EFFECTS OF AGE AT PEPPER SEEDLING TRANSPLANT AND MAIZE POPULATION ON THE GROWTH AND PRODUCTIVITY OF MAIZE-PEPPER INTERCROP ON AN ALFISOL IN IBADAN

BY

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ABSTRACT

Mixed cropping of pepper (*Capsicum frutescens* L.) with arable crops is a popular cropping system among peasant farmers of southwestern Nigeria. The yield of pepper is affected by age at transplanting as well as population of the intercrop. However, there is paucity of information on the combined effects of population of intercropped maize and the age of pepper seedling transplant on the growth and productivity of the system. Therefore, the effects of age of pepper at transplanting and population of intercropped maize on the growth and yields of the two crops were investigated at the Institute of Agricultural Research and Training, Ibadan, for two years.

Two varieties of Cayenne pepper, NHVI-A and "Sombo" were intercropped with maize variety, DMR-EM-Y, which was sown at three population of 26667, 35556 and 53333 plants/ha. The treatments were assigned in a randomized complete block design with three replicates. In another experiment, the two varieties of pepper were intercropped with two weeks old maize at 26667 plants /ha at 3, 4, 5, 6 and 7 weeks after sowing (WAS). Data collected included plant height stem diameter, number of leaves and number of branches and percent seedling survival; maize grain yield and pepper fresh fruit yield were subjected to ANOVA at P = 0.05. Land Equivalent Ratio(s) were also calculated.

Population significantly reduced the height of sole maize (93.1cm) more than intercropped maize at 53333 plants/ha (136.5cm); and stem diameter of sole maize (2.36cm) than intercropped maize at 26667 plants/ha (2.6cm), respectively at 8 WAP. Compared with sole crop, intercropped maize at 53333 plants/ha was significantly taller (136.5cm) with Sombo, while at 26,667 plant/ha, it had bigger stem diameter (2.51 and 2.61 cm) when intercropped with the two varieties. The grain yields of intercropped maize (2.68 and 2.24 tha^{-1}) at population of 35,556 and 26,667 plants/ha, respectively were however significantly lower than 4.3 and 4.2 tha^{-1} obtained for intercropped maize at 53,333 plants/ha with NHVIA and Sombo, respectively. Generally, Sombo produced higher yield than NHVIA, while of number fruits and yield of the two varieties of pepper were significantly reduced by intercropping with maize at the three population. The yield (1944kgha^{-1}) of sole NHVIA was however significantly higher than the corresponding value of 1320kgha^{-1} for Sombo.

Pepper seedling transplanted into maize at 6 and 7 WAS for NHVIA and 5 and 7 WAS for Sombo had significantly taller plants, bigger stem diameter and higher number of leaves and branches at 8 WAT than the corresponding younger transplants. Similarly, 6 and 7-week old transplants of the two pepper varieties produced significantly higher yields than the corresponding younger transplants. Maximum yield (1,860kgha^{-1}) was produced by 7-week old Sombo transplant intercropped with maize.

Maize intercropped with 6 and 7-week old Sombo transplants resulted in the higher LER of 1.99 and 2.06 respectively compared with the corresponding values of 1.66 and 1.75 for NHVIA. The results obtained confirmed the productivity of maize-pepper intercrop of 6-week and 7-week old transplants are introduced into 2-week old maize at 26,667 plants/ha.

Keywords: Pepper seedling, Maize population, Intercropped pepper, Land Equivalent Ratio

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CERTIFICATION

I certify that this work was carried out by David Ogundeji Ogunleti in the Department of Agronomy, University of Ibadan.

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Supervisor

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DEDICATION

To my wife, Olusola

and

children, Grace and Gideon

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CHAPTER 1

INTRODUCTION

Peppers, which belong to the family Solanaceae and the genus *Capsicum*, are one of the most important vegetables consumed worldwide as spices. Aside tomato and onion, pepper takes the lead in vegetable cycle and it is widely cultivated in Africa to the extent that Africa sees it as a traditional African vegetable or spice (Grubben and El-Tahir, 2004). Bosland and Votava (2000) identified approximately twenty-two wild and five domesticated species in the genus *Capsicum* viz; *Capsicum annum*, *C. baccatum*, *C. chinense*, *C. pubescens* and *Capsicum frutescens*. Two of these groups of peppers; sweet pepper (*Capsicum annum*) and chilli or hot peppers (Capsicum frutescens) are widely cultivated in Nigeria (Bosland and Votava, 2000). The former group has a mild taste, non-pungent and are usually consumed green as salad vegetables while the latter contains a high concentration of capsaicin in their placenta which makes them pungent and very hot to the taste bud, but are highly cherished in Nigerian diets either as condiments in stews and soups, flavouring agent or to add taste and colour to meals.

Several local hot pepper cultivars which grow very successfully exist, but 'Rodo', 'Sombo' and the more recent improved 'NHV-1A' are popular. Being a relatively long duration crop which utilizes the potential growing period, chilli pepper is suitable for inter-cropping with early maturing and determinate crops such as maize; which constitute the dominant mixtures in many traditional inter-cropping systems. Hence, they are usually cultivated by peasant farmers in mixtures with other crops, in both southwestern and northern Nigeria, except in parts of Kaduna and Kano States where they are cultivated sole, purposely for distant markets in the southern part of the country or neighbouring countries.

Ado (1999) reported that in southwestern Nigeria, pepper is commonly grown in mixtures with cassava and maize. This is because peppers fit well into many cropping patterns and may bring in needed cash during periods when cereals and other staples cannot be grown. He also opined that young plants of peppers would grow better under partial shade or natural light shade of other crops such as yam, maize and sorghum. It has also been reported that the predominant grain produced in Nigeria is maize; this is because of its ability to thrive under different ecological conditions and its sustained increase in the output (Adekunle and Nabinta, 2000).

Several studies had been carried out on intercropping of food crops and vegetables in Nigeria; however, these studies have focused mainly on planting arrangement, spacing and fertilizer requirement with little emphasis on the appropriate time of introducing the component crops and their population densities in the mixture.

Agronomic recommendations for intercropping peppers with maize is at present scanty; especially, relating to the age of transplants, the best time of introduction into the crop mixtures and the optimum population of component crops in the mixture. Since growing of peppers under mixed cropping has been found to be popular among the peasant farmers in the southwestern part of Nigeria, it is necessary to determine the appropriate age of transplanting pepper seedlings in the intercrop with maize.

The objective of the study was to evaluate the effects of maize population densities and age of transplanting pepper seedlings on the growth and yield of two varieties of pepper in a maize-pepper intercrop

CHAPTER 2

LITERATURE REVIEW

The *Capsicum* peppers are indigenous to Central and Tropical America while primary and secondary centres of diversity were Mexico and Guatemala, respectively. Pickertgill (1971) reported that the Portuguese introduced peppers into West Africa in the 15th Century. By the end of the 17th century, it was grown as a popular vegetable and spice everywhere in the tropics; and many very distinct types and landraces have been developed (Grubben and El-Tahir, 2004). In the past decades, peppers have spread through the tropical and sub-tropical regions of the world with Asia being the world's largest producer of *Capsicum* peppers (FAO, 1997; Bosland and Votava, 2000).

2.1 Botany of *Capsicum* Peppers

Capsicum species are members of the *Solanaceae*, a large tropical family of crops that includes tomato, potato and tobacco. There are two main species; the sweet peppers (*Capsicum* annum) which are annuals that produce large fruits and the more widely grown types, Chilli peppers (*Capsicum frutescens*), which are short-lived perennial plants that live up to two or three years giving economic yield, under good management.

Generally, peppers are slightly woody and upright in growth but produce branches dichotomously; so that the first branching has no main or control stem. The chillis produce more branches than the sweet peppers (Tindall, 1983). These varying numbers of branches also have a direct influence on the fruit production (CTA, 1989).

The leaves of peppers are considerably varied in sizes, from fairly large in sweet peppers to small in hot peppers (Reddy, 1995). There is also a wide variability of the two species in terms of fruit shape, colour and pungency; and demand is usually based on a lot of these fruit morphological characteristics. The variations in fruit shape and size also account to some degree, for the differences in fruit yield of different cultivars (Ado, 1999).

According to the International Board for Plant Genetic Resources (IBPGR), *Capsicum* peppers are also classified commercially by the level of pungency and the concentration of capsaicin in the fruits (IBPGR, 1993). Chillies are more pungent than the sweet peppers due to the presence of higher concentration of capsaicin in them. The capsaicinoids are produced in glands on the placenta of the fruit and distributed throughout the plant but more concentrated in the fruits placenta (Collins and Bosland, 1994). Small fruited cultivars are however more pungent than the thick-fleshed large fruited cultivars (Tindal, 1983).

2.2. Dietary and Economic Importance of *Capsicum* Peppers

Peppers (*Capsicum* spp.) were identified as very important fruit vegetables worldwide, which ranked high among the most important vegetables in the world (FAO, 1997). In Nigeria, peppers represent about 40% of the daily vegetable consumption in the country. Currently, Nigeria is the largest producer of peppers, especially Chillies, in Africa accounting for over 50 % of the total African production (Grubben and El-Tahir, 2004). Primarily, pepper fruit is consumed as a fresh vegetable or dehydrated for use as a spice. The fruits add spice flavouring and colour to foods while providing essential vitamins and minerals (Bosland and Votava, 2000). The two species are the main ingredients in cooking soup and stew in both the tropical and temperate regions of the world (Purseglove, 1991). The distinctive aromatic flavour and natural pungency had been identified as classic qualities that enhance the uses of peppers as condiments in African foods (Denton and Olufolaji, 2000).

Peppers are good sources of vitamins C and E as well as pro-vitamins, thiamine (B_1), riboflavin (B_2) and niacin (B_3). The wide range of vitamin levels reported in pepper has been attributed to differences in cultivars, maturity, growing practices, climate and post harvest handling (Mozafar, 1994). Pepper is also extremely rich in ascorbic acid (Vitamin C), greater than that of tomatoes (Keshinro and Ketiku, 1983). The ascorbic content in peppers increases during fruit ripening (Osuna-Garcia and Wall, 1998). Since the ripe chillies are also comparatively richer in vitamins than the matured green sweet peppers; they are widely used as condiments all over the world (Norman, 1992).

Economically, peppers are good sources of income to small scale producers and exports in many of the developing countries. Nigerian chillies which were once identified as having the suitable quality for the international markets, particularly to the United Kingdom and Europe and formerly, were sources of foreign exchange in the 60’s and 70’s before the advent of oil boom (Ado, 1999). In recent years, the export of chillies has been resuscitated as a result of renewed emphasis on the export of non-oil products, especially the agricultural sector, in Nigerian economy. Peppers also have some medicinal and herbal values which could be due to the higher vitamin

C and carotene contents of the fruits. Pharmaceutical products like carminative, stimulant rubberfacient and some counter-irritant have some elements of pepper preparations in them (Adeoye and Fatokun, 1992). Peppers are also used as folk remedies for dropsy, colic, diarrhea, asthma, arthritis, muscle cramps and toothache (IBPGR, 1993). Indigenous knowledge also recognized pepper as a medicinal plant that can be used in the prevention and treatment of cold and were reputed to increase appetite and digestion (Olarenwaju, 2003). In traditional storage of farm produce, chilli peppers are used for insect pest control in stored grains and the pungent chemical compound (capsaicin) is also used in the manufacture of tear gas.

2.3 Ecological Requirements of Peppers

Peppers are a warm season crop that require about the same growing conditions as tomatoes and egg plants. Peppers are widely grown throughout the world because of their genetic make-up that enables them to develop under different environmental conditions; however, the best growth and optimum yield for chillies are obtainable in areas of relatively low rainfall, where the ripening and drying of the harvested fruits can take place easily. Ado and Asiribo (1989) reported that the climate in Nigeria, particularly the Northern Guinea Savannah with its abundant sunshine hours, loamy soils and adequate rainfall and temperature, provides a suitable environment for pepper production. Olarenwaju (2003) also reported that chillies can grow in all ecologies of Nigeria provided that correct varieties are used at the appropriate time of planting.

A number of workers had reported the effects of different environmental conditions on pepper growth and yield. Wien *et al.* (1989) observed that mild shading, about 25 % reduction of clear light condition increased pepper yields; while heavier shade induced the abscission of flower buds, flowers and fruits. Smith (1980) also reported that humidity levels around 75 % recorded optimum growth of pepper while too dry an atmosphere resulted in floral abortion. Fluctuations had also been observed from season to season as a result of poor weather conditions, increased pest and diseases and moisture stress, especially during the dry season. Ado and Olarenwaju (1987) observed striking seasonal variation in the fruit characteristics and yields of peppers grown in the savannah in two distinct seasons. They reported that the dry season which was characterized by higher evaporation, lower relative humidity and low temperature associated with cold-dry northeast trade wind caused stagnation in the growth and ability of the pepper plants to produce fruits. Bosland and Votava (2000) also reported that higher yields resulted when daily air temperature ranges between 18 and 32 ^{o}C during fruit set; while temperature above 35 ^{o}C, at the peak of dry season caused male sterility due to pre-meiotic degeneration of pollens, especially in large fruited cultivars. Generally, peppers are susceptible to frost and grow poorly in the 5 – 15 ^{o}C temperature range. Chillies also require regular and adequate watering during the dry season to keep the soil moist through the growth cycle since excessive or inadequate moisture had been reported to cause premature flower droppings (Reddy, 1995).

Peppers also grow on a wide range of soils, but thrive best on well-drained soils that contain ample organic matter, free from root knot nematodes and bacterial wilt organisms. Norman (1992) indicated that fertile soils usually hasten peppers growth, while poor soils caused stunted growth, early flowering and fruit setting when the plants were still very small and consequent adverse effect on the yield and quality of pepper fruits.

2.4. Cultural practices in pepper production

The usual practice of growing peppers in West Africa is to first sow the seeds on nursery beds or seed trays. Though, in certain parts of southwestern United States, seeds are occasionally grown directly in the field (Tindall, 1983), transplanted plants were found to perform better than direct seeded plants (Adigun *et al.*, 1992; Schulthesis *et al.*, 1988; Olanrewaju, 2003). Transplanting of peppers was found to be a suitable option because of the slow rate of seed germination. According to Bosland and Votava (2000), transplanting of peppers guaranteed a well- distributed stands of plants, reduces seed, seeding and thinning. Pepper plants established from transplants are also more uniform and can tolerate or escape early a-biotic and biotic stresses; and may achieve earlier maturity than direct-seeded plants. Raising of seedling in the nursery also promotes planting to time on the field. By using transplants, fields can be maximized for productivity as a result of the possibility of increasing the number of harvests and consequently, yield per unit area. In many systems, transplants are produced in green houses or in outdoor seed beds.

The seedlings of peppers are usually transplanted when they have attained an average height of about 7.5 cm or when they are four to six weeks old in the nursery. They are also transplanted in the field at a spacing of 60 – 100 cm between rows and

30 – 60 cm between plants when intercropped or 45 – 60 cm within rows and 75 – 90cm apart in sole cropping, depending on the variety (Leong, 1995; NIHORT, 1998).

