EVALUATION OF SOME PEPPER VARIETIES FOR DRY SEASON PRODUCTION IN OWERRI SOUTHEASTERN NIGERIA

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CERTIFICATION

This is to certify that this research work entitled:"**Evaluation of some Pepper Varieties for dry Season Production in Owerri Southeastern Nigeria** was carried out by Ugo, Akuoma Basillia Precious in the Department of Crop Science and Technology, School of Agriculture and Agricultural Technology, Federal University of Technology, Owerri.

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DEDICATION

This research work is dedicated to the Almighty God, the giver of life, and my beloved mother Mrs I.E Ugo

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ABSTRACT

Pepper species are species of importance in the cuisines of southeastern Nigeria. Every pepper specie is cherished for its characteristic pungency, aroma or taste. Very few of these species are, however, grown in Owerri, southeastern Nigeria. The experiment was laid out as a 7 x 2 factorial in a randomized complete block design with three replications. The research was carried out at the Teaching and Research Farm of the Federal University of Technology, Owerri. Seven varieties of Pepper namely: Danjarawa pepper, Green pepper, Local pepper, Ngwa pepper, Nsukka yellow pepper, Shombo pepper and Tatase were evaluated for their responses to fertilizer 20:10:10 NPK at the rate of 0 kg ha^{-1} and 200 kg ha^{-1} in the late season in Owerri, South-Eastern Nigeria. Land preparation was manually done; Seeds were sown in drill 5cm apart in the nursery. Transplanting was done 5 weeks after sowing. Fertilizer application was done at first week after planting. Weeding: Was done when necessary. Data collected included: plant height per plant, number of leaves per plant, number of flowers per plant, days to 50% flowering and fruiting, number of fruits per plant, fresh fruit weight per plant, fruit diameter per plant, fruit length per plant and disease incidence in pepper plant. All data were subjected to analysis of variance, and means were separated using Least Significant Difference at 5% probability Level. Results show that application of NPK fertilizer significantly increased plant height, number of leaves, number of flowers, number of fruits, fresh fruit weight, fruit diameter and fruit length and reduced disease incidence. When fertilizer was not applied, days to 50% flowering, days to 50% fruiting were delayed for about 10 days and days to first harvest by 15 days. Among the species, the fruits of Green pepper and Shombo matured earliest at 94-95 DAP. Other species matured 100-138 DAP with Nsukka yellow pepper being the most late maturing (138 DAP). Results show that number of fruits per plant was highest in Local pepper (215) and least in Green pepper (16). Generally, total of 172- 2300 grams per plant was obtained from the experiment. All the pepper species performed well in the study environment in all the parameters measured and responded to fertilizer application. Shombo which had the highest yield of 2300 grams appear to be most promising among the species evaluated.

KEYWORDS: Danjarawa, Green pepper, Local pepper, Ngwa pepper, Nsukka yellow pepper, Shombo, Tatase, Fertlizer.

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CHAPTER ONE

INTRODUCTION

Capsicum species (pepper) belongs to the family *Solanaceae* (Night shade) that includes tomato, potato, tobacco and petunia (Greenleaf, 1986). The unripe fruits are green or purple in colour but turn red, orange, yellow or brown when ripe (Udoh *et al.*, 2005, OCED, 2006). Pepper is grown as a popular spice everywhere in the tropics (Berke *et al*., 2005) and very many distinct cultivars had been developed. It is one of the most important fruit vegetable in the tropics and the world second most important vegetable after tomatoes (Olaniyi and Ojetayo, 2010). Nigeria contributes 50% of total pepper production in Africa. Food and Agricultural Organization (.FAO) (2009) reported that Nigeria produced 695,000 metric tons from total area of 77,000 ha. Some species of Pepper increase the visual appeal of food and have wide spread uses in Nigerian Cuisines. Foods containing peppers, especially chili peppers, often have a strong aftertaste which is due to the presence of capsinoids (Grubben and Denton, 2004, Janick and Paull, 2008). They are mainly valued for their pungency and color, as well as their nutritional and medicinal qualities. They have wide spread uses in cosmetics and plant based insecticides (Dagnoko *et al.*, 2013). The crop is widely cultivated in Nigeria with very low yield compared with the yield in Western Europe. The low yield in Nigeria could be attributed to some production constraints which include disease, pest and poor management practices (Jaliya and Sani, 2006, Fekadu and Dandena, 2006). The bulk production of pepper occurs in the drier Savanna areas of Nigeria (Anon, 1985). In this zone, pepper production is mostly carried out with irrigation systems during dry season (September-March). The output of rainy season crop (June – September) in the zone is limited by pests and diseases (Alegbejo, 1999). Although pepper is a high value commodity, which has the potential for improving the income and the livelihood of thousands of smallholder farmers in Southern Nigeria, *Capsicum species* or varieties available for cultivation are limited.

Capsicum frutescens is cultivated so widely in Nigeria that Nigerians consider hot pepper as a traditional African vegetable or spice, while sweet pepper *Capsicum annuum* is seen as an exotic, newly introduced European vegetable. Sweet pepper, one of the most important greenhouse and summer vegetables in Western industrialized countries, is more adapted to temperate climates than hot pepper (El-Tohamy *et al*., 2006). Some hot pepper varieties, including aromatic hot pepper, are adapted to temperate climate, whereas the growth of bird pepper is considered too slow for outdoor cultivation in a temperate region (Idowu-Agida et al., 2012). Varietal information on the performance of the crop in terms of fruit yield in the agro-ecological zones of Southern Nigeria is lacking. Information on the production of pepper variety using inorganic fertilizer is necessary as pepper has high demand in the Southeastern Nigeria and at present dependent on the supply from the Northern part of the country. Since most pepper varieties do not do well on poor soils, soil amendment in the low soil fertility areas is an option. Inorganic fertilizers are easy to use, and rich in essential nutrients for plant use. Inorganic fertilizers though highly criticized for abuse and misuse, remains the most popular and convenient source of plant nutrients if we must meet the food demand of our ever increasing population. Evaluation of available varieties of pepper for growth and yield is therefore important in order to identify the varieties that are adaptable to the agroecology of owerri for optimum production and yield of the pepper species.

The aim of this study therefore, is to access the agronomic characteristics of the different cultivated varieties of *Capsicum grown* in Owerri, Southeastern Nigeria using inorganic fertilizer in Owerri .

This study was therefore carried out with the following objectives:

1. To assess the agronomic performance of different cultivated varieties of *capsicum* in Owerri, rainforest agroecology of Southeastern Nigeria.

2. To assess the effect of NPK fertilizer on Capsicum varieties grown in Owerri, Southeastern Nigeria.

CHAPTER TWO

LITERATURE REVIEW

2.1 Origin and Distribution of Pepper

Capsicum Species commonly referred to as pepper have been known since the beginning of civilization in the Western Hemisphere. The origin of *Capsicum* species extends from Mexico in North America to Bolivia in the South of Latin America, where they have been part of human diet since about 7500 BC (Mac Neish, 1964). Pepper was introduced into Spain in 1493, England in 1548 and Central Europe in 1585, by Spanish and Portuguese explorers and then from Europe it spread to Asia. Currently the crop is produced in various countries in all continents except Antarctica. The main peppers producing countries are India, Thailand, Japan, China, Mexico, Kenya, Sudan, Uganda and Nigeria (Amusa *et al*., 2004, Ekefan and Ngishe, 2011). India is the world leading country in pepper production, followed by China and Indonesia (Berk, 2002, Ekefan and Ngishe, 2011).

