment and the yield data were subjected to logarithmic transformation which improved the homogeneity (Appendix Table 3 - 8 p.121 - 123). Analysis of variance for both untransformed and transformed data may be compared in Appendix Tables 42 - 65. In addition, variances were high and possible sources of variability were bad site and poor management at Dangora in 1980 and lack of uniformity in irrigation of plots which resulted from the land surface

not being level at Samaru in 1981.

4.1 Thielavia Wilt of Pepper, Samaru Experiment

The attack of Thielavia wilt, a fungal disease caused by Thielavia terricola, came during flowering and fruit set. Many stands of pepper were killed and on a few plots, stand loss of more than 50% was recorded. The disease appeared in patches suggestive of a soil-borne pathogen and no post-planting control measure is known. Identification of the pathogen was by the Plant Pathology Section of the Institute for Agricultural Research, Zaria. The disease was significantly more severe with early transplanted treatments which had significantly greater stand loss than the late transplanted treatments (Table 4.1).

Table 4.1 Sweet Pepper Plant Stand Loss Due to Wilt Disease (%) at Samaru in 1981, Irrigated Experiment

Age of Transplant (week)	Cropping Pattern				Mean of Mixtures	Main Effect
	Sole Crop	Maize Spacing (cm)				
		240	180	120		
7½	36.8	38.6	33.0	29.4	33.7	34.45
9½	17.2	10.4	14.2	12.2	12.3	13.50
Main Effect	27.0	24.5	23.6	20.8	23.0	

S.E. Main Effects: Cropping Pattern 4.72
Age of Transplant 3.34
S.E. Mean of Mixtures 3.85
S.E. Interaction 6.67

4.2 Yield of Peppers:

4.2.1 Chilli Pepper Yield, Dangora 1980

In 1980 at Dangora, significant differences in yield of chilli pepper were shown between the cropping patterns. Sole crop had the highest yield with 360,270 and 180cm. maize spaced crop mixtures producing 44, 35 and 16% of the sole crop respectively (Table 4.2). The age of transplant produced a highly significant effect on yield. The 6 weeks old transplanted pepper had the highest yield with the 8 weeks old and 10 weeks old transplanted pepper producing 22 and 6% of the 6 weeks old transplanted pepper.

Table 4.2 Chilli Pepper Dry Yield (kg/ha) at Dangora in 1980, Rainfed Experiment

Age of Transplant (week)	Cropping Pattern				Mean of Mixtures	Main Effect
		Maize Spacing (cm)				
	Sole Crop	360	270	180		
6	105	39	39	13	30	49
8	19	15	4	6	8	11
11	4	2	3	2	2	3
Main Effect	43	19	15	7	13	

Note: The table was analysed under logorithmic transformation (Appendix Table 3 p.121).

There was no significant interaction, but the 6 weeks transplanted pepper had the highest yield for the

mean of the mixtures and yielded 29% of the 6 weeks sole crop pepper with the 8 and 10 weeks producing 8 and 2% respectively of the 6 weeks sole crop pepper.

4.2.2 Marketable Yield of Sweet Pepper, Samaru 1981

In 1981, Thielavia wilt disease attacked late in life of the pepper and so compensatory growth by healthy plants was unlikely to have occurred. Therefore, an adjusted yield was calculated:

$$\text{Adjusted Yield} = Y \times \frac{C_1}{C_2}$$

Where Adjusted Yield = expected marketable yield of plot if no wilt had attacked.

Y = marketable yield obtained per plot after disease attack.

C_1 = population of pepper per plot before disease attack.

C_2 = population after attack.

Cropping pattern and the age of transplants had no significant effect on the adjusted marketable yield of sweet pepper. However, the sole crop had the highest yield with the 240, 180 and 120cm. maize spaced crop mixtures producing 80, 52 and 54% of the sole crop yield respectively (Table 4.3). Over all cropping patterns, the 9½ weeks old transplanted pepper (late pepper) yielded 12% more than the 7½ weeks old transplanted pepper (early pepper). The interaction

between cropping pattern and transplant age was not statistically significant, however, the 9½ week-old transplants yielded 43% more than the 7½ week-old for the mean of the mixtures but 29% less for the sole crops.

Table 4.3 Sweet Pepper Adjusted Marketable Yield (kg/ha) at Samaru in 1981, Irrigated Experiment

Age of Transplant (week)	Cropping Pattern				Mean of Mixtures	Main Effect
	Sole Crop	Maize Spacing(cm)				
		240	180	120		
7½	6678	3324	2995	2454	2924	3863
9½	4773	5799	2944	3766	4170	4321
Main Effect	5726	4561	2970	3110	3547	

Note: The table was analysed under logarithmic transformation (Appendix Table 4 p.121)

Similar results were obtained with the unadjusted marketable yield (Table 4.4). Sole crop pepper yielded more than the pepper in mixture with maize. The 240, 180 and 120cm. maize spaced crop mixtures yielded 82, 54 and 57% of the sole crop respectively. Overall, the late transplants yielded 35% more than the early transplants. The interaction between cropping pattern and transplant age was not statistically significant, however, the late yielded 81% more than the early for the mean of the mixtures but 22% less for sole crops.

Table 4.4 Sweet Pepper Unadjusted Marketable Yield (Kg/ha) at Samaru in 1981, Irrigated Experiment

Age of Transplant (week)	Cropping Pattern				Mean of Mixtures	Main Effect
	Sole Crop	Maize Spacing (cm) 240	180	120		
7½	5069	2178	2227	1775	2060	2813
9½	3963	5197	2611	3387	3732	3789
Main Effect	4516	3687	2419	2581	2896	

Note: The table was analysed under logarithmic transformation (Appendix Table 5 p.122).

4.2.3 Total Yield of Sweet Pepper, Samaru 1981

There was no significant effect on unadjusted total yield resulting from age of transplant and cropping pattern. Sole crop pepper had the highest total yield with 240, 180 and 120cm. maize spaced crop mixtures producing 79, 52 and 51% of the sole crop respectively (Table 4.5). Overall, the late transplanted pepper yielded 33% more than the early transplanted pepper. The interaction between cropping pattern and transplant age was not statistically significant, however, the late yielded 64% more than the early for the mean of the mixtures but 9% less for sole crops.

Table 4.5 Sweet Pepper Unadjusted Total Yield (kg/ha) at Samaru in 1981, Irrigated Experiment

Age of Transplant (week)	Cropping Pattern				Mean of Mixtures	Main Effect
	Sole Crop	Maize Spacing (cm)				
		240	180	120		
7½	6562	3326	2954	2370	2883	3803
9½	5988	6595	3576	4033	4735	5049
Main Effect	6275	4961	3265	3203	3809	

Note: The table was analysed under logarithmic transformation (Appendix Table 6 p.122).

..2.4 Number of Sweet Pepper Fruits per Unit Area, Samaru 1981

Significant differences in number of fruits per ha. resulted from the effect of cropping pattern. Sole crop had the highest number with the 240, 180 and 120cm maize spaced crop mixtures producing 76, 53 and 44% of the sole crop respectively (Table 4.6). Age of transplant and interaction has no significant effect, however, over all late transplanted pepper produced 30% more fruits than the early transplanted pepper. The late yielded 39 and 17% more than the early for the mean of the mixtures and sole crop respectively.

Table 4.6 Number of Sweet Pepper Fruits (Thousands per ha) at Samaru in 1981, Irrigated Experiment

Age of Transplant (week)	Cropping Pattern				Mean of Mixtures	Main Effect
	Sole Crop	Maize Spacing (cm)				
		240	180	120		
7½	400	272	202	155	210	257
9½	469	386	260	226	291	335
Main Effect	435	329	231	191	250	

Note: The table was analysed under logarithmic transformation (Appendix Table 7 p.123).

Table 4.7 Number of Fruits Per Sweet Pepper Plant, at Samaru in 1981, Irrigated Experiment

Age of Transplant (week)	Cropping Pattern				Mean of Mixtures	Main Effect
	Sole Crop	Maize Spacing (cm)				
		240	180	120		
7½	8.0	10.0	6.0	6.0	7.3	7.5
9½	10.6	12.0	7.8	9.0	9.6	9.9
Main Effect	9.3	11.0	6.9	7.5	8.5	

S.E. Main Effects: Cropping pattern 1.43
Age of transplant 1.01

S.E. Mean of Mixtures 1.17

S.E. Interaction 2.03

4.2.5 Number of Sweet Pepper Fruits per Plant, Samaru, 1981

None of the factors being investigated had a significant effect on the number of fruits per plant. The 240, 180 and 120cm maize spaced crop mixtures produced 118, 74 and 81% of the sole crop respectively (Table 4.7). Irrespective of maize spacing, late transplanted pepper plants had more fruits than early, averaging 32% more overall.

4.2.6 Mean Fruit Weight of Sweet Pepper, Samaru 1981

This was obtained by dividing the total weight of pepper per hectare by the total number of fruits per hectare on a plot basis. Although differences were not significant for any effect, the early sole pepper had bigger fruits than the late sole pepper while the late peppers had bigger fruits in the mixture than the early in mixture (Table 4.8). This interaction is in the same direction as for marketable yield (Table 4.3).

Table 4.8. Sweet Pepper Mean Fruit Weight (g), at Samaru in 1981, Irrigated Experiment

Age of Transplant (week)	Cropping Pattern				Mean of Mixtures	Main Effect
	Sole Crop	Maize Spacing (cm)				
		240	180	120		
7½	14.06	11.70	13.62	15.36	13.56	13.69
9½	12.40	15.96	13.08	15.48	14.84	14.23
Main Effect	13.23	13.83	13.35	15.42	14.20	

Note: See page 61 for S.E.s

S.E. Main Effects: Cropping Pattern 0.88
Age of transplant 0.62

S.E. Mean of Mixtures 0.72

S.E. Interaction 1.24

Comparism of the pepper yield of Dangora and Samaru showed that irrespective of cropping system the young seedlings (6 weeks old) yielded better than the older seedlings at Dangora under rainfed condition but at Samaru under irrigated conditions the old seedlings (9½ weeks) yielded better than the young ones (7½ weeks) but only in mixtures. A suggested explanation for the result at Samaru might be that the older seedlings received better management and attention with respect to watering, fertilization and weeding in the nursery bed for a longer period. This then influenced their growth and performance in the field giving them an advantage over the young seedlings in mixtures.

4.2.7 Picking Profile of Sweet Pepper; Samaru 1981

The quantity of pepper at each picking was expressed as the percentage of the total harvest (Appendix Table 9-14). Generally, cropping pattern and seedling age had no effect on the picking profile trend with the first picking being the lowest, the second the highest and third and fourth each being about ⅔ of the second picking (Figure 4.1 and 4.2). The later transplanted pepper had a fifth picking because of its delayed fruiting.

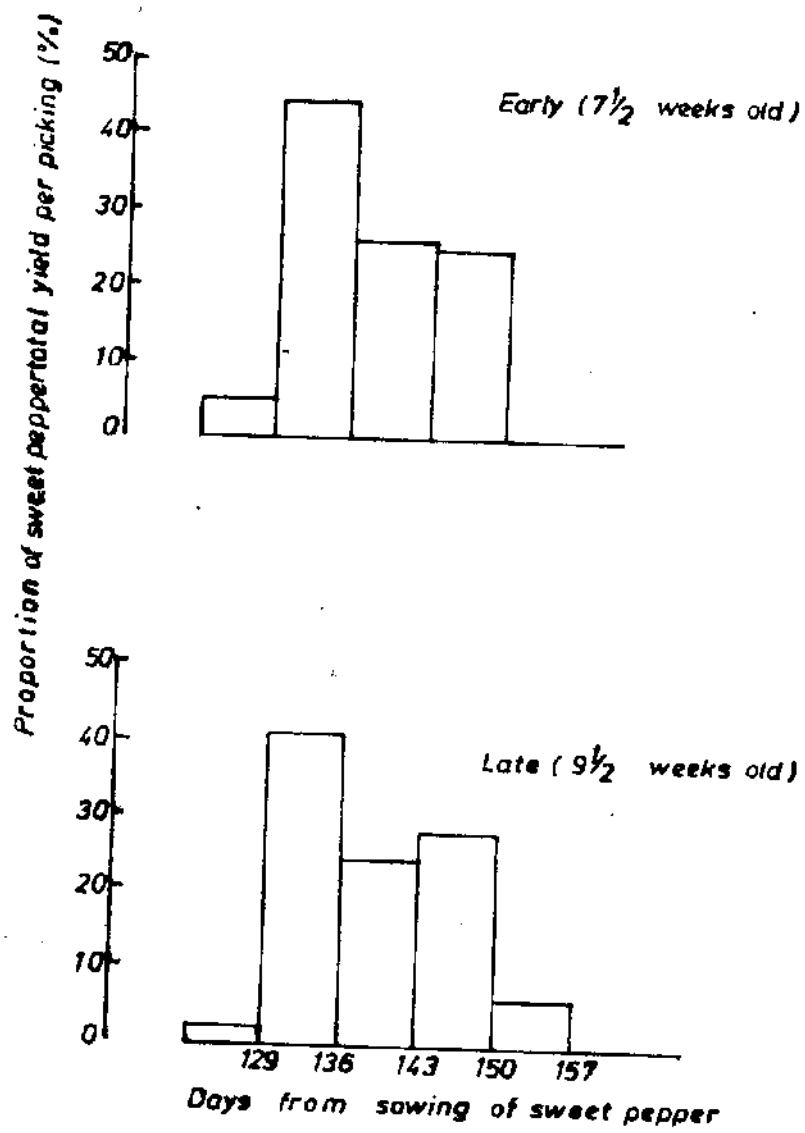


Figure 4.1: Main effect of seedling age on the proportion of sweet pepper total yield harvested at successive 7day intervals, Samaru 1981, irrigated experiment

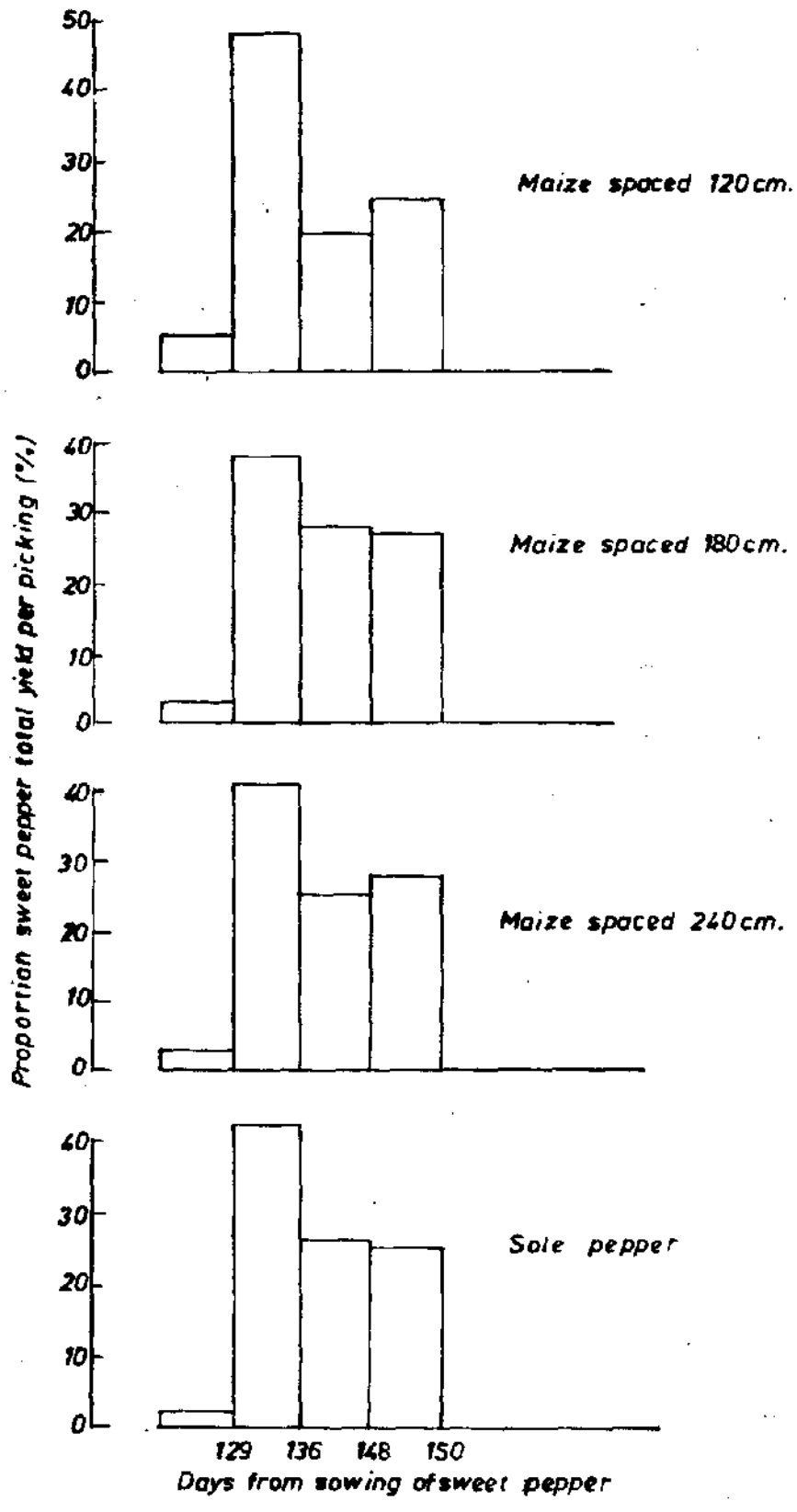


Figure 4.2: Main effect of cropping pattern on the proportion of sweet pepper total yield harvested at successive 7 day intervals, Samaru 1981, irrigated experiment

4.3 Yield of Maize (Fresh Cobs)

No transformation was carried out with maize yield data since there was no problem of heterogenous variances.