Capsicum frutescens fruits are usually harvested when they are red ripen or start to turn red. This is done once or twice in a week so as to allow enough time for ripening. Harvesting may continue for two months or more and the yield of fresh fruits range from 3.0 to 4.5 tonnes per hectare and 1.0 to 1.5 tonnes per hectare had been considered to be optimum and good enough for *C. annum* and *C frutescens* respectively (Aliyu and Kuchinda, 2002).

Norman (1977) had earlier studied the influence of the age of transplants of Chilli peppers that were planted at 5, 6, and 7 weeks after seed sowing in the nursery. He reported that 5-week and 6-week old transplants grew more quickly and yielded more than 7 weeks old plants. He further explained that flowering, fruiting and harvesting periods were delayed by late transplanting; however, he concluded that six weeks old pepper seedlings recorded highest total yield of fruits, while flowering, fruiting and maturity were delayed by transplanting. This observation was supported by the report of Ado (1999) that transplanting of six weeks old pepper seedlings recorded highest total yield of fruits. Flowering, fruiting and maturity were also delayed by transplanting after six weeks of sowing in the nursery. Bosland and Votava (2000) later recommended the use of six to eight-week old or 15 – 20 cm tall plants for transplanting. They also observed that stem diameter, which depend on the age of transplant was very important to survival rate of transplants with the thicker the ones exhibiting higher survival rate. Aliyu (2002) recommended that pepper seedlings of four to five weeks of age or 10 – 15 cm height with three true leaves, should be transplanted. These reports were however made under sole cropping conditions.

2.5 Scope and importance of intercropping system

Vandermeer (1989) described intercropping as the simultaneous growing of two or more crops on the same piece of land. Reported as the most common practice in Africa, Adejobi (1993) confirmed that more than 70 % of the food consumed in the humid tropics was being produced through intercropping. In Africa, small-scale farmers traditionally practice intercropping in order to achieve greater total land productivity and as an insurance against the failure or unpredictable market value of a single crop (Mustsaers *et al*., 1993).

Several studies carried out on intercropping of food crops with vegetables in Nigeria have established the fact that the system recorded higher and more stable crop yields compared to the respective sole crops (Ikeorgu *et al.*, 1989; Olasotan, 1988; Marchiol *et al*., 1992). The main thrust of the system is the efficient use of available resources by all the component crops. Such complementarities obviously explained most of the advantages derived from the intercropping system.

The advantages of intercropping were primarily due to the improvement in the use of resources which according to Willey (1979) could be both temporal and spatial relationship. The temporal advantage, he explained, resulted when the maturation of the associated crop is not the same. This consequently allows the combined crops to make use of growth resources available to them. On the other hand, the spatial factors such as improved light use resulted from better light interception, by the total canopy of the crops; especially when tall and short species of crops are combined or better water and nutrient absorption due to different rooting depths.

Godoy and Bennet (1991) highlighted some of the advantages and benefit associated with the practice of intercropping over the mono cropping system, which include maintenance of biodiversity, risk avoidance, nutrient recycling, effective weed management, alternative pest and diseases control, improvement of crop yield, soil conservation, among others.

Donald (1997) identified some factors that might determine the success or otherwise of intercropping. He highlighted such factors to include spacing, water availability, light intensity, duration of plant species, varying root system of component crops, labour availability, pests and diseases infestation, weed competition and suppressive ability of the component crops among others. The choice of crops to be intercropped also depend on the desire of the farmer and the compatibility of such crops in term of the growing habit of the crops, nutrient requirement of both crops as well as the rainfall regime of the area (IITA, 1984). Combination of crops in intercropping was primarily determined by the length of the growing season and the adaptation of crops to a particular environment. Usually, both early and slow maturity crops are combined to ensure efficient utilization of the growing season. Midmore (1993) reported that the relative timing of component crops would contribute greatly to the yield potentials of intercropped systems and that when crops were sown at different times the earliest sown crop has an earlier competitive advantage (Ofori and Stern, 1987).

Sebastiani (1981) reported that plants of different height would make more use of light when intercropped than in the mono-cropped system. This was feasible where the leaves of the taller plants are vertical as in cereals, and the leaves of the under storey plants are horizontal, to enhance the interception and use of the dim light as in the case of legumes and vegetables. Hence maize and pepper with quite different growth habit will judiciously utilized solar energy, when they are intercropped than in their mono-crop situation.

In addition to the technique of employing plant of different sizes, it is also possible to make a greater use of solar energy by planting crops that will make maximum use of sunlight at different times. Therefore, maize, a determinate crop, and pepper, an indeterminate crop, which keep on growing and producing fruit after maize had reach its senescence, were identified as compatible crops in intercropping.

Intercropping of compatible plants also encourage biodiversity by providing a habitat for a variety of insects and soil organisms that would not be present in a single crop environment. This biodiversity can in turn help to limit outbreak of crop pests by increasing the diversity or abundance of natural enemies such as spiders, and parasitic wasps (Altieri, 1994). Increasing the complexity of the crop environment through intercropping also limits the places where pest could find optimal foraging or reproductive condition, hence pests and diseases may not spread rapidly in mixtures because of differential susceptibility of the component crops to pests and disease pathogens.

Cook (1991) identified viral diseases as major constraints to successful production of peppers globally irrespective of the geographical location and the varieties of peppers. Maize and pepper intercrop was found to be a probable way of reducing the spread of this viral diseases in peppers(Cheng,1989); which was later confirmed by Fajimi (1997) who reported that intercropping of maize with pepper recorded higher degree of protection against viral diseases on pepper plant. According to the report this was made possible by the surface area of the leaves of the tall companion maize plants that provided good landing plate for the virus vector, aphids, which serves as a camouflage for the pepper plant since the viral diseases is host specific. It also showed little or no effect on the maize leaves.

Elemo *et al.* (1990) also observed that there was a better control of weeds, which was made possible by intercropping that provided a more competitive community of crop plants either in space or time than in sole cropping. When crops are carefully selected, other agronomic benefits are also achieved. Plants prone to lodging may be given structural support by their companion crop(s) and light sensitive plants may be given shade or protection, or otherwise wasted space can be utilized (Nazim *et al*., 2003)

Several researchers have reported greater total yield and income under intercropping than sole cropping. It was also reported that intercropping encouraged diversification, which reduced exposure of farmers to risks associated with sole cropping. Baker (1983) observed that when total yield ratio was considered, all intercropping treatments, at a given yield ratio produced more dry matter than those obtained from mono cropping at that yield ratio. Osiru (1983) also reported a greater stability of yields over different seasons, which was considered as one of the major reasons for the extreme importance of intercropping practice in developing countries since it offers the desired insurance against uncertainties of the sole cropping system (IITA, 1984).

Godoy and Benet (1991) reported that farmers obtained higher financial returns from intercropping than in mono-cropping system. To this end, Donald (1997) remarked that intercropping results in enhanced agricultural productivity in terms of yield for a given energy input per unit area, less destruction in terms of environmental impact and more profits in the long run than the modern mechanized, mono-cropped system. In particular, small farmers with limited resources are highly benefited from intercropping since there is a much lower probability of income falling below a disaster level in intercrops than an equivalent mono crop.

Intercropping can add temporal diversity through the sequential planting of different crops during the same season (Yancey, 1994). Though research shows that there are many advantages to growing two or more crops together, intercropping, there are also many disadvantages. The idea behind intercropping is to capitalize on the beneficial interactions between crops, while avoiding negative interactions. Practical challenges such as weeding and harvesting as well as decreased yields are reasons to careful evaluation of intercropping arrangements.

2.6 Estimation of productivity of intercropping system

One way to assess the benefits of growing two or more crops together or intercropping is to measure productivity using the Land Equivalent Ratio (LER). According to Vandermeer (1989) and Beets (1994) the most frequently basic tool that agricultural scientists employ to evaluate the effectiveness of intercropping or poly-culture is the Land Equivalent Ratio (LER). Land Equivalent Ratio explains how much land would be needed to produce as much in monoculture as is produced the same measure of land of mixed cropping. It quantifies the productivity benefits of growing two crops together. The biological productivity of the intercrops per unit of ground area is assessed as a ratio of inter crop to sole crop.

The equation is as given below:

$$LER = \frac{P_1}{M_1} + \frac{P_2}{M_2}$$

Where P_1 and P_2 are the yields of two different crops in mixtures and M_1 and M_2 are the yields of these crops in monocultures.

For each crop, a ratio is calculated to determine the relative yield for that crop and the relative yields of all component crops are summed to give the total LER for the intercrop. Yancey (1994) reported that the LER measures the levels of intercrop interference going on in the cropping system. A land equivalent ratio of 1.0 is critical and above this, intercrop is favoured and more efficient, but when the ratio is less than 1, monoculture is more efficient. This means that a total LER higher than this is an indication of the presence of positive interference among the component crops in mixture, and that any negative inter-specific interference that exists in the mixture is not as intensive as the intra-specific interference that exists in monoculture (Kurata, 1986).

Mazaheri and Oveysi (2004) explained that a LER of 1.2 for example indicates that the area planted in monoculture would need to be 20 percent greater than the area planted on intercrop for the two to produce the same combined yields. In the assessment of LER of two varieties of corn (*Zea mays* L.) intercropped at various nitrogen levels, Mazaheri *et al*. (2006) reported that intercropping combinations had significant effect on LER for grain yield and biological yield.

2.7 Maize Cultivation in Intercropping System

Globally, maize had also been identified as one of the most important cereal crop, providing nutrients for humans, animals and serving as a basic raw material for the production of starch, oil and alcoholic beverages, food sweeteners as well as fuelling. Maize has been the dominant cereal crop in the Southwestern part of Nigeria as well as in other parts of the country. The reasons for its popularity in traditional farming might be due to the relatively shorter growth period of maize compared to the root and tuber crops. Coupled with this is its ease of conversion to consumable products, which have wider range of uses in both human nutrition and livestock feeds than any other cereals. These have made it to be continually replacing the more traditional cereals like sorghum and millet (Ogunsunmi *et al*., 2005)

Alofe *et al.* (1998) had earlier confirmed the possibility of growing two crops of maize in a year (early or first season crop and late or second season crop) due to the bimodal rainfall pattern in the southern part of Nigeria; though, moisture stress and dry season negative effects on yields of maize had earlier been reported by Fakorede (1985).

In developing countries like Nigeria, about 50% of all the maize produced is consumed by humans as a direct food sources while 43% is for livestock feed and remainder for industrial and seed purposes (Balogun and Tanimola, 2001). It is therefore not surprising that about 561,397.29hectares of Nigerian land were planted with maize, which constitutes about 61% of total cultivable land in Nigeria (Ogunsunmi *et al.*, 2005). In traditional farming, intercropping of maize is as old as the known history of the crop itself and the cultivation of maize in combination with other crops is a widespread practice in the tropics.

Low and Weddington (1989) reported that in Africa, between 45 and 60% of the maize area cultivated by small farmers were grown with other species like legumes, okra, cassava, melon etc. A larger number of intercropping systems have also been devised by farmers which feature maize with other crops because of the relative importance of this crop in producing fodder for livestock, and grains which are the basis of number of foods, feeds, pharmaceutical and industrial products.

Increase in the utilization of maize in the West and Central Africa has brought about a reduction in spacing of this crop so as to increase the population of plants grown on a particular land area to produce higher grain yield (Jennifer, 1996). This report supported the earlier observations at IITA (1986) that grain yield of maize increased as plant population increased to an optimum number of plants per unit area; above which it declined, due to a reduction in the size and number of grains per ear. Higher productivity obtained in high plant densities resulted from the optimum use of available resources like moisture, carbon dioxide and nutrients. This development brought about the recommended maize population of 53,333 plants per hectare, obtainable by planting at a spacing of 75 x 50 cm of two plants per stand or 75 x 25 cm at one plant per stand (IITA, 1986; Alofe *et al.*, 1998; FAO, 2000). Alofe *et al.* (1998) also recorded non-significant yield difference when maize was grown at this recommended spacing either at one or two plants per stand. This resulted into an average grain yield of 1 to 2 tones per hectare in West African countries which was reported to be far below the 4.3 tones per hectare of world average (CIMMYT, 2001).

In intercropping system, it had been reported that sowing of crops in the normally recommended uniform row distance would afford little or no opportunity for accommodating a companion crop (IITA, 1982). For instance, intercropping of maize with other crops would necessitate planting the crop in widely-spaced rows to give intercropped plants a chance to compete for minerals, water and sunlight (Alofe *et al.*, 1986). Farmers also prefer wider within row or between row spacing because planting and management appeared to be less tedious than at closer spacing. Hence, in most black African countries, maize is still hand-planted at very wide spacing with two or three stands per hill and the reasons for this method of planting maize are not far fetched. In the first instance, the farmers usually intercrop maize with other crops like melon, beans, okra and peppers. The CIDA-CRI project also recommended intercropping of maize at low population of about 31,000 plants per hectare with cassava at 120cm by 80cm spacing (Lafitte, 1987).

Cruz and Sinoquet (1994) supported this view that much of maize in west Africa was grown under low density in mixed stands with one or more associated crop, including cassava, sorghum, pumpkin, yam, cowpea etc. though, it has lower maize yield but it helped the farmers to increase the overall productivity of the resources invested in agriculture and reduced losses, if any of the crop failed.

Balogun and Tanimola (2001) reported benefits associated with planting of maize at wider spacing in which a compensatory production was recorded from maize plants which had more space and other growth necessities to themselves and apparently led to higher production of cobs and grains per individual plants in low density plots of maize. According to Alabi and Onolemhemben, (2001) the common system in Africa, is the random mixture where there is no definite stand geometry. In this system, planting is fully at the discretion of the farmer without recourse to standard or recommended spacing for the various crops. This may not allow farmers to enjoy intercropping advantages.

Edmeades (1990) reported that the land equivalent ratio obtained in maize-cowpea intercrop was as high as 1:5 and higher yields were obtained from maize densities of 25,000 to 40,000 plants per hectare and cowpea densities of 40,000 to 60,000 plants per hectare; with both crops sown at the same time. Ogunbodede and Olakojo (2001) also reported that farmers were found to grow maize in wider spacing and low density of about 30,000 plants or less, as against the recommended 53,333 plants per hectare; this was to allow intercropped plants a chance of competing favourably for water, minerals and sunlight and to allow easy movement in the performance of management operations such as weeding.

2.8 Pepper cultivation in traditional farming

According to Adeniyi (2001) horticultural crops (Vegetables and Spices) are generally cultivated by most farmers as minor crops which could be inter-planted with major root and cereal crops in their farms. Chillies in particular, are well adapted to both sole cropping and intercropping systems of agriculture and are often relay – cropped with tomatoes, Onions, garlic, okra, brassica species and pulses as well as among newly established perennial crops such as oil palm and annuals such as maize.

Ado (1988) had earlier stated that pepper production was limited to peasant farmers who grow them in mixtures with either cereal crops or vegetables but scantly as sole crops. This report was supported by the reports of Kapeller (1994); Olarenwaju and Sowemimo (2003), that peppers were usually grown in mixtures with other crops in Nigeria, except in parts of Kaduna and Kano states where they are cultivated sole purposely for export to southern part of the country and Nigeria's neighbouring countries. However, many of the farmers in the southern part of Nigeria traditionally interplant peppers with other crops especially cassava and maize, which occupy more than 80% of the arable land in the zone. Shaib *et al.* (1997) related this characteristic mixed cropping of arable crops in the South-Western zone of Nigeria to the effects of rapid population growth in the country which is putting a lot of pressure on scarce land resources.