2.2 Botany of Pepper

Pepper belongs to the Family Solanaceae. The Family of *solanaceae* contains about 90 genera and nearly 3000 species. The genus *Capsicum* consists of approximately 22 wild species and is further classified into the division Magnoliophyta, class magnoliopsida, order solanates and family Solanaceae (Heiser and Smith, 1953). There are over 200 local selections of pepper grown in Nigeria but certainly no cultivars are recommended for cultivation in this agroecological zone for optimum yield (Erinle, 1989). Also, in the future, many landraces are likely to disappear as African growers switch to improved cultivars. Consequently, there is the need to collect *Capsicum* landraces for conservation in Gene bank (Grubben and Tahir, 2004). Cultivated peppers are all members of the world *capsicum* species. There is an estimate of 1,600 different varieties of pepper throughout the world with only five main domesticated species that includes *C. annum* L., *C. frutescens* L. C. *Chinense,* C. *baccatum* L.*, and C. pubescens* R. (Bosland and Votava, 2000). *Capsicum species* are mostly erect while some others are climbers. They vary in size, shape, color, flavor and degree of hotness (from mild to very hot) (Tong and Bosland, 2003). *Capsicum species* have a solitary (single) flower that starts at the axils of the first branching node with subsequent flowers forming at each additional node. While flower differentiation is not affected by day length, the most important factor determining differentiation is air temperature, especially at night. The capsicum flower is complete, bisexual, hypogenous and usually pentamerous (Bosland and Votava, 2000). Depending on the environmental conditions and variety, the period of receptivity of the stigma is 5-8 days, from several days before anthesis to fewer days afterwards, with maximum fertility on the day of anthesis (Aleemullah *et al*., 2000). The most actively growing organ of a pepper plant after flowering is the fruit. The fruit is ordinarily seeded, but parthenocarpic forms exist. The seed set affects development and subsequent growth of the fruit. On average there is a direct linear relationship between the number of seeds per fruit and final fruit size, until saturation at perhaps over 200 seeds per fruit (Marcelis *et al*., 1997). Fruits of typically cultivated pepper species reach the mature green stage in 35-50 days after the flower is pollinated. The fruits are characterized as non-climacteric in ripening (Bosland and Votava, 2000). The fruit is a berry and may be green, yellow, or red when ripe (OCED, 2006). *Capsicum species* are mostly herbs with branched tap roots. The stem is herbaceous, erect and hairy. Leaves are alternate, opposite in flora region, simple and estipulate. The varieties and cultivars of *Capsicum annuum* are classified on the basis of their fruit shapes. Fruits form as a result of the development and differentiation of the gynoecium after fertilization. They are therefore the product of late morphological and structural modifications in the carpel (Cutler *et al.*, 2008). The genus *Capsicum* (sweet and hot pepper) shows intra- and inter-specific diversity in fruit type, colour, shape, taste, and biochemical contents (Dagnoko *et al.*, 2013, OCED, 2011). The species encompass a wide variety of shapes and sizes of peppers, both mild and hot, ranging from bell peppers to chili peppers (Zang *et al.*, 2002). Fruit characters have been extensively used in the taxonomy of the family *Solanaceae* (Pabon and Litt, 2011). *Capsicum* terminology is very confusing with pepper, chilli, chile, chili, aji, paprika, and *capsicum* all used interchangeably to describe the plant (Dewitt and Bosland, 2009, Mcmullan and Livsey, 2013). *Capsicum species* are tender annual or perennials. They have straight woody stems and single, star shaped, white flower in the axils of the leaves. The flowers are followed by pods and vary in shapes and sizes. They are green at first and gradually change to yellow. They contain many flat, kidney shaped seeds which are very hot. It is a perennial shrub plant that grows to 30 cm to 180 cm high (Idowu- Agida *et al*., 2012, Okwulehie and Okoli, 1999). Branches are angular, usually enlarged and slightly purple at the nodes (Nwachukwu *et al.*, 2007). Petioles are medium in size, peduncles slender, often in pairs and longer than fruit. The calyx is cup shaped, and clasping base of fruit which is red, ovate and from 1 to 4 cm long. Seeds are small and flat. Seed remains viable for 2–3 years without special conservation methods if kept dry at room temperature, but it rapidly loses viability if stored at high temperatures or humidity (Denton *et al*., 2000). Seed dormancy may occur to a limited extent during some months after harvest, especially if seed is harvested from immature fruits.

Seeds germinate 6–21 days after sowing. Continuous flowering starts 60–90 days after sowing and flowers open 3 hours after sunrise and are open for 1–3 days (Nwachukwu *et al.*, 2007). Although normally self-pollinated, 2– 90 % cross-pollination may occur, depending on activity of bees and thrips collecting nectar and pollen. On average, cross-pollination is about 15%. Certain cultivars show strong heterostyly, a polymorphism of flowers having unequal stamen and style, causing a high level of cross-pollination. In the bud stage the stigma is receptive, but the pollen is not yet mature, so hand pollination is easy. Under normal circumstances 40–50 % of the flowers set fruit. Fruits begin to mature 4–5 weeks after flowering, and can be picked every 5–7 days. The peak harvest period is 4–7 months after sowing. In the absence of frost and diseases growth continues and plants may become perennial (Paulo, 1994).

2.3 Climate and Soil Requirements

Rain fed pepper crop, requires an annual rainfall of 650 to 1250 mm with relative humidity of 75 to 88 % (Messiaen, 1992). Rainfall greater than this range leads to poor fruit set and rotting of fruits (Purseglove *et al.*, 1981). Peppers require full sunlight for its growth; they are adapted to growing at altitudes up to 2000 cm (Tindall, 1983). *Capsicum annuum* is a tropical species, but adapted to cultivation in temperate regions during the summer or, in protected cultivation, year-round. Adverse effect of different night temperatures at constant day temperature on fruit set. Optimal temperatures for growth and production are between 18 and 30°C and under partial shade at 50 to 60 % of tropical solar radiation than full daylight (Messiaen, 1992). Seeds germinate best at 25–30°C. Flowering is delayed if day temperatures drop below 25°C and flower buds abort if night temperatures are too high (above 32°C). Pollen viability is significantly reduced at temperatures above 30°C and below 15°C. Cool nights down to 15°C favor fruit setting. Sweet pepper needs cooler nights and is clearly more adapted to cooler growing conditions than hot peppers. Adequate water supply is essential as water stress can cause abscission of fruits and flowers, especially when it occurs during flowering (Matta and Cotter, 1994). Sweet pepper cultivation is difficult in the hot and humid tropical lowland. *Capsicum* is day-neutral, but certain forms may show photoperiodic responses as a long days may slightly delay the first flowering (Idowu-Agida *et al.,* 2012). Pepper tolerates shade up to 45 % of solar radiation, although shade may delay flowering. It is moderate moisture loving perennial tropical crop often grown as annual (Grattan and Grieve, 1993) that bears fruits of different sizes. *Capsicum species* grow on almost all soil types, but is most suited to well-drained sandy or loamy soils, rich in lime, with a pH of 5.5–6.8 and a high water retention capacity. Severe flooding or drought is injurious. Water logging causes poor fruit setting, diseases and fruit rotting. *Capsicum species* are moderately sensitive to soil salinity and the land should be level to 0.01- 0.03 % slope to allow adequate drainage and prevent root diseases.

2.4 Varieties of Pepper

There are many cultivars with wide variations in morphological characteristics (Ado, 1988, 1990) useful in pepper improvement programmes especially for yield and fruit quality. *Capsicum* has a great genetic diversity which has been little exploited (Pickersgill, 1989; Manju and Sreelathakumary, 2002; Grubben and Tahir, 2004). Diverse pepper (*Capsicum* species) genotypes have been widely grown in Nigeria over centuries. More than 695,000 tons (annual average) of dry fruit of *Capsicum species* are produced for local consumption in the country and for export. Others traits that distinguishes the varieties include, number of branches per plant, plant height, number of fruits per plant, days to maturity, fruit length and single fruit weight (Lemma *et al., 2008). Capsicum annum* and *Capsicum frutescens* are the most common species in Nigeria. Heiser and Smith (1953) reported two *Capsicum species* cultivated as vegetables. All varieties of pepper are obtained from the breeds of either *capsicum annum* or *capsicum frutescens. Capsicum annum* is not known in a wild state. The species of *capsicum annum* commonly cultivated are known as sweet pepper, bell pepper, cherry pepper and green pepper (Messiaen, 1992). *Capsicum frutescens* on the other hand occurs in the wild though has become domesticated in many parts of the tropics. Species commonly cultivated in ca*psicum frutescens* are known as bird eye pepper, red pepper and Tabasco pepper (Heiser and Smith 1953). In Nigeria, Bird peppers or local pepper (*Capsicum frutescens*), Cayenne pepper or red pepper—Shombo (*Capsicum frutescens*), Green pepper (*Capsicum annum*), Tatase (*Capsicum annum*) and Habenero *(Capsicum chinesis),* are widely grown. The fruits of these types of pepper vary in size, color, shape, and pungency. Both bird pepper and cayenne pepper are used either fresh or dried, while Tatase and Green pepper are mostly used fresh. The genus *Capsicum* (sweet and hot pepper) shows intra- and inter-specific diversity in fruit type, colour, shape, taste, and biochemical content (Dagnoko *et al.*, 2013).The species encompass a wide variety of shapes and sizes of pepper, both mild and hot, ranging from bell peppers to chili peppers.