4.3.1 Marketable Yield of Maize

At Dangora, there was no significant difference between yield of sole crop marketable maize from the mean of mixed crops though sole crop had a higher yield with the mixed crops yielding 64% of the sole crop (Table 4.9). There was no significant effect of mixed cropping but the 180, 270 and 360cm. maize spaced mixed crops produced 83, 55 and 56% of the sole crop respectively. The age of pepper transplant also had no significant effect on marketable yield and the interaction was not significant.

Table 4.9 Maize Marketable Yield (kg/ha) at Dangora in 1980, Rainfed Experiment

Age of Transplant (week)	Cropping Pattern				Mean of Mixtures
	Sole Crop	Maize Spacing (cm)			
		180	270	360	
6	-	1647	823	913	1128
8	-	798	553	849	733
10	-	798	759	412	656
Main Effects	1305	1081	712	725	839

Note: See page 65 for S.E.s

S.E. Main Effects: Cropping Pattern (except sole maize) 176.23

Age of transplant 176.23

S.E. Sole Maize 215.83

S.E. Mean of Mixtures 176.23

S.E. Interaction 305.24

Table 4.10 Maize Marketable Yield (kg/ha) at Samaru in 1981, Irrigated Experiment

Age of Transplant (week)	Cropping Pattern				Mean of Mixtures
	Sole Crop	Maize Spacing (cm)			
		120	180	240	
7½	-	3183	1389	1493	2022
9½	-	2199	787	1702	1563
Main Effect	3559	2691	1088	1597	1792

S.E. Main Effects: Cropping Pattern 426.09

Age of Transplant 347.90

S.E. Mean of Mixtures 347.90

S.E. Interaction 602.58

At Samaru in 1981, the reverse was the case, a highly significant difference was obtained in marketable yield between sole crop and the mean of mixed crops. Sole crop had a higher yield with the mixtures producing 50% of the sole crop yield (Table 4.10). Significant differences in marketable yield of mixtures were also revealed. The 120, 180 and 240cm maize spacing crop

mixtures produced 76, 31 and 45% of the sole crop respectively. Age of pepper transplant had no significant effect on marketable yield of maize and there was no significant interaction.

4.3.2 Total Yield of Maize

In 1980 at Dangora, there was a significant difference between sole crop and the mean of mixed crops with the sole crop yielding a higher total fresh cobs and the mixed crops producing 62% of the sole crop (Table 4.11). Maize spacing had no significant effect on total yield. The 180, 270 and 360cm maize spaced crop mixtures produced 76, 56 and 53% of the sole crop respectively. Age of transplanting pepper and interaction had no significant effect on total yield of fresh maize.

Table 4.11 Maize Total Yield (kg/ha) at Dangora in 1980, Rainfed Experiment

Age of Transplant (week)	Cropping Pattern				Mean of Mixtures
	Sole Crop	Maize Spacing (cm)			
		180	270	360	
6	-	2109	1054	1196	1453
8	-	1093	965	1222	1093
10	-	1209	1222	656	1029
Main Effect	1929	1470	1080	1025	1192

Note; See page 67 for S.E.s

S.E. Main Effects: Cropping pattern (except sole maize) 208.83

Sole maize 255.76

Age of transplant 208.83

S.E. Mean of Mixtures 208.83

S.E. Interaction 361.70

Table 4.12. Maize Total Yield (kg/ha) at Samaru in 1981, Irrigated Experiment

Age of Transplant (week)	Cropping Pattern				Mean of Mixtures
	Sole Crop	Maize Spacing (cm)			
		120	180	240	
7½	-	4537	2373	2268	3059
9½	-	3519	2014	2720	2751
Main Effect	6030	4028	2193	2494	2905

S.E. Main Effects: Cropping pattern 545.10

Age of transplant 445.07

S.E. Mean of Mixtures 445.07

S.E. Interaction 770.89

In 1981 at Samaru, the total yield of fresh cobs for sole crop was significantly higher than the mean of mixed crops, with the mixed crops producing an average yield of 48% of the sole crop (Table 4.12). There were no significant

differences in total yield between mixed crops, though the 120, 180 and 240cm. maize spaced crop mixtures produced 67, 36 and 41% of the sole crop respectively. The age of transplanting pepper had no significant effect on maize total yield. There was no significant interaction.

4.3.3 Number of Marketable Fresh Cobs per Unit Area, Samaru 1981

Sole maize crop had a significantly higher number of cobs than the mixed crops which produced 46% of the sole crop on average (Table 4.13). Significant differences were found within the mixed crops with the 120, 180 and 240cm. maize spaced mixtures producing 69, 27 and 42% of the sole crop respectively. Age of transplant and interaction were not significant.

Table 4.13 Number of Marketable Maize Cobs per Ha at Samaru in 1981, Irrigated Experiment

Age of Transplant (week)	Crop Pattern				Mean of Mixtures
	Sole Crop	Maize Spacing (cm)			
		120	180	240	
7½	-	15509	7176	7870	10185
9½	-	12268	3936	9028	8410
Main Effect	20255	13889	5556	8449	9298

S.E. Main Effects: Cropping pattern 2224.65
Age of transplant 1816.42
S.E. Mean of Mixtures 1816.42
S.E. Interaction 3146.13

4.4 Grain Yield of Cowpea, Dangora 1980

At Dangora, in 1981, there were no significant differences in yield resulting from age of pepper transplant and mixed cropping. The interaction was not significant. However, the 270cm. maize spaced crop mixture had the highest yield with the 360 and 180cm. maize spaced crop mixtures producing 87 and 76% of it respectively (Table 4.14).

Table 4.14 Cowpea Grain Yield (kg/ha) at Dangora in 1980, Rainfed Experiment

Age of Transplant (week)	Cropping Pattern Maize Spacing (cm)			Main Effect
	180	270	360	
6	156	162	222	180
8	123	248	144	162
10	166	180	176	174
Main Effect	148	196	171	172

Note: The table was analysed under logarithmic transformation (Appendix Table 8 p.123).

4.5 Bivariate Analyses

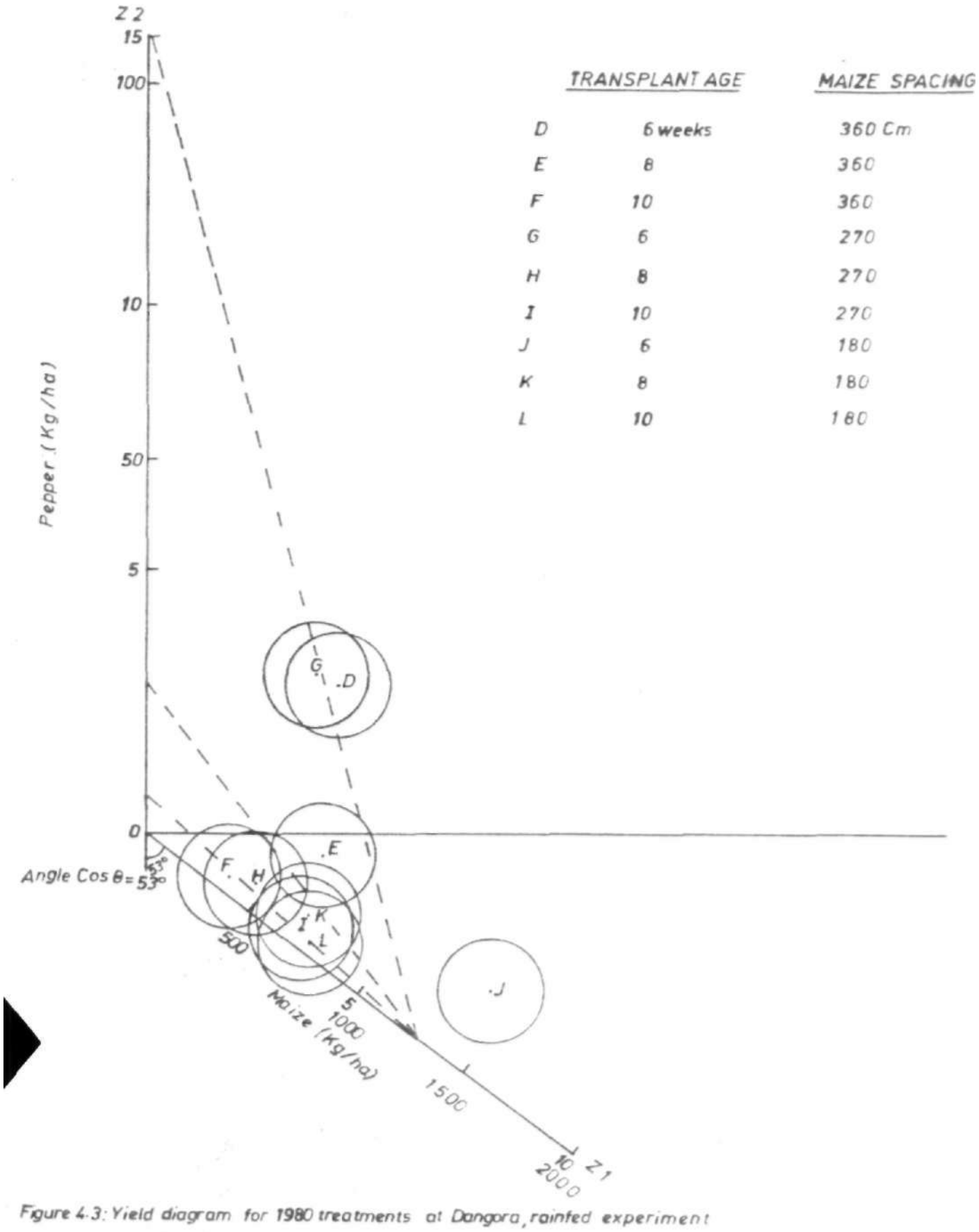
When two or more crop species are interplanted, the interpretation of experimental data presents statistical difficulties because the yields of the crops will not in general be independent. In the past the statistical

problems have sometimes been evaded by combining crops on some basis such as total calorific value, monetary value or even total yield. Another approach has been to analyse each set of crop yields separately, as if the species grew independently of one another. Although both approaches are not necessarily wrong, they are open to certain objections.

It is therefore, desirable to have a method that will deal with the species in conjunction. Pearce and Gilliver (1978) have shown that bivariate analysis of variance can be carried out for two interplanted crop species with little difficulty. The bivariate analysis requires adjusting the error variances and error covariance of the two crop yields which are then used to calculate new variates. The new variates have error variances equal to one and error covariance equal to zero, i.e. they are independent with respect to sampling errors. In the graphical presentation, a point is determined for each treatment as the mean of n plots, and a circle of radius $\frac{1}{\sqrt{n}}$ drawn with the point as centre is comparable to a standard error in the same way as limits round a mean show a standard error in the univariate case. Error correlation in the yields is accommodated in the graph by skew axes such that the $\cos \theta = r$ where r is the correlation coefficient computed from the error covariance and variances.

Taking x_1 to be the yield of maize and x_2 as the corresponding yield of pepper, the treatment means and the corresponding new variates, z_1 and z_2 are given in Appendix Tables 40 and 41 for 1980 and 1981 respectively. In 1980, the error correlation between maize and pepper was positive (Figure 4.3) indicating that mixed plots with higher yields of one crop also tended to have high yields of the other. The broken lines join the sole crop yields for 3 transplanting dates. Treatments D, G and J had the best yields among all the mixed crop treatments, they yielded as well as or better than predicted from sole crops of maize and 6 weeks transplanted pepper. This is indicated by their points being above or near the sole crop line on the graph. Treatment E did better than the 8 weeks sole crop pepper and maize but not significantly better while K yielded almost as the sole crops and H yielded much below the sole crops. Treatments F, I and L all yielded as well as the sole crop pepper transplanted at 10 weeks and maize but below all the other treatments. With the exception of treatment J, the circles all enclose a segment of the sole crop yield line of the corresponding transplant age, indicating no significant yield advantage or disadvantage from mixed cropping. Since the circles of all treatments, except D, G and J, intersect they may be considered not significantly different.

G and D were not different, but J had yields significantly different from any other mixed treatment due to the very high yield of maize and low yield of pepper.