Norman (1992) attributed the fitness of chillies into intercropping to their ability to live longer than other staple crops and the shorter size that are not densely leafy which allow other crops to be grown between them without much interference with their production. Young plants of peppers also grow better under partial shade or natural light shade of other crops like yam, maize, and sorghum and usually live long enough to be well suited to intercropping without much interference with the growth and yield of the crops (Cenpukdee and Fuka, 1992).

Squire (1990) observed that the mixed canopy of cereal–pepper intercrop used solar energy much more efficiently than sole pepper and sometimes, slightly more than cereals. This was supported by Midmore (1990) that there was an improved total interception of radiation where taller species of crop were intercropped with pepper, especially where a C_4 crop (maize), with special photosynthetic adaptation to the tropics was planted. A more efficient use of high instantaneous receipts of solar radiation by maize was evident over the under-storey intercrop pepper. There were also the benefits of a wind break effect, reduced evapo-transpiration and disruption of aphids alignment and spread of virus. However, the magnitude of such advantages would depend upon the relative planting or sowing times, densities of component crops and the spatial distributions of the companion crops in the intercrops (Midmore *et al.*, 1995).

Intercropped peppers were also reported to have produced flowers late compared to sole plants (Osiru and Willy, 1972) and the fruit set of intercropped peppers, both during and after intercropped period, was reduced compared to sole crops. In essence, yields of pepper fruits were always reduced in intercrops but there was no evidence of significant reduction of maize yields when intercropped with peppers (Midmore *et al.*, 1995).

Denton and Makinde (1993) also reported that maize yields in inter crop on farmers' fields exhibited a reduction of about 20 – 35 % compared to sole maize. This reduction they observed was as a result of low competitive nature of the pepper plant which resulted in shorter height, reduced number of branches and consequently low fruit yield of about 0.5 – 0.8 tons/ha; especially from the landraces cultivated by farmers in mixed cropping systems.

Further investigation by Fajimi (1997) revealed that there was an increase in the number of branches per plant and significant higher values of plant height in intercrop pepper and maize plants to their sole counterparts, respectively; this consequently contributed to the increase in the yield of peppers within maize. Generally, intercropping maize and pepper had been shown to result in Land Equivalent Ratios greater than the sole crops of either (Ado, 1999).

Rapid population growth rate in Nigeria is putting a lot of pressure on scarce agricultural land resources, especially in southwestern states and this continues to reduce the area available for arable land occupied by maize and cassava which are important staple foods of most people in this zone (Shaib *et al.*, 1997). Apart from this problem, few farmers, especially in Africa, practiced sole cropping in spite of the focus on research and extension services. These subsistence farmers that produce nearly the entire food crops in Nigeria, have not been eager to adopt sole cropping; which might be because of its requirement of large quantities of inputs (e.g. fertilizers), risk of weather, crop failure, unstable market prices, labour constraint, family financial and dietary needs, among other problems, as identified by Sabirin and Hamdam, (2000).

Pepper is well fitted into many cropping system in Nigeria; and may bring in needed cash during periods when other staples cannot be grown, however, farmers grow it under the traditional mixed cropping system without considering their adaptability to the system and their economic suitability. In order to reduce farmers' problems and meet their needs and priorities more effectively, research should emphasize on the prevailing cropping system in this southwestern zone; with respect to pepper and maize cultivation since agronomic recommendation for intercropping of peppers with other food crops like maize, cassava and yam are at present, scanty.

CHAPTER 3

MATERIALS AND METHODS

3.1 Description of the Experimental Sites

The two sites used for the study were located at the experimental plots of the Federal College of Agriculture, Institute of Agricultural Research and Training, Moor Plantation, Ibadan (Latitude 7^0 22.5`N and Longitude $3^0$ 55`E) in the dry forest vegetation of Nigeria where tender trees predominate over other life forms, both in terms of species composition and the abundance of each species. The trees are closely spaced with the crowns of many of them touching, thereby forming a more or less continuous canopy over the forest interior. Other woody species such as the shrubs, herbs and climber are also present (Fatubarin, 1993). The location has two distinct seasons, the wet (April to September) and dry (October to March), with a bimodal rainfall pattern which has the peaks in July and September. The mean annual rainfall of the location is 1,400 mm while the mean monthly temperature is 25 ^{0}C. It is also characterized by high relative humidity with the mean monthly relative humidity of not less than 70 % (IAR&T, 2004). Monthly rainfall pattern and mean temperature of IAR&T, the location of the experiment for 2007 and 2008 are presented in Table 3.1.

The mean monthly temperature ranged between 23 and 28 ^{0}C in both years, while the total rainfall was 1,465.4 and 1,526 mm in year 2007 and 2008, respectively. The total rainfall in August and September, growth period of the crops was found to be higher in 2008 (551.5 mm) than in 2007 (267.9 mm). Rainfall also commenced earlier in 2008, with a total of 168.7 mm for period of January – March, compared to 144.2 mm in 2007 for the same period (Table 2). Conversely, the rainfall stopped earlier in 2008 with a total of 13.4 mm in November and December compared to 39.3 mm in 2007.

USDASoil Survey Staff (1975) classified the soil of the experimental plots as *Alfisols*, which was described as being soils of basement complex rocks under dry forest vegetation. The soil is typically deep and has finer surface layer (sandy loam) over heavier sandy clay loam or sandy clay. A layer of quartz below surface and / or iron concretions is always found below the surface soil. The soil contains moderate levels of nutrients and is sometimes described as ferriginous soil. It is permeable and friable because of the good structure; thereby reducing the risk of erosion (FPDD, 2012).

Table 3.1: Monthly rainfall and mean temperature of IAR&T, Moor Plantation, Ibadan, in 2007 and 2008

Month	Rainfall (mm)		Mean temperature (^{0}C)	
	2007	2008	2007	2008
January	0.0	19.7	25.1	27.2
February	69.8	21.6	28.3	28.5
March	74.4	127.4	27.6	26.9
April	145.8	114.0	27.4	7.5
May	203.3	91.6	25.7	25.9
June	285.1	210.9	24.8	25.1
July	209.7	169.8	23.7	24.6
August	60.4	176.0	22.9	23.7
September	207.5	375.5	24.7	23.8
October	170.1	206.1	25.4	25.3
November	37.1	13.4	26.9	25.4
December	2.2	0.0	27.1	25.8
Total	1,465.4	1,526.0		

The experimental plots used in 2007 had previously been cropped with cassava-maize intercrop in early wet season of 2006, while the plots of land used for Experiment II (2008) was planted into sole maize in the early season of the same year, which was harvested fresh in early July before land preparation for the experiment.

3.2 Methodology

The two field experiments were conducted at the separate sites in the late wet season of 2007 and 2008 between August and December. The two long Cayenne pepper cultivars of chillies used for the study in both years were NHV-1A (Bawa) and Sombo. The NHV-1A cultivar was one of the popular early maturing and high yielding NIHORT *Capsicum frutescence* line. It has been described as being relatively tolerant to viral, bacterial, fungi and nematode diseases. It is an annual erect plant with considerable branches. The leaves are simple, dark green and are alternatively arranged. The flower is white and solitary, while the fruits are long, pendulous, smoother, glossier and bigger in size, but tapper to the base than those of Sombo. The fruits of NHV-1A are brick-red when fully ripe and its calyx is dome-shaped or flat at the point of attachment to the fruit. Sombo is a local cayenne pepper or red pepper cultivar grown and marketed in Ibadan environment. The fruits of Sombo are slimmer, longer and more wrinkled and elongated than those of NHV-1A. Both varieties of pepper adapt to various agro-ecologies in Nigeria.

The seed of the maize variety used for this experiment is an open pollinated early maturing composite (DMR-EM-Y), with resistance to downy mildew and maize streak virus diseases. The seed was obtained from IAR&T Seed Store. The variety has also been recommended for cultivation during the late wet season in both Savannah and forest agro-ecological zones of Nigeria (FPDD, 2002). Both experiments were laid out in a randomized complete block design with three replicates. Each plot size in the experiments was 4.5 x 3.0 m (13.5 m^2).

The experimental plot was ploughed and harrowed after which composite soil sample was taken for physical and chemical analysis. The results of laboratory analysis of the pre-cropping soil samples at the two sites in both years (2007 and 2008) are presented in Table 3.2. Results of the laboratory analysis of the soil samples from the experimental sites used in 2007 and 2008 respectively (Table 3.2) revealed that the soils were low in nitrogen (0.07 and 0.09 %) and organic matter (1.17 and 1.69 %). The phosphorus values (3.6 and 6.4 mg kg^{-1}) were also low while the potassium values (0.49 and 0.93 cmol mg^{-1}) were moderately high according to the soil fertility rating classes of FPDD (2002). Therefore, fertilizer was applied to maize at 120 kg N, 60 kg P_2O_5 and 60 kg K_2O per hectare with the use of NPK 15:15:15 for 60 kg ha^{-1} N_2, P_2O_5 and K_2O and urea for 60 kg N ha^{-1} at 2 and 5 WAP, respectively. The rates of fertilizers applied to peppers were 52 kg N, 45 kg P_2O_5 and 30 kg K_2O using NPK 15:15:15, urea and SSP as materials at 2 weeks and 6 weeks after transplanting (FPDD, 2002). The fertilizer materials were compounded and applied as side placement to each stand.

Table 3.2: Chemical and physical properties of pre-cropping soil samples of the experimental sites in 2007 and 2008

Parameters	2007	2008
pH (H_2O)	5.30	6.10
Organic matter (%)	1.17	1.69
Nitrogen (%)	0.07	0.09
Available P (mg/kg)	3.60	6.40
Exchangeable bases (cmol/kg)		
Ca	0.84	1.20
Mg	0.46	0.88
K	0.46	0.93
Na	0.25	0.24
Cation exchange capacity (CEC)	2.12	3.25
Mechanical analysis (%)		
Sand	78.0	72.0
Silt	14.0	11.0
Clay	8.0	17.0
Textural class	Sandy loam	Sandy loam

3.2.1 Experiment 1: Growth and yield of two varieties of chillies (*Capsicum frutescens*) intercropped with maize at different population

In the field experiment conducted in late wet season of 2007, the two cultivars of *Capsicum frutescens* (NHV-1A and Sombo) were intercropped with three population densities of maize as indicated below:

i. NHV-1A intercropped with maize of 26, 667 plants/ha.
ii. NHV-1A intercropped with maize of 35,556 plants/ha.
iii. NHV-1A intercropped with maize of 53, 333 plants/ha.
iv. Sombo intercropped with maize of 26,667 plants/ha.
v. Sombo intercropped with maize of 35, 556 plants/ha.
vi. Sombo intercropped with maize of 53,333 plants/ha.
vii. Sole Crop of NHV-1A.
viii. Sole Crop of Sombo.
ix. Sole Crop of maize planted at 53,333 plants/ha.

Seeds of the two varieties of peppers were first sown in the nursery, four weeks before planting of maize seeds, to produce six-week old seedlings of that were transplanted equidistant into inter-rows of maize seedlings at two weeks after planting (WAP) maize, as it is practiced by farmers in southwestern Nigeria (Appendix 1).

The experimental plot was ploughed and harrowed at 2-week interval after which a pre-planting composite soil sample was taken for laboratory analysis. Three seeds of maize were sown on 75 cm wide rows at three intra-row spacing 100 cm, 75 cm and 50 cm. Plants were later thinned to two per stand to obtain the required population densities of 26,667, 35,556 and 53,333 plants/ha. The sole maize was however planted at a spacing of 75 x 25 cm and seeding rate of 2, which were thinned to 1 to obtain a population of 53,333 plants/ha.

Weeding commenced at 3 WAP and continued every three weeks. Karate was used at the rate of 5 ml per liter of water to spray pepper plants at 3 and 6 WAT to control insect pests.

Data collection commenced at two and four weeks after planting of maize seeds and transplanting of pepper seedlings, respectively. Five plants of both maize and pepper were randomly tagged per plot for data collection on number of leaves per plant, which was determined by counting the functional leaves, plant height (cm), which was measured with a meter rule from the ground level to the end of the stem and stem diameter (cm) measured with vernier calipers at 5 cm from ground level in both crops. The leaf area of maize was determined from tagged leaves in sample plant by non-destructive length x width method described by Saxena and Singh (1985) using the relation: leaf area = 0.75 (length x width) where 0.75 is a constant. Other parameters taken on pepper plants were number of flowers per plant at 50% flowering and number of branches, which were determined by counting. Yield parameters taken on maize included number of grains per cob, which was determined by counting grain yield per plant (g), which was weighed with sensitive electronic scale, while grain yield per hectare was calculated by multiplying grain yield per plant with the respective plant population. Data collected on yield parameters of pepper included number and weight of fresh fruit per plant and per plot, which was taken after each harvest by counting and weighing with sensitive electronic scale respectively. The cumulative weight was calculated as total harvest. Fresh fruit yield per hectare was determined by extrapolating the yield per plot to its equivalent hectare in tonnes. Data were subjected to analysis of variance and means separated using Duncan's Multiple Range Test. Land Equivalent Ratio (LER) was used to measure the relative yield of the intercrops to determine the biological productivity of the intercropping system as described by Willey (1979):

$$\text{LER} = \frac{\text{Intercrop yield of maize } (P_1)}{\text{Sole yield of maize } (M_1)} + \frac{\text{Intercrop yield of pepper } (P_2)}{\text{Sole yield of pepper } (M_2)}$$

3.2.2 Experiment II: Growth and yield responses of two varieties of chillies (*Capsicum frutescens*) to different transplanting ages when intercropped with maize

The field experiment was conducted during the late wet season of 2008. Thirteen treatments of ten intercrops of two varieties of chilli peppers, NHV-1A and Sombo were evaluated at five transplanting ages of 3, 4, 5, 6 and 7 weeks after sowing in intercrop with constant maize population (26,667 plants/ha) were compared with two varieties of six weeks old pepper transplants and sole maize at 53,333 plants/ha as shown below:

i. 3-week old NHV-1A seedlings of intercropped with maize
ii. 4-week old NHV-1A seedlings of intercropped with maize
iii. 5-week old NHV-1A seedlings of intercropped with maize
iv. 6-week old NHV-1A seedlings of intercropped with maize
v. 7-week old NHV-1A seedlings of intercropped with maize
vi. 3-week old Sombo seedlings of intercropped with maize
vii. 4-week old Sombo seedlings of intercropped with maize
viii. 5-week old Sombo seedlings of intercropped with maize
ix. 6-week old Sombo seedlings of intercropped with maize
x. 7-week old Sombo seedlings of intercropped with maize
xi. 6-week old Sole crop NHV-1A
xii. 6-week old Sole crop Sombo
xiii. Sole crop of maize

Seeds of the two pepper varieties were first sown on nursery beds at 5, 4, 3, 2 and 1 weeks before sowing of maize and the seedlings transplanted at 2 WAP at pepper seedling age of 7, 6, 5, 4 and 3 weeks. The seedlings of peppers were transplanted at inter-row spacing of 50 cm as intercrop in the inter-row at equidistance from 75 cm wide maize rows.