2.5 Uses of Pepper

Capsicum species have been incorporated into most of the world's cuisines. They are used as pungent spices for domestic culinary purposes and by food manufacturing industries for seasoning of processed foods, hot sauce and in pickling (Tindall, 1983). The fine powdered pungent product is an indispensable flavoring and coloring ingredient in the common traditional sauce whereas the green pod is consumed as a vegetable with other food items. Pepper has increased in popularity, value and importance over a long period, thus making it an indispensable part of the daily diet of millions of Nigerian. Pepper is normally used as a spice in the preparation of soup and stew when cooked with tomatoes and onions. Sweet peppers are very often used as a bulking agent in ready-made meals and take-away foods, because they are cheap, have a strong flavour, and are colourful (Janick and Paull, 2008). Its potential uses and benefits to mankind cover many areas such as food and nutrition, medicine, cosmetics, plant based insecticides, and income (Dagnoko *et al.*, 2013). The fruits of nonpungent (sweet) varieties are eaten raw in salads or cooked as a vegetable (Janick and Paull 2008). According to Bosland and Votava (2000), sweet pepper and hot pepper, like tomato and eggplant are rich in Vitamins A and C. They are also good sources of vitamin B2, potassium, phosphorus and calcium (Anonymous, 1998). It has been found that as hot peppers mature, the Pro-vitamin A (B Carotene) and ascorbic acid increase. Additionally, the fruit of pepper contains 90 % water, 20 % protein, 0.5 % fat, 6.0 % carbohydrate, 1.0 % fiber, 0.02 % calcium, 0.001 % iron, 0.0006 % thiamine, 0.0008 % riboflavin, 0.001 nicotinamide and 0.15 % ascorbic acid (Knott and Deanon, 1967, Chaudhury, 1975; Tindall, 1975; Ekefan and Ngishe, 2011). The dried fruits are ground to a powder (paprika) and used as an ingredient in curry powder (Dewitt and Bosland, 2009, Idowu –Agida *et al*., 2012). It can also be used as a condiment and extensively in flavouring of processed meat, coloring certain food preparation and also used for medicinal purposes (Alabi, 2006). Peppers are of great importance in native medicine, and capsaicin is used in modern medicine—mainly in tropical medications—as a circulatory stimulant and analgesic. *Capsicum* contains an alkaloid that as a digestive stimulant is used in ointment for relief of arthritic and neuropathic pains. In more recent times, an aerosol extract of capsaicin, usually known as capsicum or pepper spray, has become widely used by police forces as a nonlethal means of incapacitating a person, and in a more widely dispersed form for riot control, or by individuals for personal defense (Ekefan and Ngishe, 2011). For example, anti-mugger aerosols with chilies pungency as the active ingredient have replaced mace and tear gas in more than a thousand police departments in the United States. The spray will cause attackers to gasp and twitch helplessly for 20 minutes (Bosland and Votava, 2000). According to Bosland and Votava (2000), pepper is the most recommended tropical medication for arthritis. The pharmaceutical industry uses capsaicin as a counter-irritant balm (cream), for external application of sore muscles (Thakur, 1993). Creams containing capsaicin have reduced pain associated with postoperative pain for mastectomy patients and for amputees suffering from phantom limb pain. Prolonged use of the cream has also been found to help reduce the itching of dialysis patients, the pain from shingles and cluster headaches. It is not only their nutritional quality and medicinal value that makes pepper an important food crops, peppers also stimulate the flow of saliva and gastric juices that serve in digestion (Alicon, 1984). Peppers raise body temperature, relieve cramp, stimulate digestion, improve the complexion, reverse inebriation, cure a hangover, soothe gout and increase passion. Pepper in vegetable oils, as a horticultural product can be used in gardening as a natural insecticide.

2.6 Cultivation and Output of Capsicum Species

The seeds of pepper are sown shallowly in nursery beds or flats, broadcast or in rows 20 cm apart. Direct seeding is rarely practiced. Seedbeds should be protected against rain and direct sun. They are usually covered with straw, palm leaves or plastic. For better production, seedlings may be transferred to seedling pots (soil blocks, plastic pots, paper cups, banana leaf-rolls) when the cotyledons are fully expanded. In the nursery, starter fertilizer is recommended at 2-week intervals. Transplants are planted out in the field when they have 8–10 leaves, usually 30–40 days after sowing. Restriction of watering and removal of shade protection, starting a week before transplanting, is recommended to produce hardy transplants. Transplanting should be done during cloudy days or in the late afternoon; when planted in dry soil, irrigation should be applied (Erinle, 1989). *Capsicum* is suitable for intercropping and is then sometimes sown directly in the field. A normal spacing is 50–80 cm between the rows and 20–40 cm in the rows, with densities of 50,000 - 80,000 plants per ha. (Idowu-Agida et al., 2012). FAO statistics estimate world production of capsicum peppers in 2001 at 21.3 million tons from a harvested area of 1.6 million ha (average yield 13.4 tons ha^{-1}). India is the largest producer with 10 million tons, followed by China (1.9 million tons) and Mexico (1.5 million tons). Turkey is probably erroneously represented with only 50,000 tons. Production in tropical Africa is estimated at 1 million tons, with Nigeria producing 715,000 tons from 90,000 ha and Ghana (270,000 tons from 75,000 ha). According to Salter (1985), the production and consumption of pepper steadily increased worldwide during the 20^{th} century due to their roles as both vegetable and spices. Just like their Solanaceous cousins, tomato and potatoes, peppers have rapidly become important components of diverse cuisine around the world. This is reflected in the large acreages devoted to their production in such countries as India, Mexico, China, Korea, USA and Nigeria. In addition, interest in both sweet and pungent types of pepper is growing in many countries not traditionally associated with spicy cuisines. Protected culture has developed in northern latitude countries such as Holland and Canada and also in Mediterranean countries such as Spain, and Israel, in order to meet the increasing demand (Wien, 1997).

2.7 Fertilizer Requirements

Plants requirement for growth and yield includes water, suitable light, carbon dioxide and several other elements of which nitrogen phosphorus and potassium are most important, and to get high yields, fertilizer containing these elements must be applied to satisfy plants need (Lammers, 1989). The sole use of inorganic fertilizer has been helpful under intensive agriculture in the tropical ultisols because it aggravates soil degradation (Sharma and Mittra, 1991). The degradation is brought about by loss of organic matter which consequently results in soil acidity, nutrient imbalance and low crop yields (Ibeawuchi, 2007). The amount of fertilizer to be applied depends on soil fertility, fertilizer recovery rate, and organic matter, soil mineralization of nitrogen (N), and soil leaching of Nitrogen (Berke *et al.*, 2005). Most soils in this agroecology as a result of cultivation over time, have suffered nutrient depletion such that high yields can only be attained through the judicious application of inorganic fertilizers (Akinride, 2006). The invention of chemical fertilizers has allowed man to raise soil productivity higher than could be attained by relying on natural recycling process. Fertilizer requirements vary with soil type and previous crop history. The major nutrients normally used on peppers are nitrogen and phosphorus. The first nitrogen application and all the phosphorus can be broadcasted before leveling the field. Alternatively, phosphorous can be banded at 8-10 cm below the seed. And thus a balanced nutrient level is required for maximum production In Nigeria, the recommended fertilizer rate for pepper species is 200 kg ha^{-1} for nitrogen. This is the most efficient method of applying phosphorus. In a nutrient practice in semi arid areas of Senegal, 10 ton ha^{-1} organic manure, 200 kg ha^{-1} N, 100 kg ha^{-1} P_2O_5, and 200 kg ha^{-1} K_2O are applied on a light soil (Bosland and Votava, 2000). It is believed that phosphorus results in a better yield and more red colored fruit (Matta and Cotter, 1994). During growth, further nitrogen may be applied to achieve more yields. Too much nitrogen on the other hand can over stimulate growth, resulting in large plants with few early fruits, or delaying maturity and increasing risk of serious plant or pod rots (Bosland and Votava, 2000). Pepper equally requires sulphur and magnesium for increase in yield.