	TRANSPLANT AGE	MAIZE SPACING
D	6 weeks	360 Cm
E	8	360
F	10	360
G	6	270
H	8	270
I	10	270
J	6	180
K	8	180
L	10	180

Figure 4.3: Yield diagram for 1980 treatments at Dangora, rainfed experiment

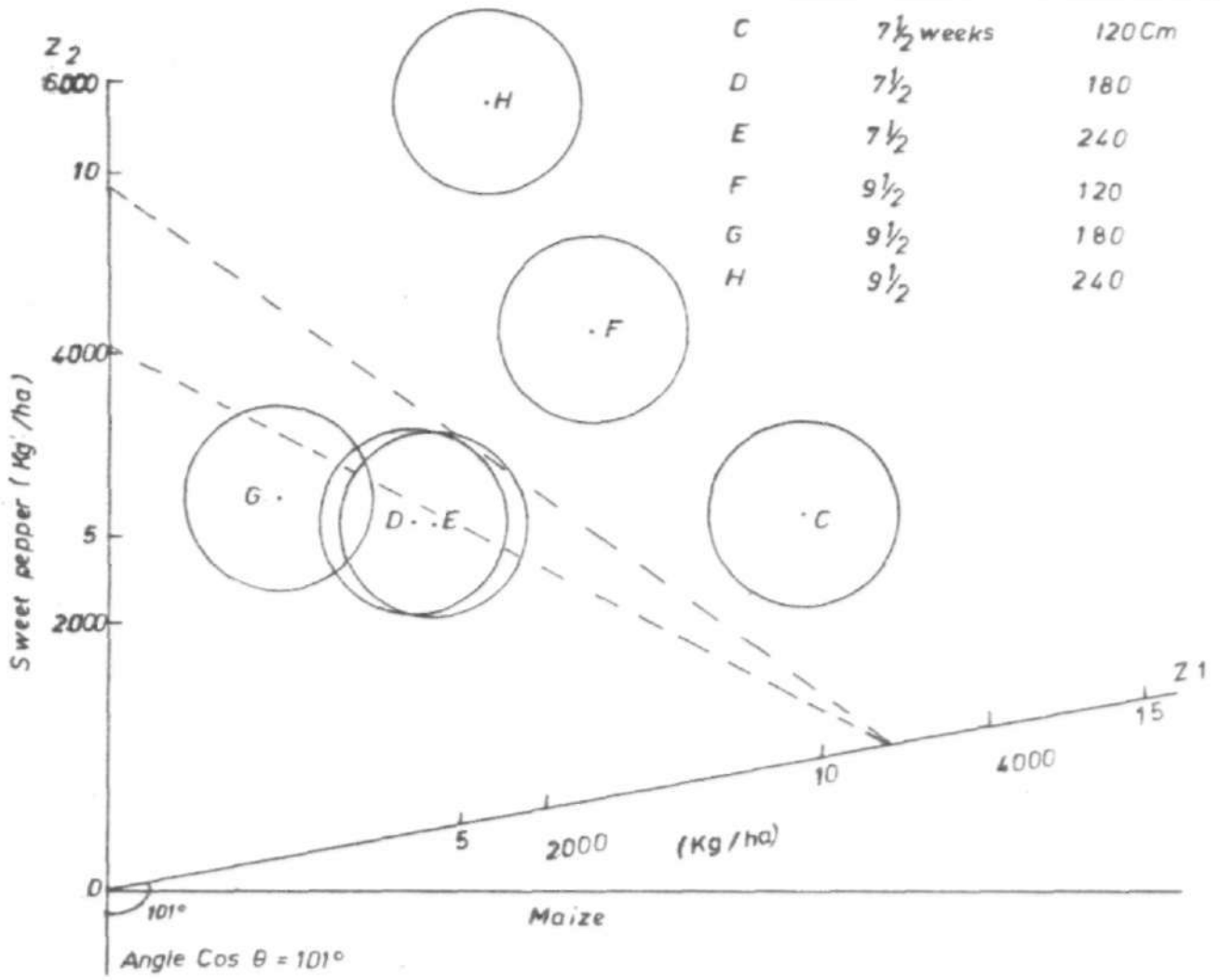


Figure 4.4 : Yield diagram for 1981 treatments at Samaru, irrigated experiment

In 1981, the correlation between pepper and maize yield was negative indicating that one of the two species suppressed the other in the mixture (Figure 4.4). Treatments C, F and H had the best yields, above the sole crop line with C and H differing significantly from each other, and from all other mixed treatments, except F. Treatments D and E were not significantly different and were about equal to the sole crop pepper transplanted at 9½ weeks and maize but lower than the 7½ weeks transplanted pepper. Treatment G had the poorest yield, below all sole crops but not significantly different from D and E.

The analysis highlights one difference between the experiments in that in 1980, age of transplant was the factor most responsible for differences in yield, although the 180cm. maize (J) had much more maize and less pepper than the other two mixed treatments with early transplanting (D and G). In 1981, the distinctive treatments (C, F and H) included one early and two late transplanted treatments; two 120cm. maize spacing and one 240cm.

4.6 Crop Growth and Development of Sweet Pepper and Maize, Samaru 1981

Germination was slow due to the cold weather. Germination of pepper started 2 weeks after sowing and completed after another week. Complete maize germination took 2 weeks, with germination started after a week.

4.6.1 Days to First Flower Opening of Sweet Pepper, Samaru 1981

The age of transplants had a highly significant effect on the number of days from sowing to first flower bud opening. The early treatments opened their first flower 10 days before the late transplanted pepper (Table 4.15), 87 and 97 days after sowing for early and late transplanted pepper respectively. Cropping pattern and interaction had no significant effect on the number of days to first flower opening.

Table 4.15 Days from Sowing to First Flower Opening of Sweet Pepper at Samaru in 1981, Irrigated Experiment

Age of Transplant (week)	Cropping Pattern				Mean of Mixtures	Main Effect
	Sole Crop	Maize Spacing (cm) 240	180	120		
7½	87.4	86.8	88.0	86.8	87.2	87.3
9½	98.4	94.6	97.0	98.6	96.7	97.2
Main Effect	92.9	90.7	92.5	92.7	92.0	

Note: See page 77 for S.E.s

S.E. Main Effects: Cropping Pattern 1.42

Age of transplant 1.00 .

S.E. Mean of Mixtures 1.16

S.E. Interaction 2.01

4.6.2 Days to 50% Flowering of Sweet Pepper, Samaru 1981

The number of days from sowing to 50% flowering was significantly affected by the age of transplant but not by cropping pattern. The early treatment reaching 50% flowering after 100 days, 6 days before the late transplanted pepper (Table 4.16).

Table 4.16 Days from Sowing to 50% Flowering of Sweet Pepper at Samaru in 1981, Irrigated Experiment

Age of Transplant (week)	Cropping Pattern				Mean of Mixtures	Main Effect
	Sole Crop	Maize Spacing (cm)				
		240	180	120		
7½	101.4	100.2	100.0	99.0	99.7	100.2
9½	106.0	104.4	106.4	105.2	105.3	105.5
Main Effect	103.7	102.3	103.2	102.1	102.5	

S.E. Main Effect: Cropping pattern 1.21

Age of transplant 0.86

S.E. Mean of Mixtures 0.99

S.E. Interaction 1.71

4.6.3 Days to 50% Fruit Set of Sweet Pepper, Samaru 1981

The age of transplant had a highly significant effect on the number of days from sowing to 50% fruit set, with the early transplanted pepper reaching 50% fruit set at 109 days, 7 days before the late transplanted pepper (Table 4.17). Cropping patterns had no significant effect.

Table 4.17 Days from Sowing to 50% Fruit Set of Sweet Pepper at Samaru in 1981, Irrigated Experiment

Age of Transplant (week)	Cropping Pattern				Mean of Mixtures	Main Effect
	Sole Crop	Maize Spacing (cm)				
		240	180	120		
7½	107.8	107.0	112.4	110.4	109.9	109.4
9½	118.0	114.0	117.6	114.0	115.2	115.9
Main Effect	112.9	110.5	115.0	112.2	112.6	

S.E. Main Effects: Cropping Pattern 1.46

Age of transplant 1.03

S.E. Mean of Mixtures 1.19

S.E. Interaction 2.06

4.6.4 Number of Flowers per Sweet Pepper Plant, Samaru 1981

The difference between the number of flowers of early and late transplanted pepper was highly significant but cropping pattern had no effect. The early planted pepper produced only 58% of the flowers on late planted

crop (Table 4.18). Though there were no significant differences between cropping patterns, the 180cm. maize spaced cropping pattern had 25% fewer flowers than the sole crop pepper.

Table 4.18 Number of Flowers per Sweet Pepper Plant at Samaru in 1981, Irrigated Experiment

Age of Transplant (week)	Cropping Pattern				Mean of Mixtures	Main Effect
	Sole Crop	Maize Spacing (cm)				
		240	180	120		
7½	14.8	16.0	10.0	14.4	13.5	13.8
9½	25.4	26.8	19.4	22.4	22.9	23.5
Main Effect	20.1	21.4	14.7	18.4	18.2	

S.E. Main Effects: Cropping pattern 2.45

Age of transplant 1.73

S.E. Mean of Mixtures 2.00

S.E. Interaction 3.46

4.6.5 Percentage Fruit Set of Sweet Pepper Flowers, Samaru 1981

Significant differences for total percentage fruit set were not found between cropping patterns and age of pepper transplants (Table 4.19).

Table 4.19 Total Fruit Set of Sweet Pepper (%) at Samaru in 1981, Irrigated Experiment

Age of Transplant (week)	Cropping Pattern				Mean of Mixtures	Main Effect
	Sole Crop	Maize Spacing (cm)				
		240	180	120		
$7\frac{1}{2}$	33.6	37.0	38.9	30.4	35.4	35.0
$9\frac{1}{2}$	36.8	38.2	29.1	33.2	33.5	34.3
Main Effect	35.2	37.6	34.0	31.8	34.5	

S.E. Main Effects: Cropping pattern 3.76

Age of transplant 2.66

S.E. Mean of Mixtures 3.07

S.E. Interaction 5.32

In India, Mote et. al. (1975) estimated that up to 11% of the flowers set fruit and Warade and Singh (1977) reported that only 5% set fruit. This is much lower than what was obtained in this experiment. Among several factors reported by Olarewaju (1980), to be unfavourable to fruit set were low radiant exposures (such as caused by shading) and infrequent watering. The level of shading resulting in poor fruit set appears to be variable. Shading of 50% reduced fruit set, but 30% increased fruit set in Italy (Olarewaju, 1980 citing Quagliotti, 1976). In Korea a reduction in radiation of 25 and 60% reduced fruit set (Olarewaju,1980 citing Park and Jeong, 1976) but a reduction of 45% actually increased fruit set in the Carribean area (Schoch, 1972).

Percentage fruit set of flowers opening at different times revealed that, the early transplanted treatments had maximum fruit set from the late flowers, but the late treatments set most fruits from early flowers with maximum fruit set of 53.5 and 67% for early and late treatment respectively (Figure 4.5 and 4.6).

There were no differences in the trend of fruit set with the early transplanted treatments (Figure 4.5). All the four cropping patterns tended to shed most of the early flowers with maximum fruit set from late flowers. Fruit set declined between 90 and 96 days after sowing for all patterns after which it increased reaching the peak of 45, 40, 53.5 and 39% for sole crop, pepper in maize spaced 240, 180 and 120cm. respectively at 111 to 114 days after sowing. The late transplanting treatments exhibited a different trend with early flowers setting most fruits for all cropping patterns and the later flowers shed (Figure 4.6). Sole crop and pepper in maize spaced at 180cm. showed a decline in fruit set at 99 - 102 days after sowing. Maximum fruit set was 67, 63, 47 and 55% for sole crop, pepper in maize spaced 240, 180 and 120cm. respectively. The time period for maximum fruit set varies with the cropping patterns, the earliest being sole crop with the pepper in maize spaced 240, 180 and 120cm. following in descending order.

The marked difference in fruit set patterns of early from late treatments could be explained by the effect of water stress which resulted from delayed application of water on the field at the time period 90 to 96 days after sowing of pepper. At this time the weather was very dry with relative humidity 9%, evaporation 14.4mm/ day and maximum temperature of 37^{o}C and a check in leaf expansion was noted (page 93). The early treatments were adversely affected by the stress resulting in abortion of the early flowers and therefore, low fruit set. Fruit set, however, increased after the stress period. The late treatments started flowering 10 days later and as a result the flowers escaped the stress period. The relatively low level of maximum fruit set of early treatments compared to late treatments may be similarly explained.

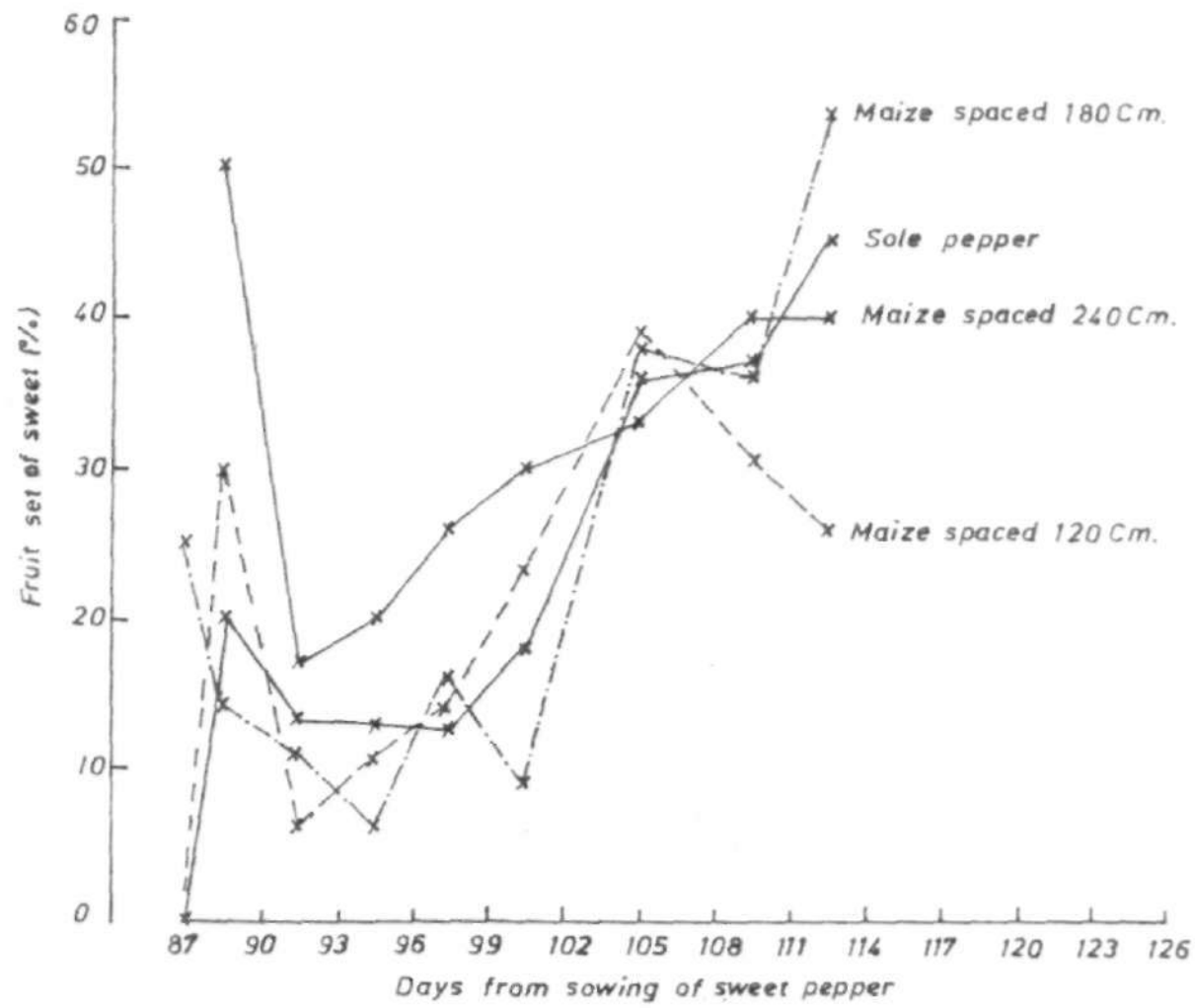


Figure 4.5: Effect of cropping pattern on sweet pepper percentage fruit set of flowers opening at different times: Early transplanted pepper, Samaru 1981

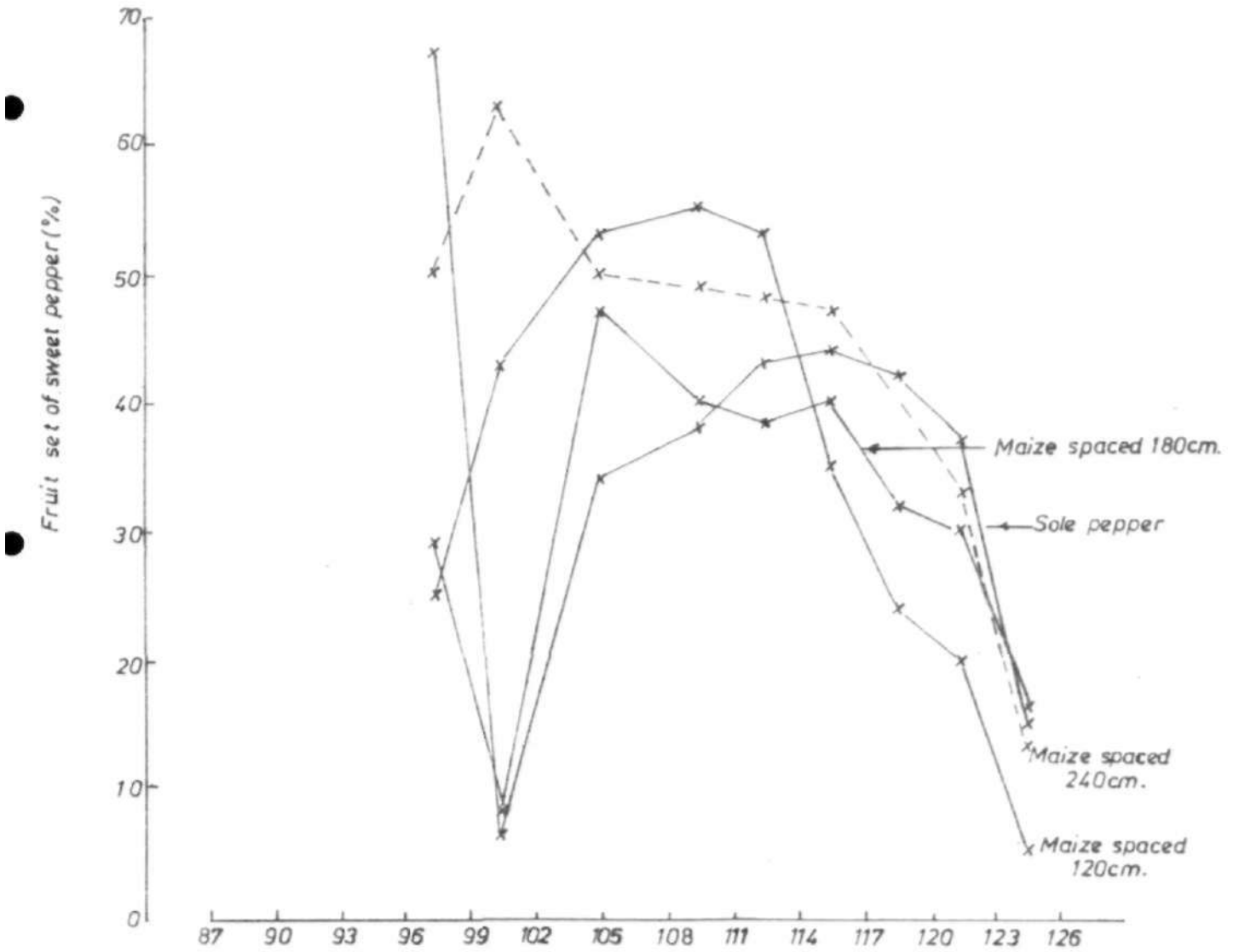


Figure 4.6 : Effect of cropping pattern on sweet pepper percentage fruit set of flowers opening at different times: Late transplanted pepper, Samaru 1981

4.6.6 Height of Sweet Pepper Plant, Samaru 1981

The age of transplant and cropping pattern had no significant effect on transplant height at 115 and 129 days after sowing. The interaction was not significant (Appendix Table 19 p.129).