Maize seeds of the intercrop were sown at intra-row spacing of 100 cm and thinned to two plants per stand giving a population of 26,667 plants per hectare. The selected intra-row spacing of maize crop was a follow-up to the result obtained from the first field experiment. However, sole maize was planted at the recommended intra-row spacing of 25 cm and 75 cm inter-row with one plant per stand to obtain 53,333 plants per hectare (Ogunbodede and Olakojo, 2001). Management operations were carried out as reported for Experiment 1.

Five plants were randomly sampled from each plot for both maize and pepper for data collection. Growth parameters were recorded in maize at 4, 6 and 8 weeks after sowing and in pepper at 4 and 6 weeks after transplanting, while yield parameters were taken at harvest. Data were collected on the growth and yields of maize and pepper using five-tagged plants each per plot. The parameters recorded for each of the crops were as follows:

Maize	Peppers
Plant height (cm)	Plant stand establishment (%)
Number of leaves	Plant height (cm)
Stem diameter (cm)	Stem diameter (cm)
Leaf area (cm^2)	Number of leaves/plant
Cob weight/plant	Number of branches/plant
Grain weight/plant	Fresh fruit weight/plant (g)
Grain weight/ha	Fresh fruit yield (ton)

All parameters were taken as described in Experiment I. However, the plant stand establishment was counted per plot at 2 WAT and the percentage calculated.

Data were subjected to analysis of variance and means were separated with Duncan's Multiple Range Test. The biological productivity of the Intercrops per unit of land area was also assessed as a ratio of intercrop to sole crop using the Land Equivalent Ratio (Willey, 1979).

CHAPTER 4

RESULTS

Experiment 1: Growth and yield of two varieties of chillies (*Capsicum frutescens*) intercropped with maize at different population densities

4.3 Effects of maize population densities and pepper varieties on the growth of maize

4.3.1 Plant height

Cropping pattern significantly affected the height of maize plant at 4, 6 and 8 weeks after planting (WAP) as shown in Table 4.1. Maximum height was produced by maize planted at 26,667 plants/ha intercropped with NHV-1A variety of pepper at 4 WAP and that at 53,333 plants/ha intercropped with Sombo at 6 and 8 WAP. Sole maize at 53,333 plants/ha was significantly shorter than the intercropped maize at 53,333 plants/ha intercropped with Sombo at 6 and 8 WAP. In all the cropping patterns, maize height increased over time to maximum at 8 WAP.

4.3.2 Stem diameter

Stem diameter of maize was significantly affected by cropping pattern at 6 and 8 WAP. Sole maize had smaller stem diameter than intercropped maize grown at 35,556 and 26,667 plants/ha and 26,667 plants/ha intercropped with Sombo at 6 WAP as well as with NHV-1A at 26,667 plants/ha with Sombo in both cases and with NHV-1A at 8 WAP (Table 4.1). The stem diameter of sole maize at 53,333 plants/ha and intercropped maize at 35,556 and 53,333 plants/ha were not significantly different at 8 WAP irrespective of the component pepper variety (Table 4.1).

4.3.3 Number of leaves

Cropping pattern did not significantly affect on the number of leaves per plant of maize at 4, 6 and 8 WAP although obvious differences among the populations of maize plant were observed (Table 4.2). However, maize at highest population of 53,333 plants/ha intercropped with Sombo produced the highest number of leaves per plant (11) at 8 WAP in this trial (Table 4.2).

4.3.4 Leaf area

The leaf areas of maize plants at 4, 6 and 8 WAP were significantly affected by the cropping pattern (Table 4.2). Maize at 53,333 plants/ha intercropped with NHV-1A had maximum value of 276.1 cm^2 at 4 WAP, while plants at 26,667 plants/ha intercropped with the same pepper variety had the maximum values of 374.9 and 420.5 cm^2 at 6 and 8 WAP, respectively.

Table 4.1: Effects of population and intercropping with pepper varieties on plant height and stem diameter of maize in 2007

Treatment	Plant height (cm)			Stem diameter (cm)		
	------------ WAP[1] ------------			----------- WAP -----------		
	4	6	8	4	6	8
Maize (53,333 plants/ha) sole crop	29.4b[2]	64.3b	93.1b	1.90	2.01b	2.36b
Maize (53,333 plants/ha) with NHV-1A	39.6ab	71.3ab	128.8ab	2.13	2.48a	2.51ab
Maize (35,556 plants/ha) with NHV-1A	37.0ab	64.5b	118.4ab	2.10	2.42a	2.45ab
Maize (26,667 plants/ha) with NHV-1A	44.8a	72.8ab	124.1ab	2.10	2.32ab	2.51a
Maize (53,333 plants/ha) with Sombo	32.6ab	79.0a	136.5a	1.90	2.29ab	2.48ab
Maize (35,556 plants/ha) with Sombo	32.7ab	68.3ab	118.2ab	1.94	2.32ab	2.42ab
Maize (26,667 plants /ha) with Sombo	36.4ab	70.3ab	130.0ab	2.01	2.58a	2.61a
SE ±	7.50	15.07	23.90	0.13 ns[3]	0.18	0.13

1. WAP= Weeks after planting
2. Means with the same letter(s) in the column are not significantly different (P < 0.05) using Duncan's Multiple Range Test
3. ns = no significant difference

Table 4.2: Effects of population and intercropping with pepper varieties on leaf attributes of maize in 2007

Treatment	No. of leaves			Leaf area (cm^2)		
	------------ WAP[1]------------			------------ WAP------------		
	4	6	8	4	6	8
Maize (53,333 plants/ha) sole crop	5	7	9	176.1c[3]	303.8c	311.5c
Maize (53,333 plants/ha) with NHV-1A	6	8	10	276.1a	332.4b	381.0ab
Maize (35,556 plants/ha) with NHV-1A	6	7	9	234.9b	315.9bc	363.5b
Maize (26,667 plants/ha) with NHV-1A	7	7	10	261.8ab	374.9a	420.5a
Maize (53,333 plants/ha) with Sombo	6	8	11	262.1ab	334.1b	359.5b
Maize (35,556 plants/ha) with Sombo	5	8	9	176.1c	317.0bc	371.4ab
Maize (26,667 plants /ha) with Sombo	6	8	10	229.1b	372.4a	385.2ab
SE ±	0.63	0.51	0.73	50.53	67.49	57.78
	ns[2]	ns	Ns			

1. WAP= Weeks after planting
2. ns = no significant difference
3. Means with the same letter(s) in the column are not significantly different (P < 0.05) using Duncan's Multiple Range Test

Maize population at 26,667 plants/ha intercropped with NHV-1A and 53,333 plants/ha with Sombo at 4 WAS, at 26,667 plants/ha with Sombo at 6 WAP as well as at 53,333 plants/ha with NHV-1A and at 35,556 and 26,667 plants/ha both with Sombo at 8 WAP produced leaf areas comparable to their maxima (Table 4.2). The lowest value of leaf area was recorded in the sole maize plants throughout the period of growth considered i.e. 4, 6 and 8 WAP (176.1, 308.8 and 311.5 cm^2, respectively)

4.4 Effects of intercropped maize population on the growth of peppers varieties

4.4.1 Plant height

Intercropping with maize did not have significant effect on height of the two varieties of peppers at 6 and 8 WAT although maize intercropped at the three population densities resulted in taller plants of the two varieties of pepper compared with their respective sole crops (Table 4.3). Furthermore, the height of Sombo intercropped with maize increased at 8 WAT.

4.4.2 Stem diameter

Intercropping with maize had significant effect on stem diameter of the two varieties of pepper at 6 and 8 WAT (Table 4.3). Intercropped maize at 35,556 and 53,333 plants/ha at 6 WAT and at 53,333 plants/ha at 8 WAT resulted in smaller stem diameters of the two varieties of pepper compared with 0.41 and 0.43 cm for sole crops of NHV-1A and Sombo respectively at 8 WAT. Also, the two varieties of pepper recorded lowest values of stem diameters (0.21 and 0.20 cm) for NHV-1A and Sombo at 8WAT when intercropped with the highest maize population of 53,333 plants per hectare (Table 4.3).

4.4.3 Number of leaves

There was no significant difference between the number of leaves per plant of the sole crop of the two varieties of peppers and those intercropped at 26,667 plants/ha at 6WAT (Table 4.3).

Table 4.3: Effect of intercropped maize population on growth attributes of pepper in 2007

Treatment	Plant height (cm)		Stem diameter (cm)		number of leaves per plant		number of branches per plant	
	------- WAT[1] -------		------- WAT -------		------- WAT -------		------- WAT -------	
	6	8	6	8	6	8	6	8
NHV-1A intercropped with 53,333 maize plants/ ha	32.43	38.80	0.20b[3]	0.21b	31c	46c	2b	6b
NHV-1A intercropped with 35,556 maize plants/ha	31.81	38.31	0.20b	0.33a	35c	51c	4ab	6b
NHV-1A intercropped with 26,667 maize plants/ ha	32.80	38.20	0.30a	0.35a	52ab	68b	5ab	8ab
NHV-1A sole crop	30.62	36.30	0.33a	0.41a	49b	99a	6a	12a
Sombo intercropped with 53,333 maize plants/ha	24.00	38.20	0.13c	0.20b	33c	51c	2b	2c
Sombo intercropped with 35,556 maize plants/ha	30.00	36.20	0.21b	0.33a	45b	65b	5ab	7b
Sombo intercropped with 26,667 maize plants/ha	28.50	33.70	0.30a	0.35a	54ab	72b	5ab	8ab
Sombo sole crop	25.50	32.00	0.32a	0.43a	63a	89a	6a	9ab
SE ±	2.86 ns[2]	3.14 Ns	0.01	0.07	9.41	21.57	2.44	1.79

1. WAT = Weeks After transplanting
2. ns = not significant at 5% level
3. Means with the same letter(s) in the column are not significantly different (P < 0.05) using Duncan's Multiple Range Test (DMRT)

At this stage of growth, sole Sombo and those intercropped with maize at 35,556 plants/ha had significantly more leaves than the corresponding NHV-1A plants. However, at 8 WAT, sole crops of both varieties of peppers produced the highest number of leaves/plant (99 and 89 for NHV-1A and Sombo, respectively) than all their intercrops with maize at the three population densities. The number of leaves per plant of the two pepper varieties decreased with intercropped maize population at 8 WAT. The lowest number of leaves per plant (46 and 51 for NHV-1A and Sombo respectively) were also produced by pepper intercropped with maize at 53,333 plants/ha.

4.4.4 Number of branches

Maximum number of branches was produced by sole crops of NHV-1A and Sombo. Sole crops of both varieties of pepper produced significantly higher number of branches per plant than those intercropped with maize population of 53,333 plants/ha at 6 and 8 WAT as well as at 35,556 plants/ha at 8 WAT for NHV-1A (Table 4.3).

4.4.5 Number of flowers per plant

The production of flowers followed similar trends with the fruiting in the two varieties of pepper with respect to the sole crops and respective intercrops. Though there was a sharp rise in the number of fruits produced at 10 WAT relative to the number of flowers that were recorded at 7 WAT. Sombo produced more flowers and fruited earlier than NHV-1A (Figure 1). Except when intercropped with maize at 35,556 plants/ha, Sombo produced significantly more flowers than NHV-1A at 50% flowering (Figure 1). Furthermore, sole crops of NHV-1A and Sombo produced significantly higher mean number of flowers per plant (6.6 and 9.8, respectively) than the respective values of 2.8 and 1.4 for the corresponding intercropped with maize at 53,333 plants/ha (Figure 1).

4.4.6 Number of fruits/plant

The average number of pepper fruits per plant at 10 WAT was significantly affected by cropping pattern in the two varieties of pepper (Figure 1). Although, the sole crops of the two pepper varieties produced significantly higher number of fruits than their intercropped plants, irrespective of maize population under which they were grown, the highest number was produced by sole crop Sombo (25.0). Furthermore, the maximum number of fruits produced for sole crop of NHV-1A (16.6) was higher than those of its own intercrop at the three maize densities and comparable to those produced by Sombo intercropped with maize at 26,667 and 35,556 plants/ha (Figure 1).

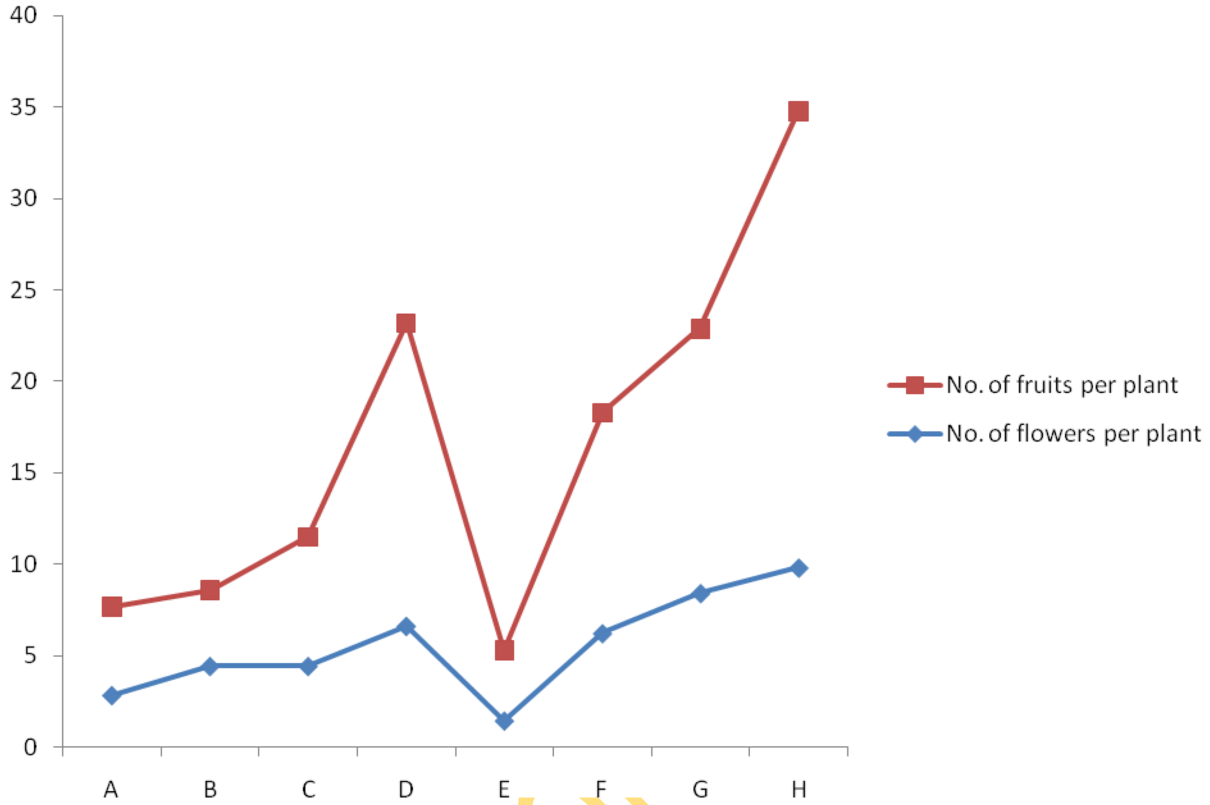

Figure 1: Effect of intercropped maize population on number of flowers at 7 WAT (50 % flowering) and fruits per pepper plant at 10 WAT[1] in 2007

Treatment

A NHV-1A intercropped with 53,333 maize plants/ ha
B NHV-1A intercropped with 35,556 maize plants/ha
C NHV-1A intercropped with 26,667 maize plants/ ha
D NHV-1A sole crop
E Sombo intercropped with 53,333 maize plants/ha
F Sombo intercropped with 35,556 maize plants/ha
G Sombo intercropped with 26,667 maize plants/ha
H Sombo sole crop

4.3 Effects of maize population and intercropping with two pepper varieties on the yield and yield components of maize

Number of maize grains and 100 g weight were not significantly affected by the cropping patterns in this trial (Table 4.4). However, maximum number of grains per cob (395) and 100-grain weight (39.2 g) were produced by maize intercropped with pepper variety Sombo at the lowest population of 26,667 plants/ha. The maximum grain yield per plant produced by intercropped maize at a population of 26,667 plants/ha each with NHV-1A and Sombo varieties of pepper (83.9 or 82.8 g, respectively), were significantly higher (67.7 g) than that of the sole maize. Grain yield was significantly higher in intercropped maize (4.28 and 4.24 t./ha for NHV-1A and Sombo respectively) at 53,333 plants/ha compared to the sole crop and the intercrop at lower populations of 26,667 and 35,556 plants/ha (Table 4.4).