2.8 Diseases of Pepper

The main diseases that directly cause low yield in pepper are virus complex like Pepper Mottle Virus, Fungal diseases including; damping off (*Rhizoctonia solani*, *Pythium* spp, and *Fusarium* spp), powdery mildew, blight (*Phytophthora capsici*) and fruit rot (*Vermicularia capsici*), Bacterial Soft Rot **(***Erwinia carotovora* pv), Rhizoctonia Root Rot (*Rhizoctonia solani*), bacterial wilt (*Pseudomonas solanacearum*), anthracnose or Ripe Rot (*Collectotrichum capsici*) (Alegbejo, 1999). The diseases of Bacterial Soft Rot **(***Erwinia carotovora* pv), Rhizoctonia Root Rot (*Rhizoctonia solani*) cause rotting the roots and the underground portion of the stem and in severe conditions causes death, some of them cause small, yellow, slightly raised spots appear on young as well as on older leaves, some attacks the crop at seedling stage, as a result followed by yield loss. (Tindall, 1983, Amusa *et al*., 2004). Therefore, the control measures includes, the use of cultural practices, resistant varieties, rotation of crops, in the severe case chemical action is relevant.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Description of the Study Area

The experiment was carried out in the Teaching and Research Farm of the School of Agriculture and Agricultural Technology, Federal University of Technology, Owerri, located $5^o20'$ N and longitude $7^o0'$ E at an elevation of 55 meters above level. Owerri is in the tropical rainforest zone of southeastern Nigeria. The vegetation of the area is generally rainforest (Nwaogu *et al.*, 2004). The area has a bimodal pattern of rainfall with peaks at July and September. The area has a minimum and maximum annual temperature of 20^oC and 32^oC respectively and mean annual rainfall of 2500 mm and relative humidity of 85-89 % (Nwosu and Adeniyi, 1980). The soils are formed from precarnbarian custal plain sands and are heavily leached and therefore have low organic matter content, low nutrients (Eshett, 1993). The soil is predominantly utisols, which are strongly acidic, coarse textured, highly leached upland soils occurring further south of south eastern Nigeria (Ofomata, 1975).

3.2 Soil Analysis

Soil samples were collected at 0 – 15 cm depth from seven locations on the plot using a soil auger. The samples were bulked, air – dried and sieved to pass through a 2 mm mesh sieve. Samples were analysed for physico-chemical properties in the laboratory.

3.3 Experimental Materials and Nursery Activities

The seven (7) cultivated varieties of pepper were collected from the National Seed Service Sub-Section Umudike, Umuahia in Abia State. Top soils were collected from the farm, 24 hours after wetting the spot and sterilized using steam- heating method in a cut drum. The sterilized top soil was used to compound the nursery soil by mixing 3 parts of soil with 2 parts of organic manure and 1 part of river sand into Nursery trays, Pepper seeds were sown after 24 hours on the 8th of October, 2013, in drill drawn 5 cm apart. The drills were 10 mm deep and were sown thinly in drills with 3-4 seeds per 25 mm to avoid overcrowding. The drilled seeds were covered gently with river sand and then were watered heavily. The nursery trays were covered with black polythene sheets for 4 days to increase warmth and enhance the speed of germination. Seeds germinated after 7- 10 days. Irrigation was carried out daily as needed using a watering can until the transplanting at 4th week after sowing.

The site was mapped out with the measuring tape, ranging poles and pegs, and was later cleared manually, using machetes, hoes and spade. The plot was laid out with the aid of measuring tape and pegs. The size of the experimental area used was 26 m x12 m (312 m^2). The size of the individual bed was 1.6 m x 2.5 m. The replicates were separated from each other by 1m and each plot had 1.5 cm apart separating them, with a total of 42 beds. This was followed with raising the beds, which were equally done manually using shovels and hoes on the 8th November, 2013. Seedlings were transplanted into the beds at the spacing distance of 40 cm between the plants and 50 cm between the rows on the 13th of November 2013. There were four rows per plot and five plants per row with a total of twenty plants per plot. The treatments used were seven varieties of pepper and two levels of fertilizer at the rate of zero levels and 200 kg ha^{-1}.

Table 1: Cultivated Species of Pepper Used in the Study, Showing their Indigenous, Common and Botanical Names.

Pepper Species	English Name	Common Name
Capicum. Frutescen	Cayenne	Shombo
C. frutescen	Pequin	Local pepper
C. annum	Poblano	Tatase
C. annum	Carlifornia wonder	Green pepper
C. chinensis	Yellow habanero	Nsukka yellow pepper
C. chinensis	Red habanero	Ngwa pepper
C .chinensis	Scotch bonnet	Danjarawa

3.4 Experimental Design

The fourteen treatment combinations were laid out in a 7 x 2 factorial experiment in a randomized completely block design (RCBD) with three replications. The field layout is presented in figure 1. The factors comprised: 7 pepper species (as shown in Table 1) and two fertilizer levels, zero 0 kg ha^{-1} and 200 kg ha^{-1}. Fertilizer application was done using NPK 20:10:10 at the rate of 200 kg per hectare at first Week After Transplanting (WAT). The application of fertilizer was followed by daily irrigation; irrigation was changed to 3 times a week afterwards. Weeding was done manually using hoe when necessary. Pests control was done by hand picking. Other necessary agronomic and horticultural practices applicable to pepper cultivation were also applied in the field.

3.5 Data Collection

Data were collected from 3 weeks after transplanting on the various parameters from the middle six sample plants in central rows.

Plant height of pepper was measured in cm using a meter rule. Measurement was made from the ground level to the top most growth points of the pepper plants; the mean height from six sample plants per plot was determined. The number of leaves and flowers per plant in the six sample plants determined by counting.

Days to 50 % flowering were determined, that is the number of days taken for 50 % of the sampled plants to flower. Days to 50 % fruiting was determined by taken record of the number of days taken by at least 50 % of the sampled plants to fruit.

Days to first harvest were determined as the number of days taken for at least 50 % of the fruits of the sampled plants to reach maturity (hardening of seeds). The numbers of primary, secondary and tertiary branches per plant of the sample middle row plants were determined by counting. The number of fruits from individual plants at each harvest was counted. Fresh weight of harvested fruit from the sample plants was determined with the use of electronic weighing scale.

Fruit length per plant measured in centimeter was determined by measuring the length of fruits from the point of attachment to the peduncle to the tip of the fruit. Fruit diameter was measured in cm using venier caliper.

Disease Incidence **(%):** The number of infected plants was considered and Percentage of plants infected with bacterial wilt incidence estimated as suggested by Agrios (2005):

Disease Incidence

Diseases incidence was measured as a percentage of diseased plants in the experimental plots, while disease severity was scored at intervals on a 5 point scale (Nwufo and Ihejirika, 2008).

$$Disease\ Incidence\ (\%) = \frac{Number\ of\ Infected\ Plant\ per\ plot}{Total\ Number\ of\ Plants\ per\ Variety} \times \frac{100}{1}$$

3.5.1 Statistical Analysis of Data

Data were subjected to analysis of variance (ANOVA), treatment means were compared using Least Significant Different at 5% level of probability using Genstat version 2015.