At transplanting the 7½ weeks old transplants were 5.3cm. high with 5 true leaves and the 9½ weeks old transplants were 9.3cm. high with 6 true leaves.

Growth in height of pepper was very rapid from 87 to 115 days after sowing (Figure 4.7). Within this period, plants grew from a mean height of 9.7cm. to 21.8cm. at an average rate of 0.4cm. per day. Growth continued after 115 days, but at a slower rate of 0.2cm. per day on the average, until 129 days when measurement ended.

Growth started gradually after transplanting for both early and late transplanted pepper, until 87 days after sowing (Figure 4.7). From the day of transplanting to 87 days after sowing, the early and late pepper grew at the low rate of 0.1cm. per day and 0.06cm. per day respectively as they recovered from transplanting. After 87 days growth was very rapid for 4 weeks. The plants grew less rapidly after 115 days which may be due to the commencement of the reproductive phase. Because of transplanting setback to the early peppers, they were

shorter than late peppers to 87 days from sowing. They grew more rapidly after 87 days so that there was little difference between early and late at 101 days. Ultimately, however, the late transplanted plants were slightly taller. The explanation for this might be etiolation of late transplanted pepper before transplanting as a result of crowding in the bed.

Growth of pepper in cropping patterns followed a similar trend of age with transplant treatment with very little differences in height between the cropping patterns.

4.6.7 Days to 50% silking of Maize, Samaru 1981

The age of pepper transplants and the crop mixtures had no significant effect on days to silking in maize (Table 4.20).

Table 4.20 Days from Sowing to 50% Silking of Maize at Samaru in 1981, Irrigated Experiment

Age of Transplant (week)	Cropping Pattern				Mean of Mixtures
	Sole Crop	Maize Spacing (cm)			
		120	180	240	
7½	-	75.2	76.8	76.8	76.3
9½	-	77.4	80.0	82.0	79.8
Main Effect	76.7	76.3	78.4	79.4	78.0

S.E. Main Effects: Cropping pattern 2.20
Age of transplant 1.80

S.E. Mean of Mixture 1.80

S.E. Interaction 3.11

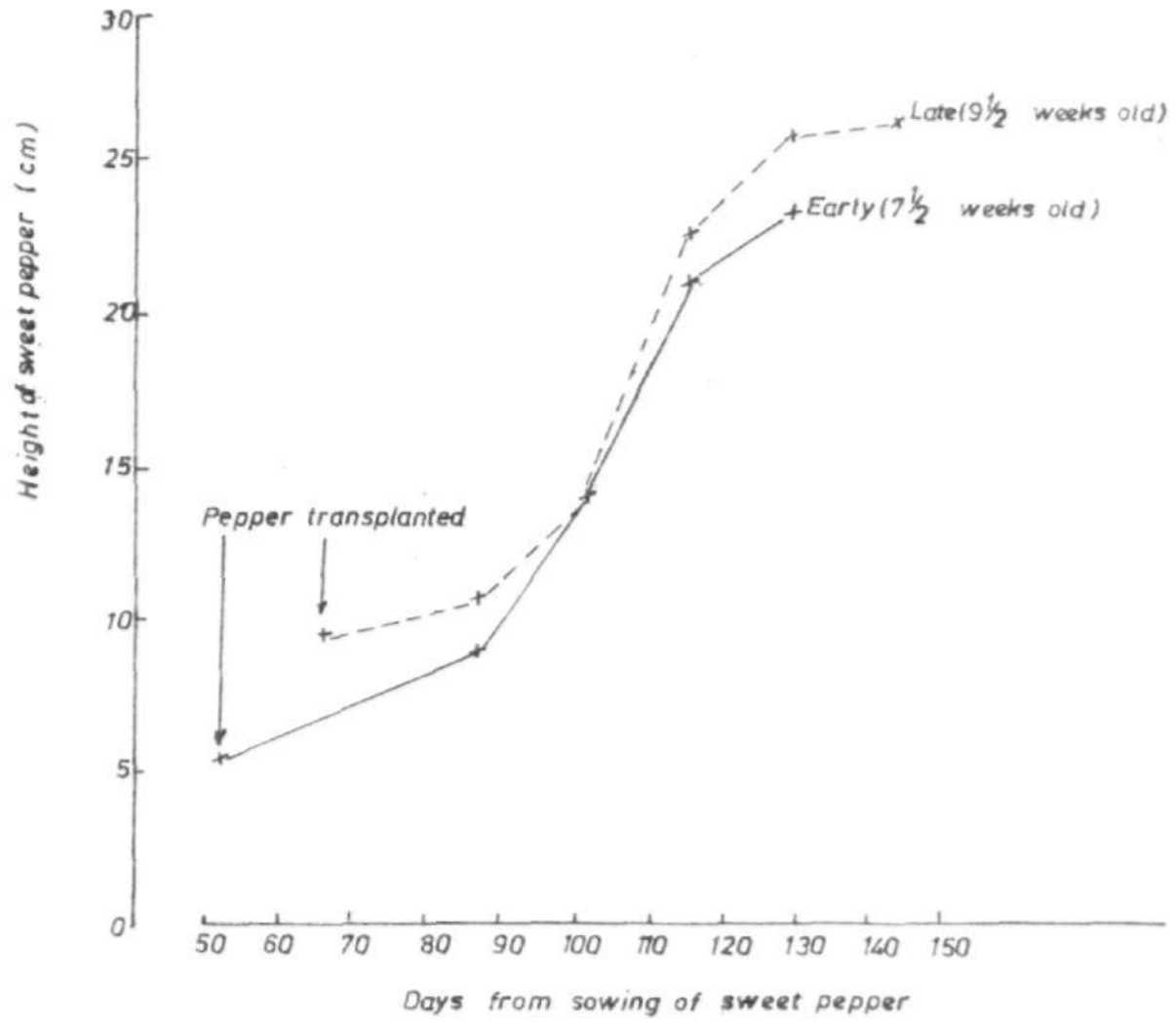


Figure 4.7 : Main effect of seedling age on height of pepper plant (cm), Samaru 1981

4.6.8 Leaf Cover of Sweer Pepper (Appendix Table 21 - 28), Samaru 1981

Significant differences in leaf cover were found between cropping patterns at 123 days. Sole crop had the greatest leaf cover with the 240, 180 and 120cm. maize spaced crop mixtures producing 80, 69 and 41% of the sole crop respectively (Appendix Table 27). The age of transplant and interaction were not significant.

Leaf cover for pepper increased rapidly up to 95 days after sowing (Figure 4.8 and 4.9), and declined between 95 and 102 days for all treatments, except sole crop which increased slightly. After 102 days increase in leaf cover resumed, at first gradually but later rapidly after 116 days and reached a peak at 123 days. The only exception was the 120cm. maize spaced crop mixture which showed no rapid increase after 116 days but a continuous increase in leaf cover.

The sole crop pepper crop had the greatest leaf cover followed, in descending order, by the peppers in the 240, 180 and 120cm. maize spacing treatments (Figure 4.8). At 123 days, sole crop had a leaf cover of 36% with 240, 180 and 120cm. crop mixtures having 29, 25 and 15% respectively. This point represents the peak of leaf cover for all the cropping patterns except the 120cm. mixture.

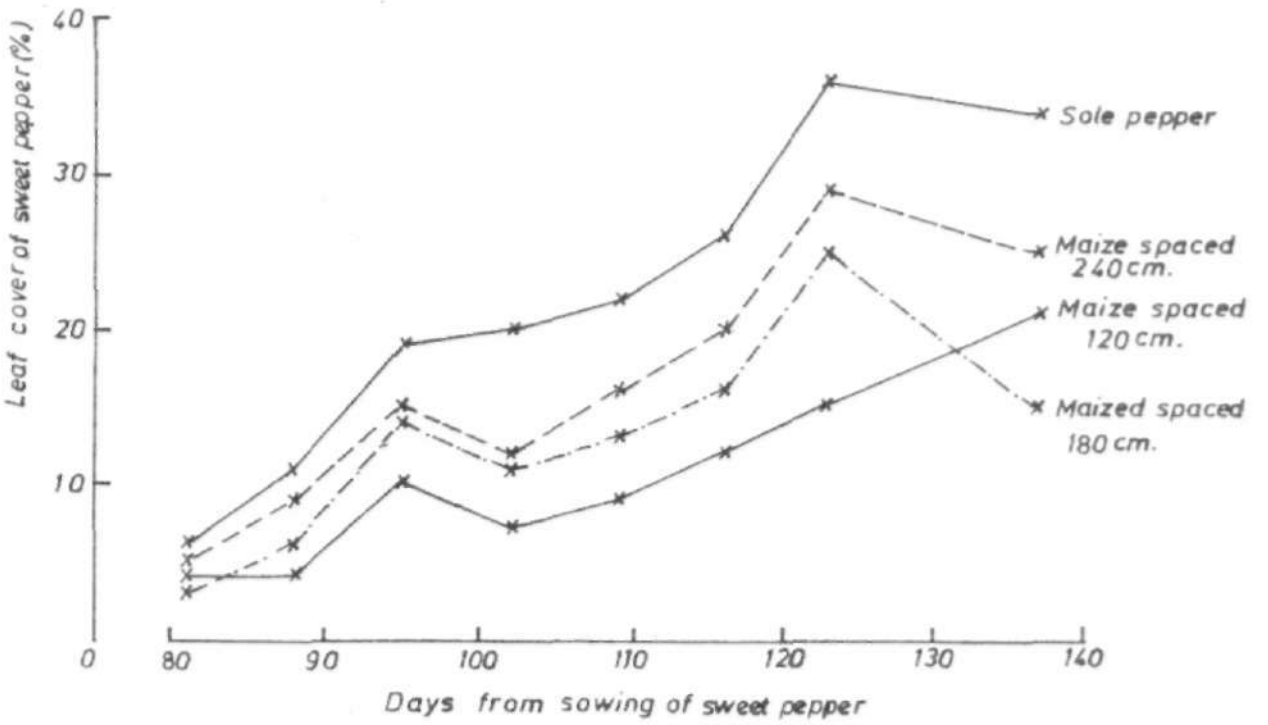


Figure 4.8 : Main effect of cropping pattern on leaf cover of sweet pepper(%) Samaru 1981

The early and late transplanted peppers increased in leaf cover fairly rapid after 81 days with the late transplanted plants having a slightly smaller leaf cover (Figure 4.9). After 95 days leaf cover declined but after 102 days leaf cover increased with a more rapid increase in late plants, so that there was no difference at 109 days. The late transplanted pepper eventually achieved a slightly greater leaf cover than the early transplanted pepper with a peak of 28% while the early had 24% at 123 days.

4.6.9 Leaf Cover of Maize (Appendix Table 29 - 36), Samaru 1981

Sole crop maize had a significantly greater leaf cover than the mean of the mixtures at 73, 80 and 87 days for the mean with the mixtures having only 54% of the sole crop (Appendix Table 35). Significant differences also occurred within the mixtures with the 120, 180 and 240cm. mixtures having 71, 44 and 44% of the sole crop respectively. The age of transplant and interaction were not significant.

Maize increased leaf cover fairly rapidly from 52 to 59 days after sowing in all the treatments, except the 240cm. mixture which increased slowly (Fig. 4.10).

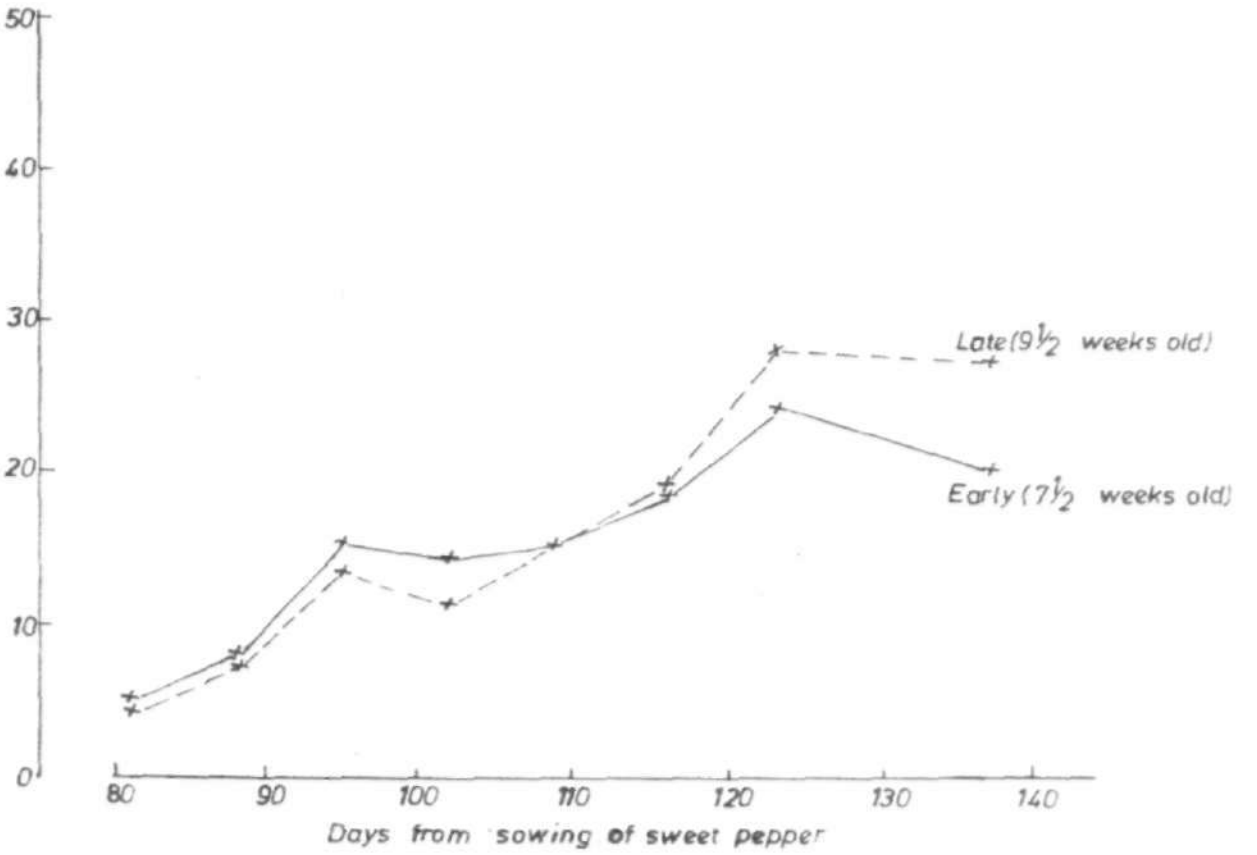


Figure 4.9 : Main effect of seedling age on leaf cover of sweet pepper (%), Samaru 1981