4.4 Effects of maize population densities on the fresh fruit yield of peppers

The sole crop of NHV-1A variety of pepper produced the highest first and second cycle harvests (247.7 and 194.4 g/plant respectively) and cumulative fresh fruit weight per plant (442.1g). Although lower than that of sole NHV-1A, the sole crop of Sombo variety (254.9g) and that intercropped with maize of 26,667 plants/ha also produced similar fruit weight (259.5 g/plant) than that were significantly higher than those of other intercropped peppers at 53,333 plants/ha of maize in both varieties (Table 4.5). The lowest fruit weight per plant (135.8 g) was produced by Sombo plants intercropped with maize at 53,333 plants/ha. As observed with fruit weight/plant, sole crop of NHV-1A variety also produced the highest first cycle harvest (1245 kg/ha), cumulative (1944 kg/ha) fresh fruit yield, while Sombo intercropped with maize at 26,667 plants/ha produced the highest second cycle harvest (762 kg/ha). Furthermore, NHV-1A intercropped with highest maize population in this study (53,333 plants/ha) produced significantly lower fruit yield than the two varieties intercropped with lower maize densities of 26,667 and 35,556 plants/ha, which were similar (Table 4.5).

Table 4.4: Effects of population and intercropping with pepper varieties on the grain yield of maize in 2007

Treatment	Number of grains per cob	Weight of 100 grains (g)	Grain weight per plant (g)	Grain yield per hectare (t/ha)
Maize of 53,333 plants/ha. sole crop	308	36.2	67.7b[2]	3.61b
Maize of 53,333 plants/ha with NHV-1A	322	38.5	80.2a	4.28a
Maize of 35,556 plants/ha with NHV-1A	336	38.1	75.5ab	2.69bc
Maize of 26,667 plants/ha. with NHV-1A	367	38.2	83.9a	2.24c
Maize of 53,333 plants/ha with Sombo	354	38.2	79.5a	4.24a
Maize of 35,556 plants/ha with Sombo	305	36.4	74.3ab	2.64bc
Maize of 26,667 plants /ha with Sombo	395	39.2	82.8a	2.21c
SE ±	37.17 ns[1]	4.73 ns	16.39	0.64

1. ns = no significant difference ($P < 0.05$)
2. Means with the same letters in the column are not significantly different using Duncan's Multiple Range Test

Table 4.5: Effect of intercropped maize population on the cumulative fresh fruits yield of chilli peppers in 2007

Treatment	per plant (g)			per hectare		
	1st fruiting cycle	2nd fruiting cycle	Total harvest	1st fruiting cycle (kg)	2nd fruiting cycle (kg)	Total harvest (kg)
NHV-1A intercropped with 53,333 maize plants/ ha	98.8c[1]	118.4d	217.2c	305d	131f	436d
NHV-1A intercropped with 35,556 maize plants/ha	77.5cd	175.0a	252.5b	384cd	281e	665c
NHV-1A intercropped with 26,667 maize plants/ ha	97.8c	157.7bc	255.5b	468c	460d	928c
NHV-1A sole crop	247.7a	194.4a	442.1a	1245a	699a	1944a
Sombo intercropped with 53,333 maize plants/ha	27.7e	108.1d	135.8d	166e	536c	702c
Sombo intercropped with 35,556 maize plants/ha	58.6d	161.6b	220.2c	243d	594bc	837c
Sombo intercropped with 26,667 maize plants/ha	66.9d	192.6a	259.5b	425c	762a	1188b
Sombo sole crop	144.0b	110.9d	254.9b	717b	603b	1320b
SE ±	10.75	39.01	70.81	56.82	145.87	215.54

1. Means with the same letter(s) in the column are not significantly different ($P < 0.05$) using Duncan's Multiple Range Test

4.5 Relative yields of maize and pepper and their land equivalent ratios

The relative yield of intercropped maize was higher at 53,333 plants/ha with NHV-1A (119%) and Sombo (118%) than at 26,667 plants/ha (61%) and 35,556 plants/ha (73%) with Sombo (Figure 2). The relative yields of intercropped peppers however decreased with increasing maize populations. The NHV-1A was more severely affected by intercropping than Sombo as reflected in the relative yields. The respective relative yields for pepper intercropped with maize populations at 26,667, 35,556 and 53,333 plants/ha were 90%, 64% and 55% for Sombo and 48%, 35% and 23% for NHV-1A (Figure 2) indicating higher fruit yield reduction with NHV-1A. The cropping pattern produced equivalent yields of between 61 and 119 % for maize as against pepper, which produced the yield of between 23 and 90 % of the sole crop. In this study, crop mixtures were more productive than sole component crops as reflected in the Land Equivalent Ratios (LERs), which ranged between 1.1 and 1.7 (Table 4.6). The productivity of maize-pepper intercropping was superior in resource use efficiency compared to sole cropping. The respective LERs of 1.73, 1.37 and 1.51 for mixtures of maize were higher at 53,333, 35,556 and 26,667 plants/ha with Sombo than the corresponding values of 1.42, 1.10 and 1.10 for NHV-1A with maize (Figure 3).

Relative yields of maize (%)

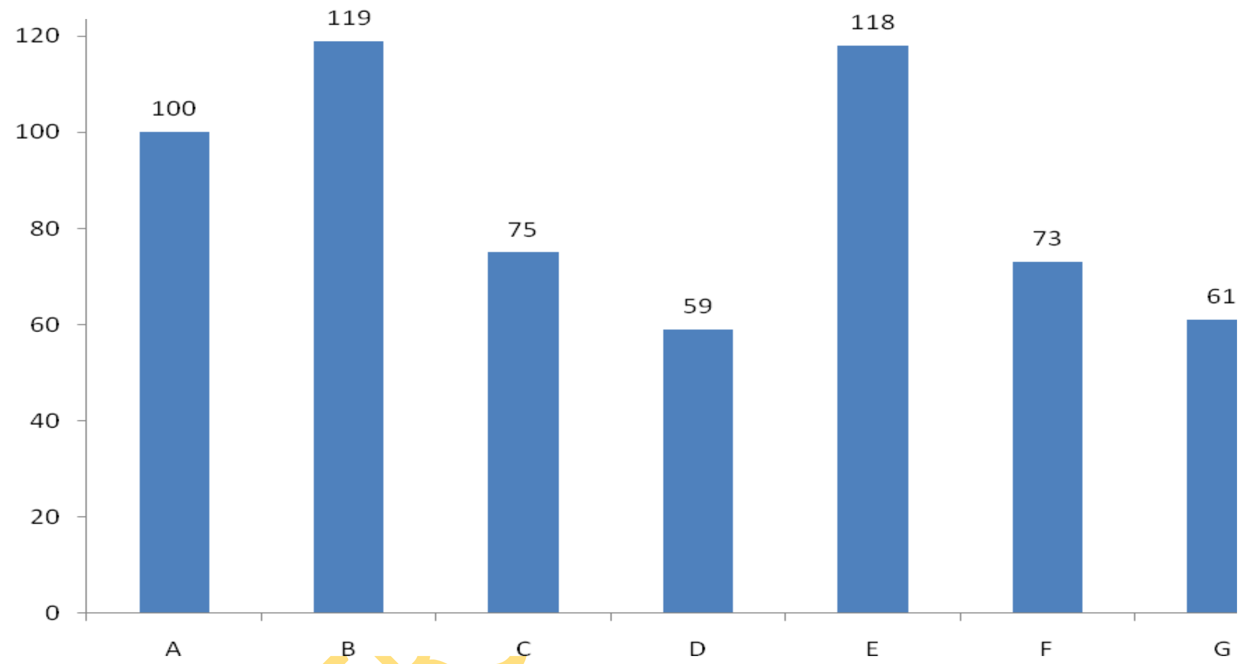

Figure 2: Relative yields (%) of intercropped maize with NHV-1A and Sombo of sole crop of maize in 2007

A. Maize of 53,333 plants/ ha sole crop
B. Maize 53,333 maize plants/ha with NHV-1A
C. Maize of 35,556 plants/ha with NHV-1A
D. Maize of 26,667 plants /ha with NHV-1A
E. Maize of 53,333 plants/ha. with Sombo
F. Maize of 35,556 plants/ha with Sombo
G. Maize of 26,667 plants/ha with Sombo

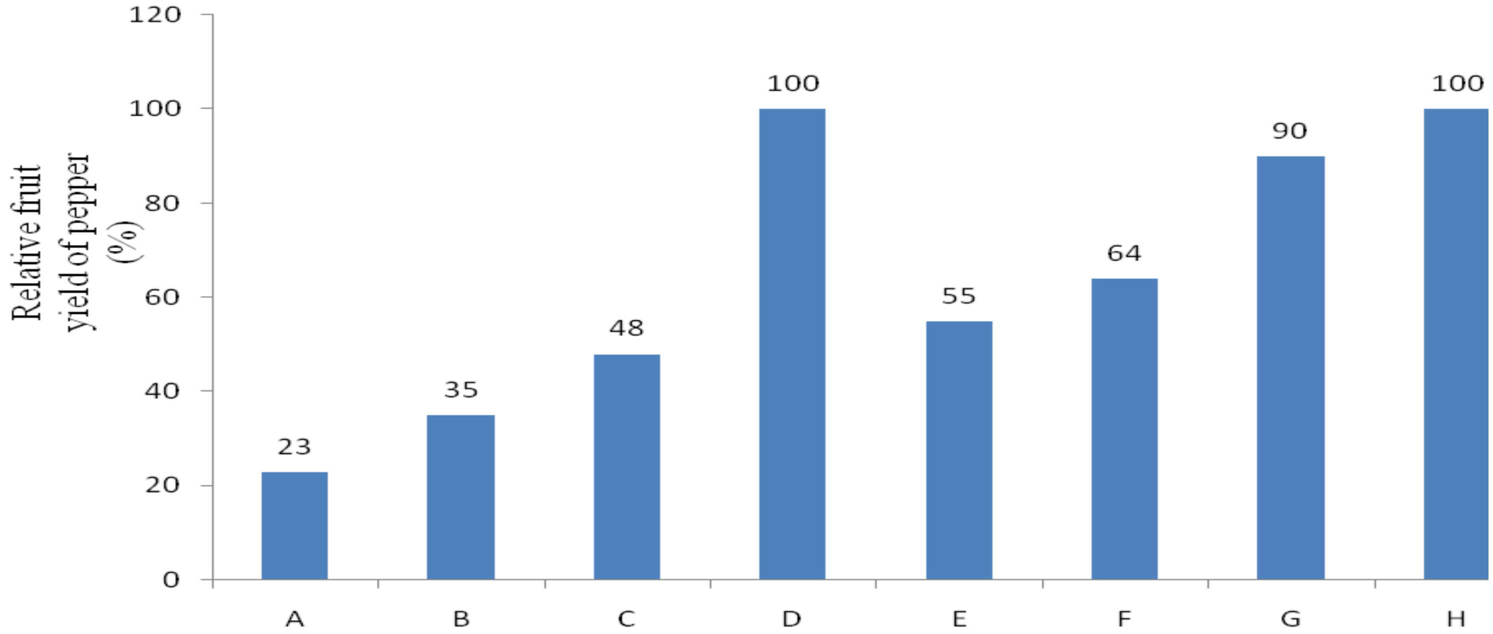

Figure 3: Relative yield (%) of intercropped pepper as percentage of respective sole crops of NHV-1A and Sombo in 2007

A. NHV-1A intercropped with 53,333 maize plants/ ha
B. NHV-1A intercropped with 35,556 maize plants/ha
C. NHV-1A intercropped with 26,667 maize plants/ ha
D. NHV-1A sole crop
E. Maize of 26,667 plants/ha. with NHV-1A
F. Maize of 53,333 plants/ha with Sombo
G. Maize of 35,556 plants/ha with Sombo
H. Maize of 26,667 plants /ha with Sombo

Table 4.6: Yields and Land Equivalent Ratios (LERs) of maize and pepper as affected by intercropped maize population densities in 2007

Treatment	Grain Yield (t/ha)	Pepper yield (t/ha)	LER
Sole crop of maize	3.61b[1]	-	1.0
Maize of 53,3333 + NHV-1A	4.28a	0.44d	1.42
Maize of 35,556 + NHV-1A	2.69bc	0.67c	1.10
Maize 26,667 + NHV-1A	2.24c	0.93c	1.10
Sole crop of NHV-1A	_	1.94a	1.0
Maize of 53,333 + Sombo	4.24a	0.72c	1.73
Maize of 35,556 + Sombo	2.64bc	0.84c	1.37
Maize 26,667 + Sombo	2.21c	1.19b	1.51
Sole crop of Sombo	-	1.32b	1.0
SE ±	0.64	0.22	

1. Means with the same letter(s) in the column are not significantly different (P < 0.05) using Duncan's Multiple Range Test

Experiment II: Growth and yield responses of two varieties of chillies (*Capsicum frutescens*) to different transplanting ages when intercropped with maize

4.6 Effect of age of transplants on the growth of intercropped pepper

4.6.1 Establishment of pepper after transplanting

Age of seedling transplants had significant effect on the establishment of pepper seedlings intercropped with maize at 2 WAT (Table 4.7). Seedling transplants at ages 3 to 5 weeks after sowing (WAS) had significantly lower establishment than the sole crops of the two pepper varieties transplanted at 6 WAS, while the six-week and seven-week old transplants were comparable with the sole crops irrespective of the varieties. Furthermore, the intercropping system severely affected the younger ages (3, 4 and 5-week old) of transplants of NHV-1A than Sombo and consequently had lower establishment than at 6 and 7 WAS in the case of NHV-1A and seven-week old seedlings for Sombo. The Sombo seedlings transplanted at 4 and 5 WAS were comparable to those at 6 WAS.