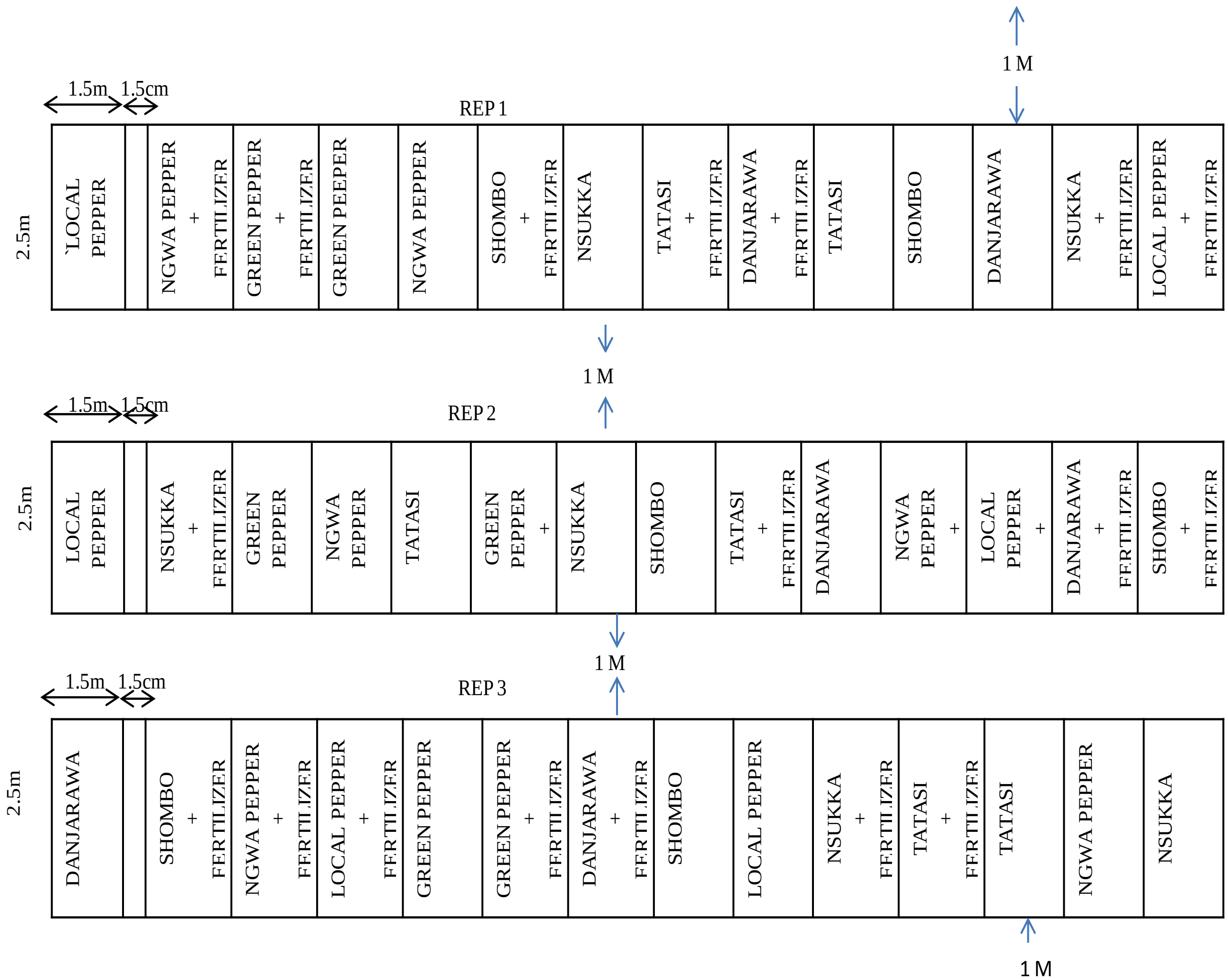

Figure 1: field layout of the experiment.

Table 2: Scoring Scale for Disease Severity

Severity estimation (%)	Score	Interpretation
0	0	No infection
1-20	1	Slight infection
21-40	2	Moderate infection
41-60	3	severe infection
61-80	4	Very severe infection
81-100	5	Completely

Source : Nwufo, M. I and Ihejirika G. O (2008)

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 RESULTS

4.1 .1 Physico – Chemical Properties of the Experimental Soil

The soil physico-chemical analysis carried out before planting (Table 3) indicated that the soil of the experimental site was loamy sand with moderate acidic pH, low organic matter content, low total nitrogen and potassium, but high in phosphorus.

4.1.2 Effects of Fertilizer application and pepper Varieties on Plant Height

The application of NPK fertilizer had significant effect on pepper plant height at 3 Weeks after Transplanting (WAT) (Table 4). Results show that plots that received 0 kg ha^{-1} had taller pepper plant (10.02 cm) compared to plots where 200 kg ha^{-1} was applied which produced (7.00 cm) pepper height. Varieties also, significantly affected plant height with Local pepper having significantly taller pepper plants (11.33 cm), although it was not significantly different from the plant height of pepper of Shombo (11.10 cm). Green pepper had the shortest plants (5.47 cm), but this was not significantly different from the heights of Tatase (6.60 cm) and Danjarawa (6.18cm). Analysis of variance (ANOVA) also showed that the interaction of fertilizer with varieties significantly affected pepper plant height. Means separation, however showed that in within varieties, a significant interaction effect that was attributable to the response of Local pepper to fertilizer application. In this instance Local pepper varieties was significantly taller (17.90 cm) when no fertilizer was applied compared to (4.77 cm) height when 200 $kgha^{-1}$ NPK fertilizers were applied.

Table 3: Physico-chemical properties of the experimental soil (0 – 15 cm) before the experiment

Parameter	Sand	Silt	Clay	OM	N	BS	P	K	Mg	Ca	Na	CEC	Ph
	← Percentages					→	mg/kg	←		cmolkg^{-1}		→	
Value	77.8 6	13.28	8.8	1.29	0.23	63.35	11.76	0.10	1.10	0.64	0.32	4.73	5.20

Table 4: Effects of Fertilizer and varieties on plant height (cm)

		3WAT			7 WAT			11WAT			15WAT		
		……………… NPK Fertilizer (kgha^{-1})………………											
Capsicum	Varieties	0	200	Mean	0	200	Mean	0	200	Mean	0	200	Mean
Danjarawa	Pepper	7.03	5.33	6.18	22.63	30.57	26.60	34.37	45.50	39.93	49.53	59.17	54.35
Green	Pepper	5.72	5.23	5.47	7.43	14.20	10.82	11.67	14.67	13.17	12.27	14.67	13.47
Local	Pepper	17.90	4.77	11.3	26.47	38.03	32.25	39.47	51.97	45.72	44.50	56.20	50.35
Ngwa	Pepper	10.07	8.57	9.32	27.10	39.17	33.13	37.57	50.70	44.13	47.50	58.20	53.08
Nsukka yellow	Pepper	9.63	9.43	9.53	26.70	35.17	30.93	35.90	45.17	40.53	51.23	62.70	56.97
Shombo	Pepper	12.03	10.17	11.10	29.80	45.30	37.55	42.87	53.83	48.35	53.33	68.20	60.77
Tatase	Pepper	7.77	5.47	6.60	8.20	13.93	11.07	33.17	45.97	39.50	37.57	50.37	43.99
Mean		10.02	7.00		21.19	30.91		33.57	43.97		42.28	52.82	
LSD for	Fert	0.78			1.17			1.16			1.05		
LSD for	Var	1.46			2.19			2.18			1.96		
LSD for	Fert x var	2.07			3.11			3.08					

At 7 WAT, Fertilizer application significantly affected the plant height in (Table 4) with plot that received 200 kg ha^{-1} having taller plant height (30.19 cm) as compared to the plots that received 0 kg ha^{-1} of NPK Fertilizer which recorded (12.19 cm). The effect of varieties was significant on plant height with Shombo having significantly the taller pepper plants (37.55 cm), compared to other varieties, although plant height (10.82 cm) was shortest in Green pepper. This was not significantly different from the height (11.07 cm) of Tatase. The interaction effect of fertilizer with varieties significantly affected plant height with Shombo having taller plants (45.30 cm) when 200 kg ha^{-1} NPK was applied. The lowest plant height (7.43 cm) was recorded in Green pepper at 0 kg ha^{-1}.