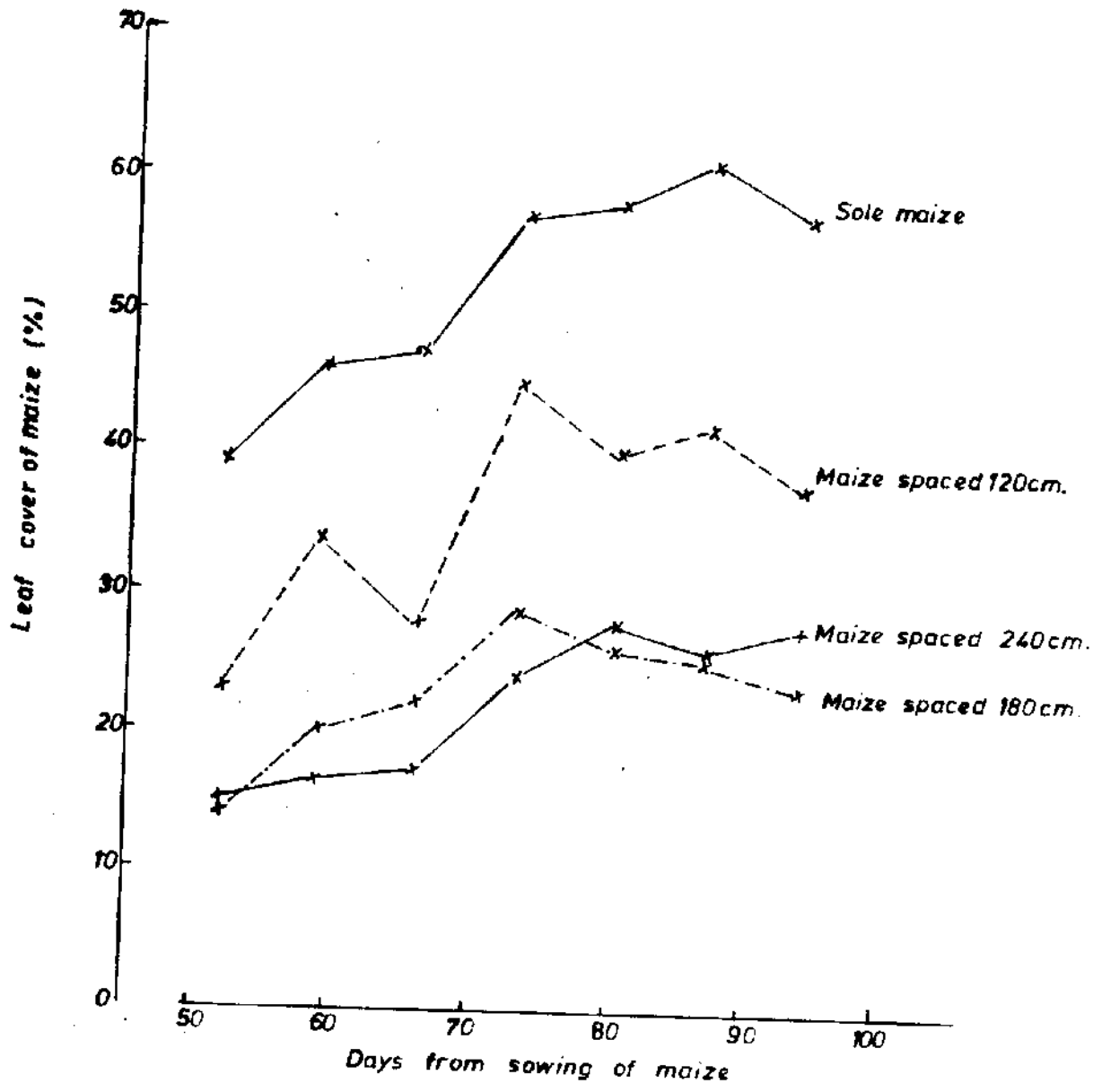


Figure 4.10: Main effect of cropping pattern on leaf cover of maize (%), Samaru 1981

Between 59 and 66 days after sowing leaf cover either increased very slowly or decreased. This was followed by a rapid increase of leaf cover for all cropping pattern treatments until 73 days which represents the peak maize leaf cover for 120 and 180cm. mixture. Sole crop maize and 240cm. mixture continued to increase leaf cover after 73 days and reached peak leaf cover at some later time.

The sole crop maize had the greatest leaf cover throughout the growth period followed by the 120cm. mixture. There was not much difference between 180 and 240cm. mixture.

The leaf cover trend of both pepper and maize revealed a check in growth at 102 and 66 days after sowing respectively. In real time, the decline occurred one week earlier in maize than pepper. It is suspected that this decline resulted from water stress due to delayed application of water coupled with the very dry weather of relative humidity of 9%, evaporation of 14.4mm/day and maximum temperature of 37°C recorded at that period (Appendix Table 2). The overall effect of this decline in growth was the generally low leaf cover percentages. A peak leaf cover of 85% has been obtained for sole crop maize at Samaru (Fisher and Egbarevba, 1980) compared to 60% obtained in this experiment.

4.6.10 Total Leaf Cover

The sole crop maize had a leaf cover almost three times that of sole pepper with the mixtures having total leaf cover of intermediate values (Figure 4.11). The mixtures generally had greater leaf cover than the midpoint between sole maize and sole pepper. This suggests greater interception of radiation by the mixtures as compared with the mean of the sole crops and indicates the possibility of improved total photosynthesis. Both crops reached peak leaf cover at about the same time so that any improved radiation interception was due to better leaf cover at any point in time rather than from spreading the leaf cover by combining crops with different growth pattern.

4.7 Leaf Curl Virus Disease of Pepper, Samaru 1981

The age of transplant had a highly significant effect on the incidence of pepper leaf curl disease with the early transplanted pepper suffering more from the disease than the late pepper, having a mean score of 1.96 as compared to 1.69 for late. Cropping pattern had no significant effect on the disease severity (Table 4.21).

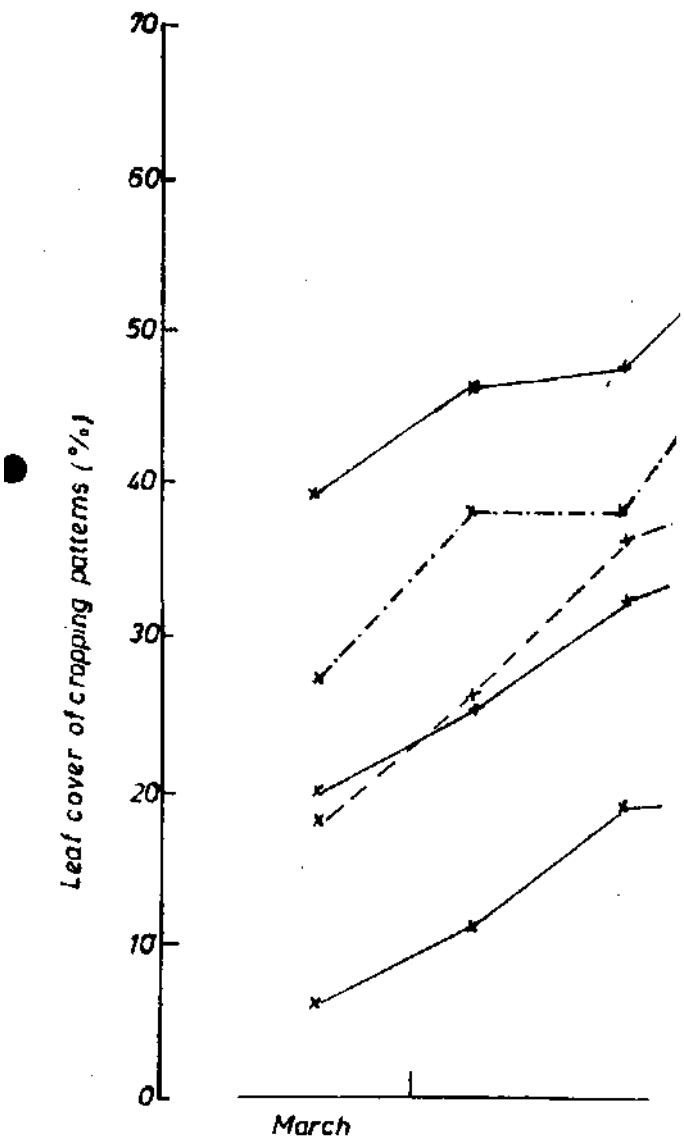


Figure 4.11 : Total (maize + pepper) leaf cover of cropping patterns (%) at 10 days intervals, Samaru 1981

Table 4.21 Pepper Leaf Curl Disease Scores of Sweet Pepper at Samaru in 1981, Irrigated Experiment

Age of Transplant (week)	Cropping Pattern				Mean of Mixtures	Main Effect
	Sole Crop	Maize Spacing (cm) 240	180	120		
7½	1.80	2.12	1.98	1.92	2.01	1.96
9½	1.74	1.70	1.62	1.62	1.65	1.67
Main Effect	1.77	1.90	1.80	1.77	1.82	

S.E. Main Effects: Cropping pattern 0.08

Age of transplant 0.06

S.E. Mean of Mixtures 0.07

S.E. Interaction 0.11

CHAPTER 5

GENERAL DISCUSSION

5.1 Relative Performance of Sole Crops and Mixtures

5.1.1 Monetary Value

In 1980 mixing chilli pepper with maize gave higher monetary value than growing pepper alone (Table 5.1). While the mean for mixtures was ₦305, sole crop pepper and maize were ₦107 and ₦326 respectively. This showed that, farmers would have increased their income by mixing pepper rather than growing pepper alone but this may only be applicable in conditions which give the generally poor pepper yields realized here. Mixing also gave better monetary value because cowpea value was included in the calculation whereas sole crop maize had no cowpea. Within the mixed crops spacing maize at 180cm appeared to give higher monetary value than spacing at 360 and 270cm. but that was not statistically significant. Mixed cropping gave more cash return than sole pepper because though maize significantly reduced the yield of pepper, there was no significant difference in the yield of sole maize and maize in mixture.

Table 5.1 Monetary Values of Maize, Pepper, Cowpea Cropping Patterns at Dangora in 1980 (₦/ha), Rainfed Experiment

Age of Transplant (week)	Cropping Pattern					Mean of Mixtures	Main Effect
	Sole Maize	Sole Pepper	Maize Spacing (cm) 360	270	180		
6	-	263	415	367	440	407	371
8	-	46	294	247	263	268	213
10	-	11	180	268	269	239	182
Main Effect	326	107	296	294	324	305	

S.E. Main Effects: Cropping Pattern (except sole maize) 45.5

Transplant Age 39.4

S.E. for Mean of Mixtures 45.5

S.E. Sole Crop Maize 55.7

S.E. Interaction 78.8

Note: S.Es do not apply to sole pepper.

Table 5.2 Monetary Values of Maize, Pepper Cropping Patterns at Samaru in 1981 (₦/ha), Irrigated Experiment

Age of Transplant (week)	Cropping Pattern					Mean of Mixtures	Main Effect
	Sole Maize	Sole Pepper	Maize Spacing (cm) 240	180	120		
7½	-	2003	1371	1246	1531	1383	1538
9½	-	1432	2165	1080	1680	1642	1589
Main Effect	890	1718	1768	1163	1606	1512	

S.E. Main Effects: Cropping pattern 190₦/ha

Transplant Age 134₦/ha

S.E. for Mean of Mixtures 155₦/ha

S.E. Interaction 268₦/ha

Note:

The prices are as follows:

1980: marketable maize = ₦0.25/kg

dry chilli pepper = ₦2.50/kg

cowpea seed = ₦0.40/kg

1981: marketable maize = ₦0.25/kg

sweet pepper = ₦0.30/kg.

The yield of maize in 180cm. mixture was almost as high as sole crop maize (Table 4.9), an advantage found elsewhere in a dry season when sole crop population may be higher than optimal (Fisher 1979c). Though the sole crop pepper yielded significantly more than the mixture (Table 4.2) the yield levels were generally too low to achieve a cash value comparable to sole crop maize.

At Samaru, mixing sweet pepper with maize gave almost as much cash return as growing pepper alone (Table 5.2), particularly, with maize spaced at 240 and 120cm. but the 180cm. mixture gave less return than the other mixtures, and the sole pepper. Sole maize had the lowest return of all the cropping pattern. It would appear, therefore, that mixed cropping of pepper at Samaru gave almost as good a value as sole cropping. No explanation is available for the low values obtained for the middle spacing in both experiments except the variability of plot yields.

The monetary values at Samaru are much higher than Dangora because the yield levels were generally higher than Dangora irrespective of treatment. Possible reasons for the high yield levels of pepper and maize obtained at Samaru include high crop population, better management and soil conditions, the cooler season and the fact that it was an irrigated crop.

5.1.2 Relative Yield Total

The biological approach is based on the concept of 'relative yield total' (R Y T), a term widely used by pasture agronomists and now adopted by mixed cropping researchers. The R Y T of a two-crop mixture is the sum of mixed crop yields as a proportion of their sole crops.

$$R\ Y\ T = \frac{Y_{m_1}}{Y_{s_1}} + \frac{Y_{m_2}}{Y_{s_2}}$$

Where Ym = yield of crop in mixture.
Ys = sole crop yield of that crop. At Dangora, maize and pepper but not cowpea were included in the calculation of R Y T.

RYT greater than 1.0 indicates that, mixed cropping is more productive than sole cropping of the component crops in the mixture, because it means that more than 1.0 hectare of the sole crops is needed to give produce equivalent to 1 hectare of the mixture.

RYTs were calculated from the experimental mean yields than on plot basis. This is because, the distribution of RYT on a plot basis may exaggerate the differences (Fisher, 1979c). At Dangora in 1980, the RYT for the three mixtures were about 1.0 for the main effects of cropping pattern (Table 5.3) indicating no advantage from the mixtures. However, except for 180cm. spacing, mixed cropping appeared slightly more productive than sole cropping for sweet pepper

at Samaru in 1981 (Table 5.4). At Samaru also, late transplanted pepper appeared to favour mixed cropping (Table 5.4).

Table 5.3 Relative Yield Totals of Crop Mixtures at Dangora in 1980, Rainfed Experiment

Age of Transplant (week)	Cropping Pattern Maize Spacing (cm)			Main Effect
	360	270	180	
6	1.071	1.002	1.386	1.153
8	1.440	0.635	0.927	1.001
10	0.816	1.332	1.111	1.086
Main Effect	0.998	0.895	0.991	

Table 5.4 Relative Yield Totals of Crop Mixtures at Samaru in 1981, Irrigated Experiment

Age of Transplant (week)	Cropping Pattern Maize Spacing (cm)			Main Effect
	240	180	120	
7½	0.917	0.838	1.261	1.006
9½	1.693	0.838	1.407	1.313
Main Effect	1.246	0.825	1.299	

5.2 Effect of Age at Transplanting

For the overall cropping pattern and mean of mixtures, early transplanted chilli (6 weeks) at Dangora in 1980 gave more monetary return than later transplantings (Table 5.1). In 1981 at Samaru for the overall cropping pattern, there was no difference between transplanting early and late but the late transplanted peppers had higher monetary value in mixture than as sole crop and the early transplanted had higher value as a sole crop than in mixture (Table 5.2). This suggests that late transplanting may earn more cash in mixed crops. This may explain the farmers tendency to transplant into mixtures, old seedlings with flower buds and sometimes with opened flowers.