4.6.2 Number of leaves of pepper

At 4 WAT, intercropped 7-week old Sombo was comparable to maxima with the sole variety, while all other intercropped Sombo seedlings had fewer leaves. Sole and intercropped NHV-1A at 6-week and 7-week transplants was however comparable to 7-week old Sombo transplants. The 3 to 6 weeks transplants of Sombo and 3 to 5 weeks transplants of NHV-1A had significantly fewer leaves than their respective sole crops and older seedling transplants.

The sole crops of the two varieties of pepper were not significantly different from each other with respect to the number of leaves per plant at 6 and 8 WAT (Table 4.7). The sole crop of NHV-1A produced significantly higher number of leaves than all the intercrops at 6 and 8 WAT (94 and 118, respectively); and the intercrops transplanted at older ages of 6 and 7 weeks produced significantly higher number of leaves than the younger ages of 3, 4 and 5 weeks at 6 and 8 WAT.

The trend observed with NHV-1A was recorded in Sombo variety with the exception of intercropped 7-week old seedling transplants which produced the same number of leaves (92 and 123, respectively) with the sole crop at 6 and 8 WAT (Table 4.7). In both varieties intercropped 6-week old seedlings intercropped with maize had significantly lower number of leaves which corresponded to sole crops in all cases.

Table 4.7: Effects of age of seedlings of chilli peppers and intercropped maize on field establishment of chilli pepper, number of leaves and branches per plant of chilli peppers at 4, 6 and 8 weeks after transplanting in 2008

Treatment	% Field establishment .... 2 WAT[1]	number of leaves ------------- WAT ------------			number of branches ------------- WAT ------------		
		4	6	8	4	6	8
Sole crop of NHV-1A (6-week old)	96.3a[2]	47b	94a	118a	5b	12a	19a
3 -week old NHV-1A + maize	65.0c	14d	27e	43cd	1d	4c	6cd
4 -week old NHV-1A + maize	69.0c	17d	27e	36e	2c	4 c	7c
5 -week old NHV-1A + maize	68.8c	14d	34d	44cd	3c	7b	8c
6 -week old NHV-1A + maize	97.1a	40b	55c	74b	4bc	7b	9c
7 -week old NHV-1A + maize	90.3ab	38bc	74b	86b	6ab	10a	11b
Sole Crop of Sombo (6 -week old)	95.7a	61a	92a	128a	7a	12a	17a
3 -week old Sombo + maize	66.7c	20cd	31d	38e	2c	3c	4d
4 -week old Sombo + maize	78.1b	19cd	33d	48d	0 d	3c	5d
5 -week old Sombo + maize	78.2b	23c	42cd	55cd	2c	6b	9c
6 -week old Sombo + maize	82.1ab	27c	40cd	63c	4bc	8b	11b
7 -week old Sombo + maize	93.3a	50ab	92a	123a	5b	9ab	13b
SE ±	14.55	3.20	8.33	21.11	0.26	0.75	1.12

1. WAT= Weeks after transplanting
2. Means with the same letter(s) in the column are not significantly different (P < 0.05) using Duncan's Multiple Range Test

Sole pepper of both varieties and intercropped 7-week old seedlings had the highest number of leaves (6 and 8 WAT). At 6 WAT, number of leaves increased with age of intercropped seedling transplants of 4 to 7 weeks in NHV-1A, while all the ages had similar number in Sombo. Intercropped Sombo had higher number of leaves than corresponding NHV-1A (Table 4.7).

4.7.3 Number of branches of pepper

Intercropped 7-week old plants of the two varieties had number of branches comparable to the maxima of the sole crops of the two varieties of chilli peppers at 6 WAT (Table. 4.7). NHV-1A that was transplanted at 7 weeks of age produced significantly higher number of branches per plant than those that were transplanted at younger ages of 3, 4, 5 and 6 weeks at 6 and 8 WAT. Similarly, Sombo seedlings transplanted at 6 and 7 weeks after sowing had significantly higher number of branches than the younger transplants of 3, 4 and 5 weeks. The number of branches generally increased with the initial age of transplant in both varieties at 4 to 8 WAT. The sole crops of both varieties produced significantly higher number of branches per plant (19 and 17 for NHV-1A and Sombo respectively) than the intercrops at 8 WAT (Table 4.7).

4.6.4 Plant height of pepper

At 4 WAT, the 6-week old NHV-1A planted sole (20.2 cm) and intercropped with maize (21.9 cm) as well as 6-week old sole (22.4 cm) and 7-week old Sombo intercropped with maize (25.4 cm) had significant plant heights comparable to their respective younger transplants of 3, 4 and 5 weeks old of Sombo and NHV-1A intercropped with maize (Table 4.8). At both 6 and 8 WAT, the sole crop of NHV-1A was significantly taller (42.2 and 51.6 cm, respectively) than sole crop of Sombo (34.4 and 38.8 cm, respectively) as well as all the intercropped plants of both varieties. At both stages, intercropped plants of NHV-1A transplanted at 6 and 7 WAS and those of Sombo at 7 WAS were comparable to those of sole Sombo in height and taller than those of their respective younger seedling transplants. Furthermore, at 8 WAT, 5-week old Sombo plants intercropped with maize also had heights comparable to that of the sole crop (Table 4.8).

4.6.5 Stem diameter of chilli pepper

The stem diameter of both varieties of pepper progressively increased from 4 to 8 WAT, while the initial age of transplant of the seedlings significantly affected the diameter of the stem at the three stages of growth (Table 4.8). At 4 WAT, sole crop NHV-1A and intercropped 7-week old Sombo had stem diameters comparable to the maxima of sole Sombo and intercropped 6-week old and 7-week old NHV-1A and significantly higher than the lowest of intercropped 3-week old NHV-1A as well as 3-week and 5-week old Sombo.

At 6 WAT, the sole crop and the intercropped 7-week old plants of the two varieties had stem with significantly bigger diameters than those of all the other intercrops. Furthermore, intercropped 6-week old NHV-1A and Sombo had bigger diameters than the lowest with intercropped 3-week and 4-week old Sombo plants. At this stage, sole crop of the two varieties had larger diameters than their respective intercrops with exception of 7-week old plants. At 8 WAT, the value of the stem diameter of crop of NHV-1A (0.76 cm) was comparable to the maximum of sole Sombo (0.83 cm), but significantly higher than those of its intercropped transplanted at ages 3, 4 and 5 weeks (0.51, 0.57 and 0.57 cm, respectively). The value of the stem diameter of sole crop Sombo (0.83 cm) was significantly higher than the respective intercrops with the exception of 7 weeks old seedlings (0.73 cm).

The stem diameter of Sombo seedlings transplanted at 5, 6 and 7 weeks old (0.64, 0.64 and 0.73 cm, respectively) were similar but higher than those of younger pepper transplants with the 3-week old one having the least value of 0.45 cm (Table 4.8).

Table 4.8: Effect of intercropped maize on the plant height (cm) and stem diameter (cm) of chilli peppers at 4, 6, and 8 weeks after transplanting in 2008

Treatment	Plant height (cm)			Stem diameter (cm)		
	------------- WAT[2] ------------			------------- WAT ------------		
	4	6	8	4	6	8
Sole crop of NHV-1A (6wks)	20.2ab[1]	42.2a	51.6a	0.45ab	0.64a	0.76ab
3-week old NHV-1A + maize	9.5d	21.6c	24.2c	0.32c	0.45bc	0.51c
4-week old NHV-1A + maize	11.8cd	21.9c	27.8c	0.38b	0.48bc	0.57c
5-week old NHV-1A + maize	11.1bc	26.6c	29.2c	0.38b	0.48bc	0.57c
6-week old NHV-1A + maize	21.9ab	31.5b	35.7b	0.51a	0.54b	0.64b
7-week old NHV-1A + maize	23.3a	33.7b	36.1b	0.48a	0.64a	0.67b
Sole Crop of Sombo (6wks)	22.4ab	34.4b	38.8b	0.48a	0.67a	0.83a
3-week old Sombo + maize	10.5d	18.6c	23.2c	0.32c	0.38c	0.45d
4-week old Sombo + maize	13.5cd	20.2c	26.6c	0.35bc	0.38c	0.51c
5-week old Sombo + maize	13.8cd	24.0c	35.5b	0.32c	0.48bc	0.64b
6-week old Sombo + maize	17.1bc	24.7c	36.2b	0.38bc	0.51b	0.64b
7-week old Sombo + maize	25.4a	34.0b	39.1b	0.45ab	0.61a	0.73ab
SE ±	4.72	3.50	3.40	0.05	0.06	0.08

1. Means with the same letter(s) in the column are not significantly different ($P < 0.05$) using Duncan Multiple Range Test
2. WAT= Weeks after transplanting

4.7 Effect of age of transplanted seedlings on growth of maize

4.7.1 Plant height of maize

Maize intercropped with older 6 and 7 weeks and relatively younger 4 weeks old pepper seedlings of NHV-1A had significantly lower values of plant height at 6 WAS than maize plants that were intercropped with all the transplants of Sombo (irrespective of ages) and those with NHV-1A at 3 and 5 WAS which were of heights comparable to that of the sole maize (Table 4.9).

4.7.2 Stem diameter of maize

Although the stem diameters of both intercropped and sole maize were not significantly different from each other at 4 and 6 WAS; that intercropped with 6-week old Sombo transplant had the biggest stem diameter of 2.39 cm (Table 4.9).

4.7.3 Number of leaves per plant of maize

The average number of leaves per plant at 4 WAS for sole maize (8.1) was significantly higher than those of the plants intercropped with NHV-1A of 6-week and 7-week old of 6.1 and 6.2, respectively as well as Sombo transplanted at 3 (6.1), 5 (6.2) and 7 (6.4) WAS (Table 4.10). At 6 WAS, maize intercropped with 3 and 7-week old Sombo transplants had significantly fewer leaves (11.2 and 11.3, respectively) than the sole crop (12.6).

4.7.4 Leaf area of maize plant

At 4 WAS maize intercropped with 4-week old NHV-1A variety of pepper had significantly higher leaf area (696 cm^2) than the other intercropped maize and the sole crop. In contrast, maize intercropped with 5-week old Sombo seedlings had the lowest value of 471.1 cm^2 (Table 4.10). At 6 WAS, leaf area of maize intercropped with 3-week old (722.3 cm^2) and 5-week old (721.6 cm^2) NHV-1A as well as 6-week old (719.0 cm^2) and 7-week old (732.4 cm^2) Sombo were significantly higher than those of all the other intercropped and sole maize (637.7 to 655.3 cm^2) which were similar (Table 4.10).

Table 4.9: Effects of age of transplants of chilli peppers on the plant height and stem diameter of maize at 4 and 6 weeks after planting in 2008

Treatments	Plant height (cm)		Stem diameter (cm)	
	------- WAS[1]---------		--------- WAS --------	
	4	6	4	6
Sole Crop of maize	75.3	157.2a[2]	1.72	2.20
Maize with 3 weeks NHV-1A	80.1	141.8ab	1.91	2.20
Maize with 4 weeks NHV-1A	70.3	124.1c	1.50	1.88
Maize with 5 weeks NHV-1A	73.4	139.3ab	1.81	2.01
Maize with 6 weeks NHV-1A	74.2	134.5b	1.78	1.91
Maize with 7 weeks NHV-1A	69.3	132.0b	1.78	1.88
Maize with 3 weeks Sombo	79.2	139.7ab	1.72	2.01
Maize with 4 weeks Sombo	76.6	138.5ab	1.91	2.10
Maize with 5 weeks Sombo	65.4	141.5ab	1.59	1.88
Maize with 6 weeks Sombo	75.9	143.4ab	1.91	2.39
Maize with 7 weeks Sombo	82.8	153.7a	1.85	2.20
SE ±	7.6	9.8	6.7	7.3
	ns[3]		Ns	Ns

1. WAS = Weeks after Sowing
2. Means with the same letter(s) in the column are not significantly different (P < 0.05) using Duncan Multiple Range Test
3. ns = Not significant (P < 0.05)

Table 4.10: Effect of age of transplants of chilli peppers on mean number of leaves per plant and leaf area of maize at 4 and 6 weeks after planting in 2008

Treatment	Mean number of leaves per plant ---------- WAS[2] ---------		Leaf area (cm^2) ------- WAS -------	
	4	6	4	6
Sole Crop of maize	8.1a[1]	12.6a	609.1c	646.1b
Maize with 3 weeks NHV-1A	6.9ab	11.8ab	591.5c	722.3a
Maize with 4 weeks NHV-1A	6.9ab	11.6ab	696.5a	638.7b
Maize with 5 weeks NHV-1A	7.0ab	11.7ab	640.3b	721.6a
Maize with 6 weeks NHV-1A	6.1b	11.3 b	587.6c	653.3b
Maize with 7 weeks NHV-1A	6.2b	11.7ab	590.8c	638.8b
Maize with 3 weeks Sombo	6.1b	11.2 b	639.9b	651.3b
Maize with 4 weeks Sombo	6.5ab	11.7ab	611.9c	655.3b
Maize with 5 weeks Sombo	6.2b	11.5 ab	471.1d	637.7b
Maize with 6 weeks Sombo	6.5ab	11.8ab	614.6c	719.0a
Maize with 7 weeks Sombo	6.4b	11.3 b	588.7c	732.4a
SE ±	0.50	1.14	40.46	49.22

1. Means with the same letter(s) in the column are not significantly different ($P < 0.05$) using Duncan Multiple Range Test
2. WAS=Weeks after Sowing

4.8 Effects of age of pepper seedlings and intercropped maize on the fresh fruit yield of pepper

4.8.2 Fruit weight per plant

In both varieties of peppers, the sole crop and intercropped 6-week and 7-week old pepper transplants fruited for earlier harvests and consequently yielded more fresh fruits per plant than those that were transplanted at younger ages of 3, 4 and 5 weeks after sowing (Figure 4). Although not statistically significant, the fruit weight of transplanted pepper tends to increase with the age of transplant in both varieties.

Among the treatments, intercropped 6-week old Sombo produced pepper fruit weight/plant and yield (61.8 g and 1.65 t./ha) comparable to the maximum of the same variety of intercropped 7-week old transplant (70.3 g and 1.86 t./ha). Furthermore, the sole crops of the varieties (52.4 g/plant and 1.4 t./ha for NHV-1A and Sombo) and the intercropped 6-week (52.8 g and 1.41 t./ha) and 7-week (54.2 g and 1.46 t./ha) old NHV-1A also produced fruit weight/plant and yield comparable to that intercropped 6-week old (Figure 4).

4.9 Effects of age of pepper seedlings on the yield of intercropped maize

The lowest average cob and grain weight per plant (105.23 and 60.53 g, respectively), were produced by sole maize. Among the treatments, maize intercropped with 4-week old Sombo transplant produced cob weight/plant comparable to the maxima of similar intercropped with NHV-1A variety, while the lowest weight was obtained with sole maize (Table 4.11). Sole maize and those intercropped with 3-week old Sombo seedlings produced significantly lower maize grain weight/plant than those intercropped with 4-week old NHV-1A as well as 4 to 6-week old Sombo. The highest maize grain yield was produced by the sole crop. Although not comparable to the highest maize intercropped with 4-week old seedlings of the two varieties as well as 5 and 6-week old seedlings of Sombo, produced significantly higher grain yield than the lowest intercropped with 3-week old Sombo and 5-week old NHV-1A.