At 11 WAT NPK fertilizer application had significant effect on pepper plant height with plots that received 200 kg ha^{-1} NPK having significantly taller plants (43.93 cm), compared to plots that received no NPK fertilizer (33.57 cm). (Table 4) varieties, however, significantly affected plant height with Shombo having the significantly taller (48.35 cm) pepper plants, followed by the plant height of (45.72 cm) of Local pepper. Among all varieties, Green pepper had the significantly shorter pepper plant (13.17 cm). Results also showed that the effects of fertilizer application with varieties interaction were significant on pepper plant height. Mean separation shows that the significant interaction effect was attributable to the effects of fertilizer rates within varieties which resulted in Green pepper having the significantly shorter plants at both fertilizer application rates and Shombo having significantly taller plants equally at both fertilizer application rates. The effects of fertilizer had a significant effect on plant height at 15 WAT, Results presented in (Table 4) show that when 200 kg ha^{-1} NPK fertilizers was applied, plants were significantly taller (52.82 cm) compared to 42.28 cm plant height produced when no fertilizer was applied. Varieties, however, significantly affected plant height with Shombo having significantly taller pepper plants (60.77 cm), and Green pepper (13.47 cm), relative to other pepper varieties. Analysis of variance also showed that interaction of fertilizer with varieties had significantly resulted to increase in plant height while Green pepper had the shorter plant height (12.27 cm) at 0 kg ha^{-1} and when 200 kg ha $^{-1}$ (14.67 cm) was applied.

4.1.3 Effects of fertilizer and Varieties on number of leaves

The effect of fertilizer application was significant on number of leaves of pepper varieties at 3 WAT (Table 5). Plots that received 0 kg ha^{-1} producing more number of leaves (16.40 leaves per plants), compared to plots that received 200 kg ha^{-1} that produced fewer number of leaves (13.22 leaves per plants). Pepper varieties, However significantly affected the number of leaves of pepper with Shombo having significantly higher number of leaves (22.63 leaves) compared to other varieties. On the other hand, Green pepper had significantly fewer leaves (7.23 leaves per plant) compared to other varieties. Mean separation showed that the application of fertilizer resulted to increase in number of leaves in the within varieties of Local pepper, Ngwa pepper, Nsukka pepper and Shombo, while the effect of fertilizer with varieties was not significant on other varieties. Among the varieties, application of NPK fertilizer resulted into fewer leaves in Tatase and Green pepper when 200 kg ha $^{-1}$ or no fertilizer was applied.

ANOVA showed that at 7 WAT, application of fertilizer was significant on number of leaves per plant. Results presented in Table 5 show that application of 200 kg ha^{-1} NPK fertilizer produced significantly more leaves (77.2 plants) compared the 59.0 leaves per plant produced when NPK fertilizer was applied. Varieties also significantly affected the number of leaves of pepper with Shombo significantly having more leaves (104.6 leaves per plant), compared to other varieties, although this was not significantly different from the number of leaves per plant in Local pepper (90.7). Among all the varieties, the 19.7 leaves per plants produced by Greepepper were significantly least compared with other pepper varieties. The interaction of fertilizer with varieties was significant on the number of leaves. Analysis of variance (ANOVA) showed that interaction of fertilizer with varieties significantly affected the number of leaves of pepper. Mean separation however showed that in within varieties, the significant interaction effect was attributable to the response of Local pepper to fertilizer application. Local pepper had more (112.5 leaves per plants) at the fertilizer rate of 200 kg ha^{-1} compared to (69.4 leaves per plants) produced when no fertilizer was applied. Among the varieties, Green pepper equally had fewer leaves at the both fertilizer rates.

Fertilizer application significantly affected the number of leaves produced per plant at 11 WAT. Plots that received 200 kg ha^{-1} NPK fertilizer produced more leaves (310.60 leaves per plant). Compared to 243.20 leaves per plants produced by plots that received no NPK fertilizer. Varieties significantly affected the number of leaves of pepper with Shombo having significantly more leaves (414.60 leaves per plant), compared to other varieties. This was however not significantly different from the 330.50 leaves per plant produced by Local pepper. Significantly lower number of leaves was produced by Green pepper (21.40 leaves per plant) as compared to other varieties. Analysis of variance also showed that the interaction of fertilizer with varieties had significant effect that was attributed to the response of all the varieties except Green pepper that had lesser number of leaves when 200 kg ha^{-1} or when no NPK fertilizer was applied . At 15 WAT, the effects of fertilizer application and varieties were significant on number of leaves per plants; Table 5 shows that significantly more leaves (408.92 leaves per plant) were produced at plots that received 200 kg ha^{-1} compared to when no fertilizer was applied where (369.08 leaves

Table 5: Effects of Fertilizer and Species on Number of leaves

		3WAT			7 WAT			11WAT			15 WAT		
		……………NPK Fertilizer (kg ha^{-1})……………											
Capsicum	Varieties	0	200	Mean	0	200	Mean	0	200	Mean	0	200	Mean
Danjarawa		17.77	16.13	16.95	43.70	58.30	51.30	259.50	316.7	288.10	417.03	432.87	424.95
Green	Pepper	8.23	6.23	7.23	14.10	25.40	19.70	17.50	25.50	21.40	17.83	21.93	19.33
Local	Pepper	18.43	14.33	16.38	69.40	112.50	90.70	247.70	413.20	330.50	490.07	525.57	507.82
Ngwa	Pepper	20.30	15.67	17.98	76.70	91.70	84.20	283.30	343.90	313.60	452.53	525.73	475.63
Nsukka yellow	Pepper	15.87	12.10	13.98	57.70	69.30	63.50	211.10	259.30	235.20	414.07	444.60	429.33
Shombo	Pepper	25.40	19.87	22.63	93.50	115.80	104.60	376.70	452.50	414.60	513.60	556.60	535.10
Tatase	Pepper	9.23	8.20	8.72	58.40	67.30	62.80	306.40	363.10	334.70	278.43	356.13	317.28
Mean		16.46	13.22		59.00	77.20		243.20	310.60		369.08	408.92	
LSD for	Fert	1.19			8.84			17.84			2.77		
LSD for	Spp	2.23			16.54			33.38			5.18		
LSD for	Fert x spp	3.15			23.40			47.21			7.33		

per plant) were produced . Varieties significantly affected the number of leaves of pepper with Shombo producing significantly more leaves (535.10 leaves per plant), while Green pepper significantly had fewer leaves (19.88 leaves per plant). The interaction of fertilizer with varieties equally significantly affected the number of leaves with interaction effect that was attributed to the response of all the varieties except Green pepper.

4.1.4 Effects of Fertilizer and Varieties on Branching

4.1.4.1 Primary Branches

The application of fertilizer had no significant effect on Primary branches at 3 WAT. Varieties however significantly affected the number of primary branches per plants with Local pepper having more (1.67) primary branches (Table 6). Mean separation showed that the interaction effect was due to the response of Local pepper to fertilizer application. Analysis of variance showed that the effect of fertilizer application had a significant effect on primary branches per plants at 7 WAT. Results presented in Table 6 shows that when 200 kg ha^{-1} NPK fertilizer was applied, significantly more primary branches (10.68) were produced compared to (4.78) primary branches produced when 0 kg ha^{-1} NPK fertilizer was applied. Varieties significantly affected the number of primary branches with Shombo having the significantly highest number (12.87) of primary branches compared to other varieties. The interaction of fertilizer with varieties was significant on the number of primary branches. Mean separation showed that primary branches increased in all the varieties with fertilizer application.