The higher return obtained in transplanting pepper late into maize at Samaru was confirmed by the replacement diagrams \Figure 5.1 and 5.2). The diagram clearly showed that early pepper gave less cash return in mixture than in proportion to its early sole crop with the result that mixed cropping gave no higher return than sole cropping (Figure 5.1). Except at 180cm. maize spacing the late pepper gave proportionately more return in mixture than the late sole crop resultingin a higher return from mixed cropping over sole cropping (Fig. 5.2).

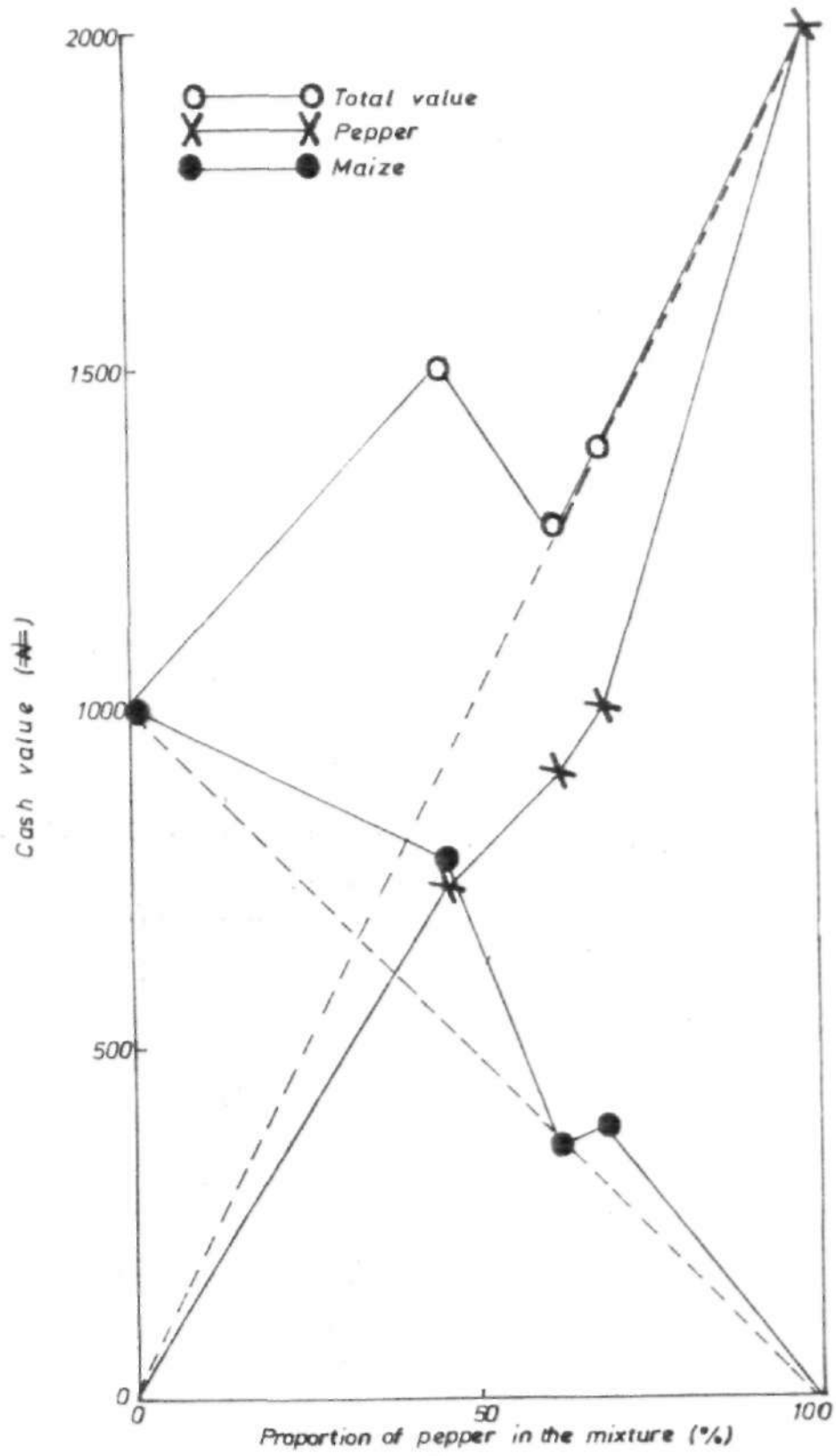


Figure 5-1 : Replacement diagram of early pepper treatment at Samaru in 1981, irrigated experiment

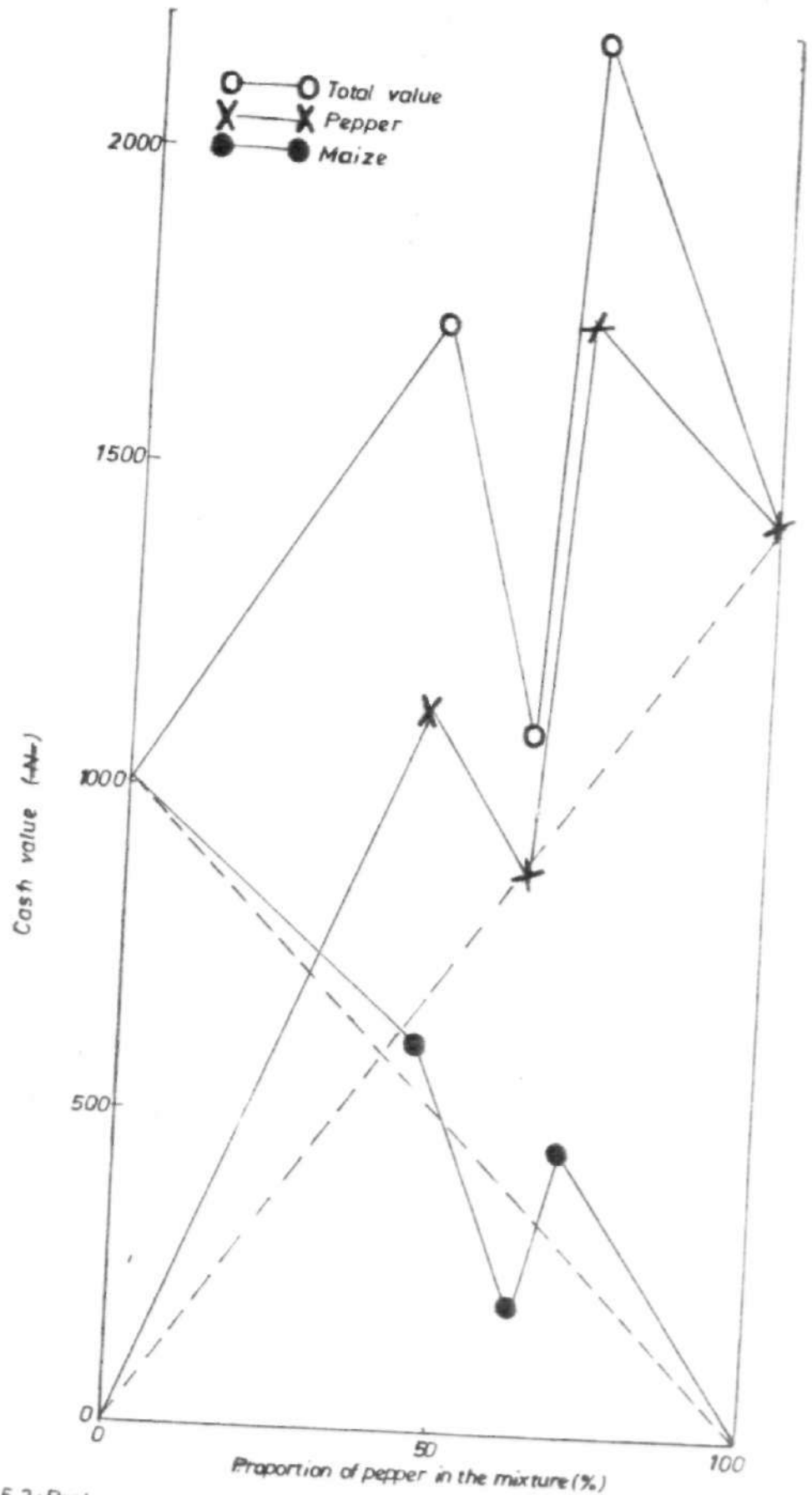


Figure 5.2 : Replacement diagram of late pepper treatment at Samaru 1981, irrigated experiment

In both early and late peppers but with the exception of 180cm. spacing the mixtures gave more return of maize than expected from the proportion of sole crop maize. This is because, the yield of maize in the mixture was probably not affected by the presence of pepper but only by the maize spacing.

5.3 Conclusions

Conclusions are tentative, because many of the differences were not statistically significant due to high variability in plot yields. In 1980 wet season at Dangora, mixed cropping had adverse effect on chilli pepper yield, but gave better total return than sole pepper. In the 1981 irrigated experiment at Samaru, mixed cropping gave no better return than sole crop pepper though slight biological advantage was found. The experiment suggested that a later transplanting time would be optimal for pepper grown in mixture with maize than in sole crop.

5.4 Suggestions for Further Investigation

1. The fact that the results of the two experiments differ in some major ways call for more work to confirm the results obtained. The following are suggested:

i) to confirm the possible advantage of late transplanting into the mixture which was found at Samaru in 1981 dry season and to ascertain whether the effect is of age itself or of transplanting date.

ii) irrespective of seedling age mixed cropping reduced pepper yield significantly below the expected value in 1980 while in 1981 mixed cropping had adverse effect only on the early transplanted pepper. A more comparable replacement proportion or design in the mixtures may better display the effect of maize on pepper and thus explain this difference in results.

2. A younger seedling age and smaller size could be included to give a wider range of seedling age and size. More so, because the 6 week old transplanted pepper yielded significantly higher, indicating that 4 week old transplants could be included.

3. A further area of research is the incorporation of a wide range of plant populations to ensure that the maximum possible productivity of mixtures can be compared with the maximum possible productivity of sole crops.

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APPENDIX I

Terminology of Cropping Systems

A cropping system is the way in which resources are organised for the generation of plant products. In particular, it is often used to describe the spatial layout of the different crops (monoculture, diversified sole crops, mixed crops) and/or the sequence of crops on the same land (shifting cultivation, crop rotation, alternate husbandry) (Fisher, 1980a).

Cropping pattern is the way in which crops are organised in space (Andrews and Kassam, 1976).

Monoculture is the growing of a single sole crop species over large areas at the same time or for many years on the same land (Andrews and Kassam, 1976).

Sole cropping is the growingof one variety in pure stand at normal density. It is the opposite of intercropping (Andrews and Kassam, 1976; Webster and Wilson, 1966; Willey 1979).

Mixed Cropping. Nicol (1935), Aiyer (1949), and Webster and Wilson (1966) used "mixed cropping" for the growing of any two or more crops species in such a way that they may compete with each other for light, water or nutrients at same time during their growth period. Kass (1978) proposed the term "polyculture" as an alternative but he contrasted it with "monoculture" by which he meant "sole cropping". Ruthenberg (1971), however, suggested that

any arrangement where there is mixing of the crop species within the row should be defined as mixed cropping.

Intercropping. Webster and Wilson (1966) used this term to describe systems in which annual crops are grown in between perennial crops, especially during the early unproductive years of the perennial. Andrews and Kassam (1976) and Willey (1979) described intercropping as the growing of two or more crops simultaneously on the same field. Willey went further to say that the crops are not necessarily sown at exactly the same time and their harvesting may be quite different but they are usually 'simultaneous' for a significant part of their growing periods. This distinguishes intercropping from "relay cropping" in which growing periods only briefly overlap. Ruthenberg (1971) and IRRI (1975) have suggested that the term intercropping should also imply that the crops are grown in separate but proximate rows. As rightly pointed out by Willey (1979), it is difficult in a review to adhere to a distinction in the definition of intercropping and mixed cropping as suggested by Ruthenberg (1971) and Webster and Wilson (1966). Moreover, these two terms have often been used synonymously. For simplification, therefore, in this review "intercropping" is synonymous to 'mixed cropping' with both used in a general sense without

implying any specific spatial arrangement or time dimension (Willey, 1979; Andrews and Kassam, 1976; Bradfield, 1972).

Relay cropping is a form of mixed cropping wherein the crops compete only for part of their life cycles because the second crop is planted late in the life of the earliest sown crops. It is something between thorough mixed and double cropping (Ruthenberg 1971; Fisher, 1980a; Willey, 1979). Ruthenberg (1971) defined it as the interplanting of seedlings or seeds as a second crop into a maturing annual crop. Andrews and Kassam (1976) gave a more rigid definition by requiring the second crop to be planted after the first has reached its reproductive stage. This cannot be applied where the first crop is a vegetative one (Fisher, 1980a). Bradfield (1972) used "relay" cropping to mean "double cropping" and what other authors call "relay cropping", he calls "intercropping".

Multiple cropping is the system whereby more than one sole crop is grown sequentially on the same land within a time span of one year (Dalrymple, 1971). This definition is to be preferred to wider definitions which would include mixed cropping or intercropping as a form of multiple cropping (Andrews and Kassam, 1976; Bradfield, 1972).

Double-triple-or quardruple-cropping are self explanatory forms of multiple cropping.

APPENDIX 2

Tables of Weather, Yield and Observations:

Appendix Table 1. Weather record for Kadawa during the period of the experiment in 1980

Month	Temperature (°C)				Relative Humidity (%)		Rain-fall (mm/mo)	Wind Run (km)
	Dry Bulb		Wet Bulb					
	9 a.m.	4 p.m.	9 a.m.	4 p.m.	9 a.m.	4 p.m.		
May	28.9	-	24.3	-		-	125.0	234.9
June	-	-	-	-	-	-	101.1	200.3
July	26.6	30.2	23.4	24.6	76	61	156.7	155.7
August	26.2	30.0	23.0	25.2	75	66	397.3	116.1
September	28.3	32.2	24.6	26.3	73	61	32.8	101.4
October	29.3	33.4	24.2	26.4	64	56	3.3	105.3
November	27.7	33.0	17.9	20.0	35	26	0.0	105.3
December	22.2	28.2	14.5	20.2	38	45	0.0	110.9

- Not available

Appendix Table 2. Weather records for Samaru during the period of the experiment (10-day means or totals)

Month		Total Rainfall (mm)		Temperature (°C)		Average Relative Humidity (%)		Average * Evaporation (mm/day)	Wind	
		1981	Average for 42 yrs.	Maximum	Mean	Morning	Afternoon		Wind Run (km)	Predominant Direction
	10	0	0	27	19	19	17	7.5	152.38	NE
January	20	0	0	29	20	16	12	8.4	156.46	NE
1981	31	0	0.25	28	20	15	11	7.7	165.81	NE
	10	0	0.25	30	23	12	12	10.6	231.93	NE
February	20	0	0.5	34	25	11	10	9.8	118.07	NE
1981	28	0	0.8	34	26	11	11	15.3	148.75	NE
	10	0	0.25	34	26	12	12	14.7	134.10	NE
March	20	0	0.3	34	27	31	21	12.4	144.47	NE
1981	31	0	0.25	36	28	18	14	13.2	119.73	Variable
	10	0	7.1	37	28	21	9	14.4	155.20	Variable
April	20	26.2	9.4	37	29	35	23	11.3	181.64	Variable
1981	30	74.5	20.3	34	28	67	47	9.9	232.02	SW
	10	48.7	32.5	31	26	72	60	7.8	218.26	SW
May	20	37.3	34.5	33	27	69	51	9.9	185.37	SW
1981	31	4.7	50.2	32	27	66	53	6.9	144.62	SW
	10	0.6	46.2	34	28	62	46	10.4	209.67	SW
June	20	100.5	59.4	31	26	71	57	10.4	181.49	SW
1981	30	57.9	59.9	28	24	82	68	5.2	188.35	SW

* Evaporation is from a raised evaporimeter pan, U.S. Weather Bureau, Class A.