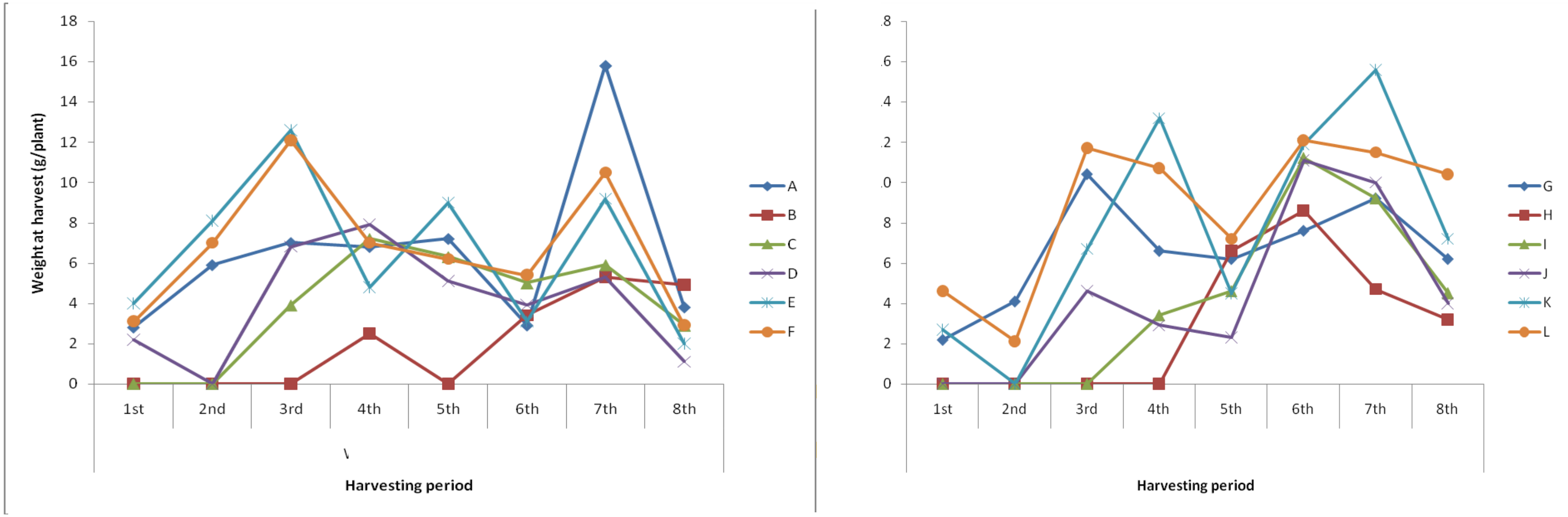

Figure 4: Effects of age of seedlings of peppers and intercropped maize on fresh fruit weight of chilli pepper at various harvests in 2008

A	6-week old Sole crop of NHV-1A	G	6-week old Sole crop of Sombo
B	3-week old NHV-1A + maize	H	3-week old Sombo + maize
C	4-week old NHV-1A + maize	I	4-week old Sombo + maize
D	5-week old NHV-1A + maize	J	5-week old Sombo + maize
E	6-week old NHV-1A + maize	K	6-week old Sombo + maize
F	7-week old NHV-1A + maize	L	7-week old Sombo + maize

Table 4.11: Yield of maize as affected by the intercropped peppers of different transplanting ages in 2008

Treatment	Cob Weight/Plant	Grain weight/Plant	Grain yield per hectare
	---------------- g/plant	--------------	------ $t.ha^{-1}$ -----
Sole Crop of maize	105.2d[1]	60.5c	3.23a
Maize + 3-week old NHV-1A	155.3b	84.1ab	2.24bc
Maize + 4-week old NHV-1A	173.8a	94.7a	2.53b
Maize + 5-week old NHV-1A	120. 9c	85.6ab	2.28bc
Maize + 6-week old NHV-1A	130.2c	78.5abc	2.09c
Maize + 7-week old NHV-1A	153.8b	85.9ab	2.29bc
Maize + 3-week old Sombo	129.7c	75.7bc	2.02c
Maize + 4-week old Sombo	162.8ab	95.7a	2.55b
Maize + 5-week old Sombo	155.3b	96.5a	2.57b
Maize + 6-week old Sombo	172.5a	98.2a	2.62b
Maize + 7-week old Sombo	152.3b	88.0ab	2.35bc
SE ±	27.88	13.98	0.26

Means with the same letter(s) in the column are not significantly different ($P < 0.05$) using Duncan Multiple Range Test

4.10 Land Equivalent Ratio (LER) of Maize Pepper Intercrop

The relative yields of all the intercropped maize were generally lower than unity, irrespective of the component pepper variety, which ranged from 0.61 to 0.81 for that intercropped with 3-week and 6-week Sombo, respectively (Table 4.12). Furthermore, the relative yields of intercropped peppers tend to increase with the age of seedling transplants in both varieties. The ranges were 0.31 and 0.41 for intercropped 3-week old seedlings transplants of Sombo and NHV-1A, respectively to 1.04 and 1.33 for the corresponding 6-week old seedling transplants (Table 4.12).

All the maize-pepper intercrop, except the intercropped with 3-week old seedlings of NHV-1A had LER higher than 1.0 (Table 4.12). The range was 1.05 for intercropped with 3-week old Sombo to 2.06 for 7-week old NHV-1A seedlings intercropped. LER increased with the age of pepper seedling transplants and especially with 6-week and 7-week old seedlings in the two varieties.

Table 4.12: Land Equivalent Ratio of maize-pepper intercrops as affected by age of pepper seedlings in 2008

Treatments	Yield per hectare (t)		Relative yield		LER
	Maize	Fresh pepper fruit	Maize	Pepper	
Sole crop of maize	3.23a[1]	-	1.00	-	1.00
3-week old NHV-1A + maize	2.24bc	0.43e	0.69	0.31	1.00
4-week old NHV-1A + maize	2.53b	0.85cd	0.78	0.61	1.39
5-week old NHV-1A + maize	2.28bc	0.89cd	0.71	0.64	1.35
6-week old NHV-1A + maize	2.09c	1.41b	0.65	1.01	1.66
7-week old NHV-1A + maize	2.29bc	1.45b	0.71	1.04	1.75
Sole crop of NHV-1A	-	1.39b	-	1.00	1.00
3-week old Sombo + maize	2.02c	0.62de	0.61	0.44	1.05
4-week old Sombo + maize	2.55b	0.88cd	0.79	0.63	1.42
5-week old Sombo + maize	2.57b	0.93c	0.80	0.66	1.46
6-week old Sombo + maize	2.62b	1.65ab	0.81	1.18	1.99
7-week old Sombo + maize	2.35bc	1.86a	0.73	1.33	2.06
Sole crop of Sombo	-	1.40b	-	1.00	1.00
SE ±	0.23	0.21			

1. Means with the same letter(s) in the column are not significantly different ($P < 0.05$) using Duncan Multiple Range Test

CHAPTER 5

DISCUSSION

5.1 Effect of rainfall vagaries on the yields of maize-pepper intercrop in 2007 and 2008

Assessment of the climatic conditions, viz rainfall and temperature in the two years of study, showed that the rainfall was adequate in 2007 and temperature was found to be within the optimum range of 20 to 30 ^{0}C in the two years as earlier observed by Berke *et al*. (2005). However, the period of rainfall was more extended to the latter part of 2007 (November and December) with a sum total value of 39.3 mm as against 13.4 mm of the same period in 2008. It also started earlier and consistent in the fruiting of January to March with a higher sum total value of 168.7 mm as against 144.2 mm of the same period in 2007. These conditions favourably supported adequate growth and yields of the two crops, especially the pepper which was stimulated pepper plants to commence the second fruiting cycle and consequently increased the total fresh fruit yield of the crop in 2007 compared with 2008. The yields of the two crops were drastically reduced by moisture stress due to earlier cessation of rains in 2008. The effects of moisture stress in dry season on the growth and fruit yield of peppers had earlier been reported by Ado and Olanrewaju (1987) and later by Bosland and Votava (2000). These authors observed that moisture stress caused male sterility and premature floral abortion, which consequently affected the fruit yield through the dropping of immature fruits and production of few smaller size harvested fruits. This was evident and more pronounced in the sole crop of NHV-1A (improved variety), which yielded 1.94 t ha^{-1} of fresh fruits in 2007 compared to 1.32 t ha^{-1} in 2008. The reverse was the case with sole crop of Sombo (local variety) whose yields were 1.39 and 1.40 t ha^{-1} in 2007 and 2008, respectively. The yields were however comparable to optimum yield of between 1.0 to 1.5 t ha^{-1} that were considered to be good enough for *Capsicum frutescens* according to Aliyu and Kachinda (2002).

5.2 Effect of maize population and pepper varieties on the growth and yield of maize

The intercropped maize grew much taller than their component sole crops. This condition suggests that radiation was not limiting as far as the intercrops were concerned. Therefore, root competition rather than shading might have contributed to the differences in the intercrop performance among the different maize population and spatial arrangements (Manu-Aduening and Poa-Amponsem, 2005). In 2007 low density maize plants (26,667 plants/hectare) intercropped with NHV-1A and Sombo varieties of pepper had significantly higher values for stem diameter as well as leaf area (420.5 and 385.2 cm^2, respectively) than the sole crops with stem diameter of 2.36 cm and leaf area of 311.5 cm^2 at 8 WAP. However, the growth of intercropped maize plants was not significantly different from each other irrespective of the pepper variety and the population of maize. It was obvious that pepper plants allowed other crops to be grown between them without much interference with the growth and production of the companion crop as reported by Norman (1992). Differences obtained in the plant population of maize, did significantly affect the yields as previously observed by Manu-Aduening and Poa-Amponsem (2005). Higher productivity of intercropped maize per plant in terms of number of grains per cob and yield per plant in wider row spacing of 75 x 100 cm and lower density (26,667 plants/ha) might be attributed to less competitions for growth resources (water and nutrient); since the plants had more space and other growth necessities to themselves than the sole crop and apparently led to higher production of grains per cob and total yield per individual plants in low density plots of maize (Balogun and Tanimola, 2001). In contrast, the grain yield of maize per hectare increased in plants with closer row spacing (75 x 50 cm) at highest density (53,333 plants/ha), which was significantly higher than those intercropped at wider spacing of 75 x 100 cm (26,6667 plants/ha) and 75 x 75 cm (53,333 plants/ha). The differences were as a result of the differences in spatial arrangement of maize and their populations, which consequently affected the number of harvested plants per unit area of land as was earlier observed by IITA (1986). Since crop arrangement is a function of plant population, there is therefore higher light interception at wider spacing than at narrower spacing (Prasad and Brook, 2005; Jiao *et al*., 2008). The highest population of sole maize and that intercropped with the two varieties produced similar yields that were significantly higher than those of the lower population intercropped with pepper. This further confirms that pepper intercropped with maize did not have any effect on maize productivity.

5.3 Effect of maize population on the growth and yield of pepper varieties

The number of branches of the two varieties of the intercropped peppers with maize population densities (35,556 and 53,333 plants/ha) were not significant at 6 WAT. However, the value of stem diameter, number of leaves, flowers and fruits per plant were significantly higher in intercropped peppers of both varieties with maize population of 26,667 plants/ha than those of highest maize population (53,333 plants/ha) at 8 WAT. As expected, significantly lower fresh fruit yields were obtained from intercropped peppers of both varieties, (except intercropped Sombo with 26,667 maize plants/ha) compared with the sole crop. This agreed with Denton and Makinde (1993) who reported that low yields of between 0.5 - 0.8 tonnes/ha were usually obtained in subsistence farmers' fields where peppers were commonly intercropped with other crops. Reduction in yields of the component crop in mixture with maize as observed in this study had been reported by Ennin *et al*. (2002) though in maize/soybean intercrop. The fruit yield of intercropped Sombo variety was however negatively affected more than the NHV-1A in the first fruiting cycle harvest of 2007, probably due to the shading effect of the intercropped maize. In the 2007 experiment, after the component intercropped maize plants were harvested with favourable climatic condition, especially rainfall, peppers commenced a second cycle of fruiting with Sombo variety producing higher yields, which consequently out-yielded the NHV-1A variety in the total harvests. This confirmed the report of Norman (1992) that chillies would keep on growing and producing fruits after the determinate component crop had been harvested.

5.4 Effect of cropping system on the biological productivity of maize-pepper intercrop in 2007

According to Vandermeer (1989), a Land Equivalent Ratio of 1 is critical; since above this, intercrop is favoured. In 2007, all the intercrops showed yield advantage (LER > 1.0) compared to mono-culture in equal land area. Intercropping of maize and pepper relatively increased the land productivity, mostly higher in cropping system with highest maize population and with Sombo variety than with NHV-1A. An increase in the productivity of these intercrops might be ascribed to both spatial and temporal advantages. There is therefore, potential for higher productivity of intercrops when intra-specific competition is less than inter-specific competition for a limiting resource such as solar radiation (Banik and Sharma, 2009) or nutrient. By mixing crops that differ in their requirements for growth resources (light, water and space) it was obvious that their demands for these resources would be at different periods. However, Ofori and Stern (1987); Midmore (1993) reported that the relative timing of component crops would contribute greatly to the yield potentials of intercrop system and when component crops were sown at different times, the earliest sown crop would have an earlier competitive advantage and dominate the other crop. In this study, the earlier sown crop (maize) had its maximum vegetative growth and canopy closure by six weeks after sowing when the intercropped peppers had just been overcoming the transplanting shock. Mutsaers *et al.* (1993) had also reported in a review paper that LERs could increase according to the timing of harvesting of the component crops. In 2007, the pepper plants were able to recover from the temporary stress imparted by maize plants during the early stages of growth after the latter's removal; hence, the pepper had a prolonged harvesting period and consequently produced higher yields in the second fruiting cycle as revealed in 2007. Hence, the combination of a long season crop (pepper) and a relatively short-season crop (maize) enabled the system to utilize the potential cropping period once the resources, especially soil moisture was still adequate for growth.

5.5 Effect of age at transplant of pepper varieties on the growth and yield of maize

In 2008, sole maize plants produced significant highest number of leaves (8.1 and 12.6) per plant at 4 and 6 WAS, respectively, but smallest leaf area of 646.1 cm^2 at 6 WAS than their intercropped counterparts. The growth performance in terms of plant height, stem diameter and number of leaves at 6 WAS and grain yields of intercropped maize plants were however similar irrespective of the variety and ages of transplants of intercropped pepper. The range of grain yield of the intercropped maize was between 2.02 and 2.60 $t.ha^{-1}$, which were significantly lower than 3.23 $t.ha^{-2}$ of the sole maize.

5.6 Effect of age at transplant on the survival and growth of pepper varieties

The lower establishment recorded in younger 3-week, 4-week and 5-week old seedlings of the two varieties of pepper compared with the older ones of 6 and 7 weeks in 2008 experiment, could be due to the fact that the younger ones were not physiologically developed to withstand transplanting shock at that age. The intercropped maize had not also developed enough canopies required at that time to sufficiently shade them from the effect of full sunshine. Similar observation had earlier been reported by Norman (1992). Bosland and Votava (2000) later suggested that transplanting of pepper at 4 – 5 weeks after sowing would only be applicable to sole pepper since the stem diameter, which depends solely on the age of transplant was very important to the survival rate of the transplants.