At 11 WAT, the effect of fertilizer application was significant on the number of primary branches with plots that received 200 kg ha^{-1} producing more number of primary branches

(16.31) compared to the plots that received 0 kg ha^{-1} (7.45) number of primary branches per plants. Varieties significantly affected the number of primary branches with Shombo having significantly more primary branches per plants (19.92) as compared to other varieties. The interaction effect of fertilizer with varieties was equally significant on the number of primary branches. Mean separation showed that the effect of fertilizer with varieties significantly increased the number of primary branches in within varieties. Green pepper on the other hand produced the fewer (3.83 per plants) branches when no fertilizer was applied and (4.93 branches per plants) when 200 kg ha^{-1}

The application of fertilizer significantly affected the number of primary branches as shown in Table 6. At 15 WAT, Results show that plots that received 200 kg ha^{-1} produced more (21.03) number of primary branches, while plots that received 0 kg ha^{-1}produced fewer (9.58) number of primary branches. Varieties significantly affected the number of primary branches with Shombo having the highest number (26.33) of primary branches compared to other varieties. The interaction of fertilizer with varieties was significant on the number of primary branches. Mean separation showed that the interaction effect of fertilizer with varieties significantly produced increase in the number of branches of the varieties with Green pepper having fewer (4.20 primary branches per plants) at 0 kg ha and (6.90 primary branches per plant) when 200 kg ha $^{-1}$.

Table 6: Effects of Fertilizer and Varieties on Primary Branches

		3WAT			7 WAT			11 WAT			15 WAT		
		……NPK Fertilizer ……											
Capsicum	Varieties	0	200	Mean	0	200	Mean	0	200	Mean	0	200	Mean
Danjarawa	Pepper	0.00	0.00	0.00	3.33	8.20	5.77	5.17	14.20	9.68	8.17	18.40	13.29
Green	Pepper	0.00	0.00	0.00	2.67	4.33	3.50	3.83	4.93	4.38	4.20	6.90	5.55
Local	Pepper	2.17	1.17	1.67	5.30	13.23	9.27	8.33	19.23	13.78	11.60	25.47	18.53
Ngwa	Pepper	0.00	0.00	0.00	5.23	14.53	9.88	8.63	20.67	14.65	9.27	21.37	15.32
Nsukka yellow	Pepper	0.00	0.00	0.00	4.07	8.13	6.10	6.43	16.50	11.47	9.27	19.27	14.32
Shombo	Pepper	0.33	0.00	0.17	7.50	18.23	12.87	14.83	25.00	19.92	16.50	36.17	26.33
Tatase	Pepper	0.00	0.00	0.00	4.20	7.50	5.85	6.07	14.27	10.17	8.03	19.53	13.78
Mean		0.36	0.167		4.61	10.59		7.61	16.40		9.58	21.03	
LSD for	Fert	NS			0.32			0.05			0.43		
LSD for	Var	0.40			0.59			0.84			0.79		
LSD for	Fert x var	0.57			0.84			1.18			1.13		

4.1.4.2 Secondary Branches

At 3 WAT, the effects of varieties, and the interaction of fertilizer and varieties were not significant on the number of secondary branches (Table 7). Fertilizer application however significantly affected the number of secondary branches at 7 WAT with plots that received 200 kg ha^{-1} producing significantly more secondary branches (18.24) compared to plots that received 0 kg ha^{-1} which produced fewer (7.62) secondary branches. The effects of varieties was significant on the number of secondary branches, Shombo produced significantly higher secondary branches per plant (16.29). The least number of secondary branches (9.43 branches per plants) was produced in Green pepper. The interaction effect of fertilizer with varieties produced significant increase in all the varieties. At 11 WAT, the effect of fertilizer was significant on number of secondary branches (Table 7). Plots that received 200 kg ha^{-1} produced significantly more secondary branches per plant (24.6) compared to plots that received 0 kg ha^{-1} which had 10.38 secondary branches per plants. Results obtained show that varieties affected the number of secondary branches significantly with Shombo having significantly the higher number of secondary branches (25.6) relative to other pepper varieties. Green pepper had significantly the least number of secondary branches (10.20) among other varieties.

The application of NPK fertilizer at 15 WAT, significantly affected the number of secondary branches (Table7). Results show that plots that received 200 kg ha^{-1} of NPK fertilizer significantly produced more (31.88) secondary branches compared to 18.25 branches per plants produced in plots that received 0 kg ha^{-1}. The effect of varieties was significant on the number of secondary branches with Shombo having significantly the higher number of secondary branches (35.0), while the significantly least (5.17 per plants) number of secondary branches was produced by Green pepper.

Table 7: Effects of Fertilizer and Varieties on Secondary Branches

		3WAT			7 WAT			11 WAT			15 WAT		
		…………………………			NPK Fertilizer (kg ha^{-1}) …………………………								
Capsicum	varieties	0	200	Mean	0	200	Mean	0	200	Mean	0	200	Mean
Danjarawa	Pepper	0.00	0.33	0.17	7.21	19.33	13.27	9.77	24.53	17.15	17.27	30.57	23.92
Green	Pepper	1.67	1.67	1.67	6.13	12.73	9.43	6.50	13.90	10.20	6.70	14.20	10.45
Local	Pepper	2.10	2.43	2.27	8.16	21.37	14.77	11.27	27.40	19.33	22.13	35.10	28.62
Ngwa	Pepper	1.33	1.67	1.50	8.13	17.30	12.72	10.53	27.23	18.88	17.27	30.57	23.92
Nsukka yellow	Pepper	0.00	0.00	0.00	6.43	15.20	10.82	8.20	18.87	13.53	13.67	32.00	22.83
Shombo	Pepper	2.33	2.67	2.50	9.42	24.23	16.83	16.37	34.83	25.60	28.33	41.87	35.10
Tatase	Pepper	0.00	0.00	0.00	7.83	17.50	12.67	10.03	25.60	17.82	19.90	34.03	26.97
Mean		1.11	1.20		7.62	18.24		10.38	24.62		18.25	31.88	
LSD for	Fert	NS			0.40			0.56			0.96		
LSD for	Var	NS			0.76			1.05			1.79		
LSD for	Fert x var	NS			1.07			1.49			2.54		

4.1.4.3 Effects of Fertilizer and Varieties on Number of Tertiary Branches.

The application of fertilizer had a significant effect on the number of Tertiary branches at 3 WAT. The results presented in (Table 8) show that application of 200 kg ha^{-1} NPK fertilizer produced significantly more (10 per plant) in pepper compared to when 0 kg ha^{-1} NPK was applied which produced (5 per plant). The effects of varieties, however significantly affected the number of tertiary branches with Shombo having significantly more (10) number of tertiary branches as compared to other varieties. Green pepper had significantly fewer tertiary branches per plant (5) number of tertiary branches. Analyses of variance (ANOVA) also show that the interaction of fertilizer with varieties had significant increase in the number of branches of all the varieties.

At 7 WAT, fertilizer application significantly increased the number of Tertiary branches (Table 8) with plots that received 200 kg ha^{-1} NPK fertilizer produced significantly more tertiary branches per plants (20) compared to the 9.60 tertiary branches per plant produced when 0 kg ha^{-1} of NPK fertilizer was applied. The effect of varieties was significant on the number of tertiary branches per plants. Shombo produced significantly more (21 per plant) number of tertiary branches compared to other varieties, while significantly the least (7) number of tertiary branches was produced by Green pepper. The interaction effect of fertilizer with varieties had a significant increase in the number of branches compared to other varieties.

ANOVA shows that at 11 WAT, application of fertilizer was significant on number of tertiary branches. Results show that significantly more tertiary branches per plant (24.10) were produced when 200 kg ha^{-1} of NPK fertilizer was applied (Table 8). The significantly lower number of tertiary branches per plant (12.84) was produced when no fertilizer was applied. Varieties significantly affected the number of tertiary branches with Shombo having significantly more tertiary branches per plants (25.18) compared to other varieties. Among all the varieties, (10.79) tertiary branches per plant produced by Green pepper was significantly the least. Mean separation showed that the interaction effect of fertilizer with varieties had significant increase in the number of branches of all the varieties. Green pepper had fewer numbers of branches at both fertilizer application rates.