Appendix Table 3. Chillies Dry Yield at Dangora in 1980 loge (kg/ha)

Age of Transplant (week)	Cropping Pattern: Sole Crop	Maize Spacing (cm): 360	270	180	Mean of Mixtures	Main Effect
6	4.14	3.52	2.58	2.08	2.73	3.08
8	2.23	2.29	1.32	1.40	1.67	1.81
10	1.56	0.99	1.00	0.75	0.91	1.08
Main Effect	2.65	2.27	1.63	1.41	1.77	

S.E. Main Effects: Cropping pattern 0.32

Age of transplant 0.28

S.E. Mean of Mixtures 0.32

S.E. Interaction 0.55

Appendix Table 4. Sweet Pepper Adjusted Marketable Yield at Samaru in 1981 loge (kg/ha)

Age of Transplant (week)	Cropping Pattern: Sole Crop	Maize Spacing (cm): 240	180	120	Mean of Mixtures	Main Effect
7½	8.40	8.02	7.74	7.79	7.85	7.99
9½	8.34	8.34	7.80	7.70	7.95	8.04
Main Effect	8.37	8.18	7.77	7.75	7.90	

S.E. Main Effects: Cropping pattern 0.21

Age of transplant 0.15

S.E. Mean of Mixtures 0.17

S.E. Interaction 0.30

Appendix Table 5. Sweet Pepper Unadjusted Marketable Yield at Samaru in 1981 loge (kg/ha)

Age of Transplant (week)	Cropping Pattern				Mean of Mixtures	Main Effect
	Sole Crop	Maize Spacing (cm) 240	180	120		
7½	7.87	7.50	7.29	7.42	7.40	7.52
9½	8.14	8.23	7.65	7.58	7.82	7.90
Main Effect	8.01	7.86	7.47	7.50	7.61	

S.E. Main Effects: Cropping Pattern 0.25

Age of transplant 0.18

S.E. Mean of Mixtures 0.21

S.E. Interaction 0.36

Appendix Table 6. Sweet Pepper Unadjusted Total Yield at Samaru in 1981 loge (kg/ha)

Age of Transplant (week)	Cropping Pattern				Mean of Mixtures	Main Effect
	Sole Crop	Maize Spacing (cm) 240	180	120		
7½	8.25	7.97	7.72	7.73	7.81	7.92
9½	8.63	8.62	7.99	7.84	8.15	8.27
Main Effect	8.44	8.29	7.85	7.78	7.79	

S.E. Main Effects: Cropping Pattern 0.23

Age of transplant 0.17

S.E. Mean of Mixtures 0.19

S.E. Interaction 0.33

Appendix Table 7. Number of Sweet Pepper Fruit per Ha. at Samaru in 1981 loge (thousand/ha)

Age of transplant (week)	Cropping Pattern				Mean of Mixtures	Main Effect
	Sole Crop	Maize Spacing (cm) 240	180	120		
7½	12.56	12.43	12.09	11.91	12.14	12.25
9½	13.04	12.81	12.37	12.13	12.44	12.59
Main Effect	12.80	12.62	12.23	12.02	12.29	

S.E. Main Effects: Cropping Pattern 0.17

Age of Transplant 0.12

S.E. Mean of Mixtures 0.14

S.E. Interaction 0.25

Appendix Table 8. Cowpea Grain Yield at Dangora in loge 1980 (kg/ha)

Age of Transplant (week)	Cropping Pattern Maize Spacing (cm) 180	270	360	Main Effect
6	5.26	4.99	4.99	5.08
8	4.73	5.47	4.59	4.93
10	5.08	5.18	4.70	4.99
Main Effect	5.02	5.21	4.76	5.00

S.E. Main Effects: Cropping Pattern 0.19

Age of transplant 0.19

S.E. Interaction 0.32

Sweet Pepper Pickings at Samaru in 1981:

Appendix Table 9. Yield at 1st Picking of Sweet Pepper at Samaru in 1981 (kg/plot)

Age of Transplant (week)	Cropping Pattern				Mean of Mixtures	Main Effect	Main Effect as % of Total Picking
	Sole Crop	Maize Spacing (cm)					
		240	180	120			
7½	0.24	0.13	0.09	0.16	0.13	0.16	4.86
9½	0.02	0.09	0.09	0.09	0.09	0.07	1.61
Main Effect	0.13	0.11	0.09	0.13	0.11		
% of Total Picking	2.40	2.56	3.19	4.69	3.34		

Appendix Table 10. Yield at 2nd Picking of Sweet Pepper at Samaru in 1981 (kg/plot)

Age of Transplant (week)	Cropping Pattern				Mean of Mixtures	Main Effect	Main Effect as % of Total Picking
	Sole Crop	Maize Spacing (cm)					
		240	180	120			
7½	2.46	1.26	0.99	1.07	1.11	1.45	44.07
9½	2.14	2.25	1.15	1.57	1.66	1.78	40.83
Main Effect	2.30	1.75	1.07	1.33	1.38		
% of Total Picking	42.44	40.79	37.94	48.01	41.95		

Appendix Table 11. Yield at 3rd Picking of Sweet Pepper at Samaru in 1981 (kg/plot)

Age of Transplant (week)	Cropping Pattern				Mean of Mixtures	Main Effect	Main Effect as % of Total Picking
	Sole Crop	Maize Spacing (cm)					
		240	180	120			
7½	1.55	0.71	0.57	0.41	0.56	0.81	24.62
9½	1.17	1.73	0.97	0.95	1.22	1.21	27.75
Main Effect	1.36	1.22	0.77	0.68	0.89		
% of Total Picking	25.09	28.44	27.30	24.55	27.05		

Appendix Table 12. Yield at 4th Picking of Sweet Pepper at Samaru in 1981 (kg/plot)

Age of Transplant (week)	Cropping Pattern				Mean of Mixtures	Main Effect	Main Effect as % of Total Picking
	Sole Crop	Maize Spacing (cm)					
		240	180	120			
7½	1.42	0.78	0.89	0.40	0.69	0.87	26.44
9½	1.40	1.38	0.69	0.71	0.93	1.05	24.08
Main Effect	1.41	1.08	0.79	0.56	0.81		
% of Total Picking	26.01	25.17	20.10	20.22	24.62		

Appendix Table 13. Yield at 5th Picking of Sweet Pepper at Samaru in 1981 (kg/plot)

Age of Transplant (week)	Cropping Pattern				Mean of Mixtures	Main Effect	Main Effect as % of Total Picking
	Sole Crop	Maize Spacing (cm) 240	180	120			
9½	0.45	0.26	0.18	0.13	0.19	0.26	5.96
% of Total Picking	8.70	4.56	5.82	3.72	5.78		

Appendix Table 14. Total Picking of Sweet Pepper at Samaru in 1981 (kg/plot)

Age of Transplant (week)	Cropping Pattern				Mean of Mixtures	Main Effect
	Sole Crop	Maize Spacing (cm) 240	180	120		
7½	5.67	2.87	2.55	2.05	2.49	3.29
9½	5.17	5.70	3.09	3.49	4.09	4.36
Main Effect	5.42	4.29	2.82	2.77	3.29	

Sweet Pepper Plant Height at Samaru in 1981:

Note:

1. Pepper plant height at 52 days after sowing, that is, at first transplanting (7½ weeks) = 5.3cm.
2. Pepper plant height at 66 days after sowing, that is, at second transplanting (9½ weeks) = 9.3cm.

Appendix Table 15. Sweet Pepper Plant Height at 87 Days After Sowing (cm), at Samaru in 1981

Age of Transplant (week)	Cropping Pattern				Main Effect	Mean of Mixtures
	Sole Crop	Maize Spacing (cm)				
		240	180	120		
7½	8.4	9.0	8.3	9.6	8.8	9.0
9½	10.4	10.2	10.7	11.3	10.6	10.7
Main Effect	9.4	9.6	9.5	10.4		9.8

Appendix Table 16. Sweet Pepper Plant Height at 101 Days After Sowing (cm), at Samaru in 1981

Age of Transplant (week)	Cropping Pattern				Main Effect	Mean of Mixtures
	Sole Crop	Maize Spacing (cm)				
		240	180	120		
7½	13.4	14.9	12.0	15.7	14.0	14.2
9½	13.1	14.1	13.4	15.5	14.0	14.3
Main Effect	13.2	14.5	12.7	15.6		14.3

Appendix Table 17. Sweet Pepper Plant Height at 115 Days After Sowing (cm), at Samaru in 1981

Age of Transplant (week)	Cropping Pattern				Main Effect	Mean of Mixtures
	Sole Crop	Maize Spacing (cm)				
		240	180	120		
7½	20.1	22.5	19.5	21.8	21.0	21.3
9½	21.0	22.6	20.9	25.8	22.6	23.1
Main Effect	20.5	22.6	20.2	23.8		22.2

Appendix Table 18. Sweet Pepper Plant Height at 129 Days After Sowing (cm), at Samaru in 1981

Age of Transplant (week)	Cropping Pattern				Main Effect	Mean of Mixtures
	Sole Crop	Maize Spacing (cm)				
		240	180	120		
7½	21.0	24.7	23.1	24.3	23.3	24.0
9½	24.8	25.2	23.8	29.2	25.7	26.1
Main Effect	22.9	25.0	23.4	26.8		25.1

Appendix Table 19. Sweet Pepper Plant Mean Height at 115 and 129 Days after Sowing (cm), at Samaru in 1981

Age of Transplant (week)	Cropping Pattern				Mean of Mixtures	Main Effect
	Sole Crop	Maize Spacing (cm)				
		240	180	120		
7½	20.5	23.6	21.3	23.1	22.7	22.1
9½	22.9	23.9	22.4	27.5	24.6	24.2
Main Effect	21.7	23.8	21.8	25.3	23.6	

S.E. Main Effects: Cropping Pattern 1.45

Age of transplant 1.03

S.E. Mean of Mixtures 1.19

S.E. Interaction 2.05

Appendix Table 20. Sweet Pepper Plant Height at 143 Days After Sowing (cm), at Samaru in 1981

Age of Transplant (week)	Cropping Pattern				Main Effect	Mean of Mixtures
	Sole Crop	Maize Spacing (cm)				
		240	180	120		
9½	25.0	26.7	25.0	28.7	26.3	26.8

Sweet Pepper Leaf Cover at Samaru in 1981:

Appendix Table 21. Sweet Pepper Leaf Cover at 81 Days After Sowing (cm), at Samaru in 1981

Age of Transplant (week)	Cropping Pattern				Main Effect	Mean of Mixtures
	Sole Crop	Maize Spacing (cm)				
		240	180	120		
7½	4.8	5.2	3.8	6.0	5.0	5.0
9½	6.4	4.6	2.8	1.2	3.8	2.9
Main Effect	5.6	4.9	3.3	3.6		3.9

Appendix Table 22. Sweet Pepper Leaf Cover at 88 Days After Sowing (%), at Samaru in 1981

Age of Transplant (week)	Cropping Pattern				Main Effect	Mean of Mixtures
	Sole Crop	Maize Spacing (cm)				
		240	180	120		
7½	10.8	7.2	8.2	4.0	7.6	6.5
9½	10.4	10.0	4.0	3.8	7.1	5.9
Main Effect	10.6	8.6	6.1	3.9		6.2

Appendix Table 23. Sweet Pepper Leaf Cover at 95 Days After Sowing (%), at Samaru in 1981

Age of Transplant (week)	Cropping Pattern				Main Effect	Mean of Mixtures
	Sole Crop	Maize Spacing (cm)				
		240	180	120		
7½	18.4	16.2	16.0	10.2	15.2	14.1
9½	18.6	13.0	11.4	9.4	13.1	11.3
Main Effect	18.5	14.6	13.7	9.8		12.7

Appendix Table 24. Sweet Pepper Leaf Cover at 102 Days After Sowing (%), at Samaru in 1981

Age of Transplant (week)	Cropping Pattern				Main Effect	Mean of Mixtures
	Sole Crop	Maize Spacing (cm)				
		240	180	120		
7½	24.0	10.4	11.8	8.2	13.6	10.1
9½	15.6	13.0	10.8	6.4	11.5	10.1
Main Effect	19.8	11.7	11.3	7.3		10.1

Appendix Table 25. Sweet Pepper Leaf Cover at 109 Days After Sowing (%), at Samaru in 1981

Age of Transplant (week)	Cropping Pattern				Main Effect	Mean of Mixtures
	Sole Crop	Maize Spacing (cm)				
		240	180	120		
7½	27.4	11.6	13.2	9.2	15.4	11.3
9½	16.8	19.6	13.6	8.6	14.7	13.9
Main Effect	22.1	15.6	13.4	8.9		12.6

Appendix Table 26. Sweet Pepper Leaf Cover at 116 Days After Sowing (%), at Samaru in 1981

Age of Transplant (week)	Cropping Pattern				Main Effect	Mean of Mixtures
	Sole Crop	Maize Spacing (cm)				
		240	180	120		
7½	27.2	16.4	15.6	11.6	17.7	14.5
9½	24.2	23.6	17.2	11.8	19.2	17.5
Main Effect	25.7	20.0	16.4	11.7		16.0

Appendix Table 27. Sweet Pepper Leaf Cover at 123 Days After Sowing (%), at Samaru in 1981

Age of Transplant (week)	Cropping Pattern				Mean of Mixtures	Main Effect
	Sole Crop	Maize Spacing (cm)				
		240	180	120		
7½	32.6	23.6	26.4	12.4	20.8	23.8
9½	38.4	33.4	22.6	17.0	24.3	27.9
Main Effect	35.5	28.5	24.5	14.7	22.6	

S.E. Main Effects: Cropping Pattern 2.86

Age of transplant 2.03

S.E. Mean of Mixtures 2.34

S.E. Interaction 4.05

Appendix Table 28. Sweet Pepper Leaf Cover at 137 Days After Sowing (%), at Samaru in 1981

Age of Transplant (week)	Cropping Pattern				Main Effect	Mean of Mixtures
	Sole Crop	Maize Spacing (cm)				
		240	180	120		
7½	32.6	15.6	12.2	20.2	20.3	16.2
9½	34.8	34.0	17.8	20.6	26.8	24.1
Main Effect	33.7	24.8	15.0	20.7		20.2

Maize Leaf Cover at Samaru in 1981:

Appendix Table 29. Maize Leaf Cover at 52 Days After Sowing (%), at Samaru in 1981

Age of Transplant (week)	Cropping Pattern				Mean of Mixtures
	Maize Spacing (cm)			Sole Crop	
	240	180	120		
7½	17.0	12.6	25.2	-	18.3
9½	12.6	16.2	21.4	-	16.7
Main Effect	14.8	14.4	23.3	38.7	17.5

Appendix Table 30. Maize Leaf Cover At 59 Days After Sowing (%), at Samaru in 1981

Age of Transplant (week)	Cropping Pattern				Mean of Mixtures
	Maize Spacing (cm)			Sole Crop	
	240	180	120		
7½	19.8	22.2	32.2	-	24.7
9½	13 2	17.0	35.2	-	21.8
Main Effect	16.5	19.6	33.7	45.5	23.3

Appendix Table 31. Maize Leaf Cover at 66 Days After Sowing (%) at Samaru in 1981

Age of Transplant (week)	Cropping Pattern: Maize Spacing (cm) 240	180	120	Sole Crop	Mean of Mixtures
7½	19.8	24.2	30.4	-	24.8
9½	14.6	19.4	25.8	-	19.9
Main Effect	17.2	21.8	28.1	46.7	22.4

Appendix Table 32. Maize Leaf Cover at 73 Days After Sowing (%), at Samaru in 1981

Age of Transplant (week)	Cropping Pattern: Maize Spacing (cm) 240	180	120	Sole Crop	Mean of Mixtures
7½	25.6	30.8	46.8	-	34.4
9½	22.0	26.6	43.0	-	30.5
Main Effect	23.8	28.7	44.9	56.6	32.5

Appendix Table 33. Maize Leaf Cover at 80 Days After Sowing (%) at Samaru in 1981

Age of Transplant (week)	Cropping Pattern: Maize Spacing (cm) 240	180	120	Sole Crop	Mean of Mixtures
7½	30.8	26.8	40.2	-	32.6
9½	25.8	25.2	40.4	-	30.5
Main Effect	28.3	26.0	40.3	57.9	31.5

Appendix Table 34. Maize Leaf Cover at 87 Days After Sowing (%), at Samaru in 1981

Age of Transplant (week)	Cropping Pattern: Maize Spacing (cm) 240	180	120	Sole Crop	Mean of Mixtures
7½	28.2	27.8	44.2	-	33.4
9½	24.0	21.6	39.8	-	28.5
Main Effect	26.1	24.7	42.0	61.4	30.9

Appendix Table 35. Maize Mean Leaf Cover at 73, 80 and 87 Days After Sowing (%), at Samaru in 1981

Age of Transplant (week)	Cropping Pattern: Maize Spacing (cm) 240	180	120	Sole Crop	Mean of Mixtures
7½	28.2	28.3	43.7	-	33.4
9½	23.9	24.5	41.1	-	29.8
Main Effect	26.1	26.4	42.4	58.5	31.6

S.E. Main Effects: Cropping pattern 2.04
Age of transplant 1.67

S.E. Mean of Mixtures 1.67

S.E. Interaction 2.89

Appendix Table 36. Maize Leaf Cover at 9½ Days After Sowing (%), at Samaru in 1981

Age of Transplant (week)	Cropping Pattern				Mean of Mixtures
	Maize Spacing (cm)			Sole Crop	
	240	180	120		
7½	28.2	24.0	40.2	-	30.8
9½	26.8	21.4	36.4	-	28.2
Main Effect	27.5	22.7	38.3	57.0	29.5

Appendix Table 37. Mean Drainage Score at Dangora in 1980

Treatment	Replication				Treatment Means
	1	2	3	4	
A	5	3	5	5	5
B	6	5	4	4	5
C	6	3	4	5	5
D	5	4	5	5	5
E	5	4	5	4	5
F	5	1	4	5	4
G	3	5	4	4	4
H	5	6	3	5	5
I	5	3	5	5	5
J	5	5	5	4	5
K	5	4	3	3	4
L	5	5	4	5	5
M	4	4	6	4	4
N	5	4	4	5	5
Block Means	5	4	4	5	

Appendix Table 38. Stand Count of Pepper, Maize and Cowpea at Harvest[a] at Dangora in 1980 (1000 plant/ha.)