Moreover, 6-week and 7-week old transplants of intercropped peppers of the two varieties were not significantly different from each other in terms of plant height stem diameter, and number of leaves. The sole crops of the two varieties produced significant higher values of number of leaves and branches than all the intercrops, while the sole crops of NHV-1A and Sombo recorded highest significant values of plant height (51.6 cm) and stem diameter (0.83 cm), respectively than all the intercropped irrespective of the age of transplants. However, it was discovered that older transplants (6-week and 7-week) of Sombo variety could withstand shading effects of the intercropped maize plants than the NHV-1A variety. This was evident in the superior growth performance of 6-week and 7-week old transplants even under intercropped maize with leaf area of 719 and 732 cm^2, respectively, which were significantly higher than the sole and intercropped maize with component younger transplants of 3, 4 and 5 WAS. This was in agreement with the earlier reports of Snoydon and Satorre (1989) and Ado (1990) that these two crops (maize and pepper) were compatible because they naturally exhibit different growth habits which allowed the more or less vertical leaves of maize to trap half of the available sunlight, while peppers with more horizontal leaves captured most of the remaining solar energy for photosynthesis.

5.7 Effect of age at transplant of pepper varieties on the yield and productivity of maize-pepper intercrop

In 2008, the mean fresh fruit yields obtained from the two varieties of chillies were very low compared to those of 2007. The lower yield obtained in 2008 could be attributed to early cessation of rain and the occurrence of the cold dry winds of the harmattan that led to shedding of flowers and young fruits. Ado and Olanrewaju (1987) and later Bosland and Votava (2000) had earlier reported these consequences of the stresses on fruit yields of peppers. Idowu-Agida *et al*. (2012) recently reported that soil moisture as well as prevailing temperature has vital effect on growth and yields of pepper. In the two varieties of peppers used for intercropping with maize, lowest relative yield was recorded from seedlings transplanted at 3 weeks old in NHV-1A (0.31) and Sombo (0.44). The highest relative yield was however obtained with the use of 7-week old seedlings as transplants resulting in values of 1.04 and 1.33 for NHV-1A and Sombo, respectively. The significantly lower reduction in the yields of both varieties of peppers that were transplanted at younger ages of three, four and five weeks into maize than those of six and seven weeks old transplants, revealed that these plants suffered more severely from transplanting shock and competition for growth resources, especially light.

In 2008, 7-week old pepper transplants of both varieties intercropped with maize had maximum relative yields of 1.04 and 1.33 for NHV-1A and Sombo, respectively and correspondingly the highest LER of 1.75 and 2.06. This result conformed with the report of Bosland and Votava (2000) that better establishment, good growth and optimum yield of peppers required that the seedlings be transplanted at ages of between 6 and 8 weeks old after sowing in the nursery.

CHAPTER 6

CONCLUSION AND RECOMMENDATION

The results obtained from the two experiments in this study revealed that chilli peppers and maize were good companions in an intercropping condition due to differences in their growth habit. Hence, the combination of these crops was found to be more productive in terms of yield for a given energy input and could be more profitable in the long run than their mono-cropped situations.

6.1 Effect of Maize Pupation on Maize –Pepper Intercrop

Yields of intercrop maize at 53,333 plants/ha was higher than other intercropped maize of lower population the assessment of Land Equivalent Ratio (LER) in both experiments also revealed that there were relative advantages in intercropping of chilli peppers with different maize population densities and ages of seedlings of chilli peppers that were intercropped with maize in this study. The intercropped peppers however produced relatively highest fresh fruit yield under the lowest maize population of 26,667 plants/ha than with those under higher maize population.

6.2 Effect of age at Transplant on growth and Yield of Chilli Pepper

The yield of the two varieties of peppers were relatively higher in intercropped peppers that were transplanted at ages 6 and 7 weeks after sowing than those of younger ages of 3, 4, and 5 weeks and even than their sole crop counterparts. The growth and relative yields of fresh fruits of the two varieties of pepper to their sole crop counterparts revealed that Sombo was move compatible for intercropping than NHV-1A. The yields were higher in seven weeks (1.04 and 1.33) than six weeks (1.0 and 1.18) for NHV-1A and Sombo varieties respectively.

Based on the consideration for optimum yield of component crops and land use efficiency, the following recommendations would be of benefits to farmers:

i. Maize should be or planted in lower population of 26,667 plants/ha or widely-spaced at 75 x 100 cm to give the intercropped peppers a chance of competing favourably for growth resources.

ii. Pepper seedlings should be six or seven weeks old in the nursery before being transplanted into maize plots to allow them gather enough potential to withstand the transplanting shock and compete favourably with the component maize crop.

iii. NHV-1A was severely affected by the maize population and age of transplants as regards to survival rate, number of leaves, branches and fruit weight; hence, Sombo is recommended for intercropping with maize.

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APPENDICES

Appendix i: Planting arrangement of maize and pepper intercrop under maize population of 53,333 plants per hectare (75 x 50 cm)

3m (width) × 4.5m (length)

X	X	X	X	X
O	O	O	O	O
X	X	X	X	X
O	O	O	O	O
X	X	X	X	X
O	O	O	O	O
X	X	X	X	X
O	O	O	O	O
X	X	X	X	X
O	O	O	O	O
X	X	X	X	X
O	O	O	O	O
X	X	X	X	X
O	O	O	O	O
X	X	X	X	X
O	O	O	O	O
X	X	X	X	X
O	O	O	O	O
X	X	X	X	X

X = Maize planted at 75 x 50 cm

O = Pepper planted at 75 x 50 cm

Appendix ii: Planting arrangement of maize and pepper intercrop under maize population of 35,556 plants per hectare (75 x 50 cm)

← 4.5m →

↑	X	O	X	O	X	O	X	O	X	O	X	O	X
	X	O	X	O	X	O	X	O	X	O	X	O	X
3m	X	O	X	O	X	O	X	O	X	O	X	O	X
	X	O	X	O	X	O	X	O	X	O	X	O	X
↓	X	O	X	O	X	O	X	O	X	O	X	O	X

X = Maize planted at 75 x 75 cm

O = Pepper planted at 75 x 50 cm

Appendix iii: Planting arrangement of maize and pepper intercrop under maize population of 26,667 plants per hectare (75 x 50 cm)

← 4.5m →

↑	X	O	X	O	X	O	X	O	X	O	X	O	X
		O		O		O		O		O		O	
	X	O	X	O	X	O	X	O	X	O	X	O	X
		O		O		O		O		O		O	
3m	X	O	X	O	X	O	X	O	X	O	X	O	X
		O		O		O		O		O		O	
	X	O	X	O	X	O	X	O	X	O	X	O	X
		O		O		O		O		O		O	
↓	X	O	X	O	X	O	X	O	X	O	X	O	X

X = Maize planted at 75 x 100 cm

O = Pepper planted at 75 x 50 cm

Appendix iv: Effects of age of seedlings of peppers and intercropped maize on fresh fruit weight of chilli pepper at various harvests in 2008

Harvest (g/plant)	Treatments							
	A	B	C	D	E	F	H	I
1st	3.73	0.00	0.00	0.00	0.00	0.00	13.58	0.00
2nd	2.35^{b}	0.00^{b}	0.00^{b}	0.00^{b}	3.08^{b}	0.00^{b}	17.91^{a}	5.51^{ab}
3rd	2.81	0.00	6.23	0.00	0.00	0.00	12.05	13.65
4th	0.00^{b}	0.00^{b}	0.00	0.00^{b}	0.00^{b}	0.00^{b}	10.97^{a}	3.38^{b}
5th	2.34^{b}	0.00^{b}	5.07	0.00^{b}	0.82^{b}	2.79^{b}	20.37^{a}	2.25^{b}
6th	0.00^{c}	0.00^{c}	3.25	0.00^{c}	0.00^{c}	0.90^{c}	27.58^{a}	8.79^{b}
7th	0.00^{b}	8.17^{b}	12.74	2.05^{b}	4.06^{b}	4.18^{b}	33.20^{a}	8.19^{b}
8th	12.46^{ab}	5.13^{ab}	4.40^{ab}	0.00^{b}	4.48^{ab}	1.30^{b}	21.36^{a}	21.04^{a}
9th	5.00^{ab}	3.03^{a}	6.43^{ab}	6.26^{ab}	1.47^{b}	6.06^{ab}	9.71^{ab}	16.70^{a}
10th	18.67^{a}	14.86^{a}	17.73^{a}	0.62^{b}	8.64^{ab}	11.42^{ab}	20.21^{a}	11.62^{ab}
11th	17.33^{a}	6.52^{ab}	10.30^{ab}	0.94^{b}	6.40^{ab}	8.96^{ab}	13.10^{a}	11.64^{ab}
12th	6.96^{bc}	11.66^{ab}	8.36^{abc}	4.03^{c}	8.47^{abc}	8.22^{bc}	14.57^{a}	9.93^{abc}
13th	8.95	8.31	7.68	2.30	8.33	6.71	6.54	7.29
14th	5.83^{abc}	2.93^{c}	5.65^{abc}	2.12^{c}	5.18^{bc}	3.69^{c}	10.33^{a}	8.98^{ab}
15th	4.55	4.62	1.88	2.77	2.76	3.52	0.58	4.12
16th	3.65	7.58	5.47	3.31	2.00	5.21	9.44	4.41
17th	2.80	2.33	2.56	1.86	0.98	2.05	2.31	5.12
18th	1.39	2.37	0.00	0.94	1.96	1.85	3.91	1.40
Cum/plant	98.82^{bc}	77.50^{cd}	97.73^{bc}	27.19^{d}	58.64^{cd}	66.86^{cd}	247.72^{a}	143.99^{b}

Appendix v: Effects of age of seedlings of pepper and intercrop maize on the fresh fruit yields of chilli peppers per hectare at 1st –8th and cumulative harvests (t)

Treatment	Harvest								
	1st	2nd	3rd	4th	5th	6th	7th	8th	Cumulative yield
Sole crop of NHV-1A	0.1a	0.2a	0.2b	0.2c	0.2a	0.1c	0.4a	0.1b	1.5b
3 weeks NHV-1A with maize	0.0b	0.0c	0.0d	0.1d	0.0c	0.1c	0.1d	0.1b	0.4 e
4 weeks NHV-1A with maize	0.0b	0.0c	0.1c	0.2c	0.2a	0.1c	0.2c	0.1b	0.9c
5 weeks NHV-1A with maize	0.1a	0.0c	0.2b	0.2c	0.1b	0.1c	0.2c	0.1b	0.9c
6 weeks NHV-1A with maize	0.1a	0.2a	0.3a	0.1d	0.2a	0.1c	0.2c	0.0 c	1.2b
7 weeks NHV-1A with maize	0.1a	0.2a	0.3a	0.2c	0.2a	0.1c	0.3b	0.1 b	1.5 b
Sole crop of Sombo	0.1a	0.1b	0.3a	0.2c	0.2a	0.1c	0.2c	0.1b	1.3b
3 weeks Sombo with maize	0.0b	0.0c	0.0d	0.0e	0.2a	0.2a	0.1d	0.2a	0.7 d
4 weeks Sombo with maize	0.0b	0.0c	0.0d	0.0e	0.2a	0.2a	0.3b	0.1b	0.8cd
5 weeks Sombo with maize	0.0b	0.0c	0.1c	0.1d	0.1b	0.3a	0.3b	0.1b	0.9c
6 weeks Sombo with maize	0.1a	0.0c	0.2b	0.4a	0.1b	0.3a	0.4a	0.1b	1.6ab
7 weeks Sombo with maize	0.1a	0.1b	0.3a	0.3b	0.2a	0.3a	0.3b	0.2 a	1.8 a

Means with the same letter(s) in the column are not significantly different ($P < 0.05$)

Appendix vi: Effect of intercropped maize population on number of flowers at 7 WAT (50 % flowering) and fruits per pepper plant at 10 WAT[1] in 2007

Treatment	No. of flowers per plant	No. of fruits per plant
NHV-1A intercropped with 53,333 maize plants/ ha	2.8c[2]	4.9d
NHV-1A intercropped with 35,556 maize plants/ha	4.4b	4.2 d
NHV-1A intercropped with 26,667 maize plants/ ha	4.4b	7.1c
NHV-1A sole crop	6.6ab	16.6 b
Sombo intercropped with 53,333 maize plants/ha	1.4c	3.9 d
Sombo intercropped with 35,556 maize plants/ha	6.2ab	12.1b
Sombo intercropped with 26,667 maize plants/ha	8.4a	14.5b
Sombo sole crop	9.8a	25.0a
SE ±	1.02	1.69

1. WAT= Weeks after transplanting
2. Means with the same letters in the column are not significantly different ($P < 0.05$) using Duncan's Multiple Range Test

Appendix vii: Effects of age of seedlings of peppers and intercropped maize on fresh fruit weight of chilli pepper at various harvests in 2008

Seedling transplant age	Weight at Harvest								Cumulative yield	
	1st	2nd	3rd	4th	5th	6th	7th	8th		
	---g/plant								---	t./ha
6-week old Sole crop of NHV-1A	2.8bc[1]	5.9b	7.0b	6.8c	7.2abc	2.9e	15.8a	3.8cde	52.4b	1.39b
3-week old NHV-1A + maize	0.0d	0.0d	0.0d	2.5e	0.0e	3.4e	5.3de	4.9bcd	16.0e	0.43e
4-week old NHV-1A + maize	0.0d	0.0d	3.9c	7.2c	6.3bc	5.0de	5.9cde	2.9cde	31.3c	0.85cd
5-week old NHV-1A + maize	2.2c	0.0d	6.8b	7.9c	5.1c	3.9e	5.3de	1.1e	32.3c	0.89cd
6-week old NHV-1A + maize	4.0ab	8.1a	12.6a	4.8d	9.0a	3.1e	9.2bcde	2.0de	52.8b	1.41b
7-week old NHV-1A + maize	3.1bc	7.0ab	12.1a	7.0c	6.2bc	5.4de	10.5bc	2.9cde	54.2b	1.45b
6-week old Sole crop of Sombo	2.2c	4.1c	10.4a	6.6cd	6.2bc	7.6cd	9.2bcde	6.2bc	52.5b	1.40b
3-week old Sombo + maize	0.0d	0.0d	0.0d	0.0f	6.6c	8.6bc	4.7 e	3.2cde	23.1de	0.62de
4-week old Sombo + maize	0.0d	0.0d	0.0d	3.4e	4.6de	11.2ab	9.2bcde	4.5bcd	32.9c	0.88cd
5-week old Sombo + maize	0.0d	0.0d	4.6c	2.9e	2.3e	11.1ab	10.0bc	4.0cde	34.9c	0.93c
6-week old Sombo + maize	2.7bc	0.0d	6.7b	13.2a	4.5de	11.9a	15.6a	7.2b	61.8ab	1.65ab
7-week old Sombo + maize	4.6a	2.1d	11.7a	10.7b	7.2abc	12.1a	11.5ab	10.4a	70.3 a	1.86a
SE ±	0.07	0.05	0.68	0.61	0.38	0.82	1.05	0.40	7.50	0.12

Means with the same letter(s) in the column are not significantly different (P < 0.05) using Duncan Multiple Range Test