Age of Transplant (week)	Cropping Pattern										
	Sole Crop		Maize Spacing (cm) 360			270			180		
	Pepper	Maize	Pepper	Maize	Cowpea	Pepper	Maize	Cowpea	Pepper	Maize	Cowpea
6	20	-	19	7	8	17	8	8	15	13	13
8	22	-	18	7	6	17	9	11	16	13	10
10	21	-	17	7	9	17	9	10	15	11	12
Main Effect	21	24	18	7	8	17	9	10	15	12	12

Footnote:

a, the intended populations are found on page 30 for 1980

Appendix Table 39. Stand Count of Pepper and Maize at Harvest[b], at Samaru in 1981 (1000 plant/ha.)

Age of Transplant (week)	Cropping Pattern							
	Maize Spacing (cm)							
	Sole Crop		240		180		120	
	Pepper	Maize	Pepper	Maize	Pepper	Maize	Pepper	Maize
7½	28	-	20	17	21	19	17	28
9½	41	-	32	18	27	18	21	28
Main Effect	34	51	26	18	24	19	19	28

Footnote:

b, the intended populations are found on page 33 for 1981.

APPENDIX 3

Tables of Statistical Analysis

Appendix Table 40. Treatment Means for the Four Variates X_1, X_2, Z_1 and Z_2, Dangora in 1980

Treatment	Yield kg/ha.		New Variates	
	X_1 (maize)	X_2 (Pepper)	Z_1	Z_2
D	913	39	2.24	2.76
E	849	15	2.08	1.03
F	412	2	1.01	0.16
G	823	39	2.02	2.72
H	553	4	1.36	0.28
I	759	3	1.86	0.18
J	1647	13	4.04	0.94
K	798	6	1.96	0.41
L	798	2	1.96	0.11
Sole Crops	1305	A 105	3.20	7.43
		B 19		1.34
		C 4		0.28

Appendix Table 41. Treatment Means for the Four Variates X_1, X_2, Z_1 and Z_2, Samaru in 1981

Treatment	Yield t/ha		New Variates	
	X_1	X_2	Z_1	Z_2
C	3.18	1.78	3.27	1.15
D	1.39	2.23	1.43	1.45
E	1.49	2.18	1.53	1.42
F	2.20	3.39	2.26	2.20
G	0.79	2.61	0.81	1.70
H	1.70	5.20	1.75	3.38
Sole Crop	3.56	A 5.07	3.66	3.29
		B 3.96		2.58

Note: For definition of X_1, X_2, Z and Z_2 see page 70-71

Appendix Table 42. Sweet Pepper Plant Percentage Stant Loss Due to Disease, Samaru 1981

Source	df	MS	F
Replication	4	214.46	0.96 ns
Treatment:	7		
Cropping Pattern	3	65.49	0.29 ns
Age	1	4389.03	19.72**
Interaction	3	60.89	0.27 ns
Error	28	22.61	
Total	39		

Note: ns not significant

* significant ($P < 0.05$)

** highly significant ($P < 0.01$)

Appendix Table 43. Chilli Pepper Dry Yield, Dangora 1980

Source	df	MS	F
Replication	3	1,528.58	0.94 ns
Treatment:	11		
Cropping pattern	3	2,817.08	1.74 ns
Age	2	9,822.65	6.07**
Interaction	6	1,792.20	1.11 ns
Error	33	1,618.03	
Total	47		

Chilli Pepper Dry Yield, Dangora 1980 loge

Source	df	MS	F
Replication	3	1.96	1.61 ns
Treatment:	11		
Cropping pattern	3	3.90	3.19*
Age	2	16.45	13.49**
Interaction	6	0.55	0.45 ns
Error	33	1.22	
Total	47		

Appendix Table 44. Sweet Pepper Adjusted Marketable Yield, Samaru 1981

Source	df	MS	F
Replication	4	24,071,148.23	5.57**
Treatment:	7		
Cropping pattern	3	17,042,139.00	3.95*
Age	1	2,094,892.90	0.49 ns
Interaction	3	8,867,900.00	2.05 ns
Error	28	4,318,703.94	
Total	39		

Sweet Pepper Adjusted Marketable Yield, Samaru 1981 loge

Source	df	MS	F
Replication	4	4.34	9.77**
Treatment:	7		
Cropping pattern	3	0.95	2.13 ns
Age	1	0.03	0.07 ns
Interaction	3	0.09	0.20 ns
Error	28	0.44	
Total	39		

Appendix Table 45. Sweet Pepper Unadjusted Marketable Yield, Samaru 1981

Source	df	MS	F
Replication	4	18,111,084.79	5.02**
Treatment:	7		
Cropping pattern	3	9,740,065.30	2.70 ns
Age	1	9,543,336.10	2.64 ns
Interaction	3	7,718,120.60	2.14 ns
Error	28	3,608,646.53	
Total	39		

Sweet Pepper Unadjusted Marketable Yield, Samaru 1981 loge

Source	df	MS	F
Replication	4	5.20	8.01**
Treatment:	7		
Cropping pattern	3	0.17	1.10 ns
Age	1	1.44	2.21 ns
Interaction	3	0.16	0.24 ns
Error	28	0.65	
Total	39		

Appendix Table 46. Sweet Pepper Unadjusted Total Yield, Samaru 1981

Source	df	MS	F
Replication	4	23,976,403.59	4.17**
Treatment:	7		
Cropping pattern	3	21,836,146.00	3.79*
Age	1	15,510,212.00	2.70 ns
Interaction	3	6,638,815.30	1.15 ns
Error	28	5,754,216.94	
Total	39		

Sweet Pepper Unadjusted Total Yield, Samaru 1981 loge

Source	df	MS	F
Replication	4	2.84	5.16**
Treatment:	7		
Cropping pattern	3	1.04	1.90 ns
Age	1	1.25	2.27 ns
Interaction	3	0.13	0.23 ns
Error	28	0.55	
Total	39		

Appendix Table 47. Number of Sweet Pepper Fruits per Ha, Samaru 1981

Source	df	MS	F
Replication	4	47,654,995,000	2.72*
Treatment:	7		
Cropping pattern	3	118,950,080,000	6.79**
Age	1	60,764,286,000	3.47 ns
Interaction	3	1,521,804,600	0.09 ns
Error	28	17,513,116,000	
Total	39		

Number of Sweet Pepper Fruits per Ha, Samaru 1981 loge

Source	df	MS	F
Replication	4	0.74	2.41 ns
Treatment:	7		
Cropping pattern	3	1.27	4.15*
Age	1	1.15	3.76 ns
Interaction	3	0.04	0.13 ns
Error	28	0.31	
Total	39		

Appendix Table 48. Number of Fruits per Sweet Pepper Plant, Samaru 1981

Source	df	MS	F
Replication	4	45.73	2.23 ns
Treatment:	7		
Cropping pattern	3	34.43	1.68 ns
Age	1	55.23	2.69 ns
Interaction	3	0.76	0.04 ns
Error	28	20.54	
Total	39		

Appendix Table 49. Mean Fruit Weight of Sweet Pepper, Samaru 1981

Source	df	MS	F
Replication	4	92.9385	12.10**
Treatment:	7		
Cropping pattern	3	10.1783	1.33 ns
Age	1	2.9703	0.39 ns
Interaction	3	16.6843	2.17 ns
Error	28	7.6788	
Total	39		

Appendix Table 50. Maize Marketable Yield, Dangora 1980

Source	df	MS	F
Replication	3	3,547,552.50	9.52*
Treatment:	9		
Sole vs. mixture	1	1,423,759.00	3.82 ns
Within mix:			
Mixtures	2	526,017.70	1.41 ns
Age	2	768,031.70	2.06 ns
Interaction	4	285,261.45	0.77 ns
Error	27	372,677.13	
Total	39		

Appendix Table 51. Maize Total Yield, Dangora 1980

Source	df	MS	F
Replication	3	4,527,291.30	8.65**
Treatment:	9		
Sole vs. Mixtures	1	3,560,248.00	6.80*
Within Mix:			
Mixtures	2	708,024.50	1.35 ns
Age	2	627,693.70	1.20 ns
Interaction	4	617,639.25	1.18 ns
Error	27	523,306.59	
Total	39		

Appendix Table 52. Maize Marketable Yield, Samaru 1981

Source	df	MS	F
Replication	4	5,085,472.40	2.80*
Treatment:	6		
Sole vs. mixtures	1	23,415,400.00	12.90**
Within Mix: Mixtures	2	6,709,325.00	3.70*
Age	1	1,580,107.50	0.87 ns
Interaction	2	926,469.75	0.51 ns
Error	24	1,815,498.30	
Total	34		

Appendix Table 53. Maize Total Yield, Samaru 1981

Source	df	MS	F
Replication	4	10,576,232.41	3.56*
Treatment:	6		
Sole vs. mixtures	1	73,237,510.00	24.65**
Within Mix: Mixtures	2	9,681,595.00	3.26 ns
Age	1	714,254.75	0.24 ns
Interaction	2	1,355,647.65	0.46 ns
Error	24	2,971,332.40	
Total	34		

Appendix Table 54. Number of Marketable Maize Cobs per Ha, Samaru 1981

Source	df	MS	F
Replication	4	114,486,263.95	2.31 ns
Treatment:	6		
Sole vs. Mixtures	1	900,386,000.00	18.19**
Within mix:			
Mixtures	2	179,009,000.00	3.62*
Age	1	23,627,913.00	0.38 ns
Interaction	2	16,120,143.50	0.33 ns
Error	24	49,490,783.50	
Total	34		

Appendix Table 55. Cowpea Grain Yield, Dangora 1980

Source	df	MS	F
Replication	3	8,945.56	1.36 ns
Treatment:	8		
Mixtures	2	6,968.11	1.06 ns
Age	2	1,028.11	0.16 ns
Interaction	4	10,462.19	1.59 ns
Error	24	6,575.43	
Total	35		

Cowpea Grain Yield, Dangora 1980 loge

Source	df	MS	F
Replication	3	0.44	1.07 ns
Treatment:	8		
Mixtures	2	0.16	1.47 ns
Age	2	0.07	0.17 ns
Interaction	4	0.31	0.75 ns
Error	24	0.41	
Total	35		

Appendix Table 56. Number of Days From Sowing to First Pepper Flower Bud Opening, Samaru 1981

Source	df	MS	F
Replication	4	12.29	0.61 ns
Treatment:	7		
Cropping pattern	3	10.27	0.51 ns
Age	1	980.10	48.55**
Interaction	3	8.37	0.41 ns
Error	28	20.19	
Total	39		

Appendix Table 57. Number of Days From Sowing to 50% Pepper Flowering, Samaru 1981

Source	df	MS	F
Replication	4	58.91	4.01*
Treatment:	7		
Cropping pattern	3	5.69	0.39 ns
Age	1	286.23	19.47**
Interaction	3	3.09	0.21 ns
Error	28	14.70	
Total	39		

Appendix Table 58. Number of Days From Sowing to 50% Pepper Fruit Setting, Samaru 1981

Source	df	MS	F
Replication	4	60.71	2.86*
Treatment:	7		
Cropping pattern	3	34.70	1.64 ns
Age	1	422.50	19.93**
Interaction	3	20.03	0.95 ns
Error	28	21.20	
Total	39		

Appendix Table 59. Number of Flowers Tagged per Pepper Plant, Samaru 1981

Source	df	MS	F
Replication	4	110.96	1.85 ns
Treatment:	7		
Cropping pattern	3	84.43	1.41 ns
Age	1	940.90	15.70**
Interaction	3	4.17	0.07 ns
Error	28	59.95	
Total	39		

Appendix Table 60. Percentage Fruit Set of Sweet Pepper, Samaru 1981

Source	df	MS	F
Replication	4	383.98	2.72*
Treatment:	7		
Cropping pattern	3	59.19	0.42 ns
Age	1	4.36	0.03 ns
Interaction	3	95.08	0.67 ns
Error	28	141.31	
Total	39		

Appendix Table 61. Number of Days From Sowing to 50% Maize Silking, Samaru 1981

Source	df	MS	F
Replication	4	132.35	2.73 ns
Treatment:	6		
Sole vs. mixtures	1	13.33	0.28 ns
Within Mix: Mixtures	2	25.04	0.52 ns
Age	1	93.63	1.93 ns
Interaction	2	5.84	0.12 ns
Error	24	48.43	
Total	34		

Appendix Table 62. Pepper Leaf Cover At 123 Days After Sowing, Samaru 1981

Source	df	MS	F
Replication	4	113.16	1.38 ns
Treatment:	7		
Cropping pattern	3	754.27	9.19**
Age	1	168.10	2.05 ns
Interaction:	3	81.70	1.00 ns
Error	28	82.06	
Total	39		

Appendix Table 63. Pepper Plant Mean Height At 115 and 129 Days After Sowing, Samaru 1981

Source	df	MS	F
Replication	4	138.50	1.83 ns
Treatment:	7		
Cropping pattern	3	29.17	1.38 ns
Age	1	42.23	2.00 ns
Interaction	3	8.22	0.39 ns
Error	28	21.09	
Total	39		

Appendix Table 64. Maize Mean Leaf Cover At 73, 80 and 87 Days After Sowing, Samaru 1981

Source	df	MS	F
Replication	4	380.10	9.10**
Treatment:	6		
Sole vs. Mixtures	1	5431.78	129.99**
Within Mix: Mixtures	2	871.78	20.86**
Age	1	97.31	2.33 ns
Interaction	2	1.74	0.04 ns
Error	24	41.79	
Total	34		

Appendix Table 65. Pepper Leaf Curl Disease Score, Samaru 1981

Source	df	MS	F
Replication	4	.2156	3.37*
Treatment:	7		
Cropping pattern	3	.0436	0.68 ns
Age	1	.8123	12.71**
Interaction	3	.0629	0.98
Error	28	.0639	
Total	39		