Fertilizer application at 15 WAT significantly affected the number of tertiary branches (31.42) compared to the (20.96) tertiary branches per plant produced when 0 kg ha^{-1} of NPK fertilizer was applied. The effect of varieties was significant on the number of tertiary branches with Shombo having significantly more tertiary branches per plant (37.08) as compared to other varieties. The significantly lower number of tertiary branches per plant (12.09) was produced by Green pepper. The results show that in the within varieties, application of NPK fertilizer significantly increased tertiary branching on the other hand, when 0 kg ha^{-1} or 200 kg ha^{-1} of fertilizer was applied.

The number of flowers produced per plant was not significantly affected by NPK fertilizer application, varieties and the interaction between fertilizer and varieties at 3 WAT (Table 9).

Fertilizer application had however a significant effect on the number of flowers per plant at 7 WAT. Results presented in (Table 9) show that when 200 kg $ha^{-1}$of NPK fertilizer was applied, significantly more flowers (21.36 flowers) were produced compared to 12.65 flowers per plant that were produced when 0 kg ha^{-1} fertilizer was applied. Varieties, also significantly affected the number of flowers per plant with Shombo having significantly more flowers (33.32 flowers per plant), compared to other varieties.

Table 8: Effects of Fertilizer and Varieties on Tertiary Branches

		3 WAT			7 WAT			11 WAT			15 WAT		
		……NPK Fertilizer ……											
Capsicum	Varieties	0	200	Mean	0	200	Mean	0	200	Mean	0	200	Mean
Danjarawa	Pepper	3.57	8.73	6.15	9.10	21.63	15.37	12.30	24.67	18.48	25.73	31.53	28.63
Green	Pepper	3.67	6.67	5.17	6.40	8.30	7.35	6.70	14.87	10.79	8.83	15.34	12.09
Local	Pepper	6.13	12.40	9.27	9.27	21.67	15.47	15.43	28.23	21.83	19.40	30.43	24.92
Ngwa	Pepper	4.33	10.13	7.23	10.27	23.73	17.00	12.70	24.83	18.77	26.43	35.60	31.02
Nsukka yellow	Pepper	3.10	8.60	5.85	8.23	14.33	11.28	10.37	18.80	14.58	16.83	28.40	22.62
Shombo	Pepper	6.20	14.53	10.37	14.00	28.20	21.10	18.97	31.40	25.18	28.80	45.37	37.08
Tatase	Pepper	3.67	8.63	6.150	9.93	21.40	15.67	13.43	26.10	19.77	20.67	33.30	26.98
Mean		4.38	9.96		9.60	19.89		12.84	24.10		20.96	31.42	
LSD for	Fert	0.35			0.37			0.60			0.65		
LSD for	Var	0.65			0.69			1.13			1.21		
LSD for	Fert x var	0.92			0.97			1.59			1.71		

4. 1. 5 Effects of Fertilizer application and Pepper Varieties on Flowering

4. 1. 5. 1 Number of flowers

The number of flowers produced per plant was not significantly affected by NPK fertilizer application, cultivar and interaction between fertilizer and cultivar at 3 WAT (Table 9).Fertilizer application had however a significant effect on the number of flower per plant at 7 WAT. Results presented in Table 9 show that when 200 kg ha^{-1} of NPK fertilizer was applied, significantly more flowers (21.36 flowers) were produced compared to 12.65 flowers per plant that were produced when 0 kg ha^{-1} fertilizer was applied. Cultivars, also significantly affected the number of flowers per plant with Shombo having significantly more flowers (33.32 flowers per plant), compared to other cultivars. The least number of flowers (5.17 flowers) was obtained from Green pepper. The interaction of fertilizer with varieties affected the number of flowers significantly. This interaction effect of fertilizer with varieties resulted to increase in the number of flowers of other pepper varieties except Green pepper which had significantly fewer flowers when no fertilizer or 200 kg ha^{-1} was applied.

ANOVA shows that at 11 WAT, fertilizer application significantly affected the number of flowers per plant (Table 9). Results show that plots that received 200 kg ha^{-1} NPK produced significantly more flowers (30.40 flowers), compared to 19.75 flowers per plants produced when no fertilizer was applied. Pepper varieties had a significant effect on number of flowers per plants with Shombo having significantly higher number of flowers per plant (38.72 flowers), compared to other pepper varieties. Among all the varieties, significantly fewer flowers per plants (4.6) were produced by Green pepper. The interaction of fertilizer with varieties significantly affected the number of flowers of pepper. The interaction effect of fertilizer with varieties resulted to increase in the number of flowers of other varieties except Green pepper which had significantly fewer flowers when no fertilizer and 200 kg ha^{-1} was applied.

The application of fertilizer had a significant effect on number of flowers at 15 WAT. Results presented in Table 9 show that plots that received 200 kg ha^{-1} NPK fertilizer significantly produced more number of flowers (27.91 per plants), compared to the 17.32 flower per plant produced when no fertilizer was applied. Varieties significantly affected the number of flowers with Shombo having significantly more flowers per plants than other varieties except Local pepper (30.08). Green pepper had the significantly lower number of flowers per plants (4.17) among all the varieties. Analysis of variance showed that the interaction of fertilizer with varieties significantly produced increase the number of flowers in all the varieties except Green pepper.

4.1.5.2 Days to 50 Percent Flowering

Results presented in Table 9 show that when fertilizer was not applied, pepper plants flowered at 52 Days after planting (DAP). This was a significant delay of about 10 days compared to the 42 days taken by the pepper plants to flower when 200 kg ha^{-1} fertilizer was applied. Among the varieties, days to 50 % flowering was significantly early in Green pepper at 34 DAP and late in Nsukka yellow pepper (72 DAP). When either 0 or 200 kg ha^{-1} was applied, flowering was significantly early (29-40 DAP) in Green pepper and Shombo, compared to other varieties. Within varieties, fertilizer application had significant effect on days to 50% flowering in all the varieties.

4.1.6 Effects of Fertilizer and pepper Varieties on yield of pepper

4.1.6.1 Days to 50 % fruiting

NPK fertilizer application, pepper varieties and interaction of fertilizer with varieties significantly affected Days to 50 % fruiting (Table 10). Results show that when fertilizer was not applied, fruiting was significantly delayed by about 10 days in pepper varieties (84 DAP) compared to 73 days that was taken by the pepper varieties to fruit when 200 kg ha^{-1} fertilizer was applied. Among the varieties, fruiting was significantly earliest in Green pepper (63 DAP) and latest in Nsukka yellow pepper (109 DAP). The results show that in within varieties, application of fertilizer resulted to increase in the number of fruits. Meanwhile when no fertilizer was applied and when 200 kg ha $^{-1}$ of NPK fertilizer was applied, Green pepper had the earliest Days to 50 % fruiting, while Nsukka yellow pepper had the longest (105-112 DAP) to 50 % fruiting.

Table 9: Effects of Fertilizer and Varieties on Number of flowers and Days to 50 % flowering.

	3 WAT			7 WAT			11 WAT			15 WAT			Days to 50 % flowering		
Capsicum	0	200	Mean	0	200	Mean	0	200	Mean	0	200	Mean	0	200	Mean
Danjarawa pepper	0.00	0.00	0.00	7.51	17.77	12.65	17.13	26.37	21.75	17.07	21.43	19.25	58.00	48.33	53.17
Green pepper	2.00	1.67	1.83	5.00	5.33	5.17	3.67	5.67	4.67	4.00	4.33	4.17	39.67	28.67	34.17
Local pepper	0.33	0.00	0.17	19.77	30.70	25.23	27.63	43.07	35.35	22.10	35.37	28.73	51.33	42.00	46.67
Ngwa pepper	0.33	0.00	0.17	12.93	25.40	19.17	20.63	32.67	26.65	21.83	33.10	27.47	57.00	42.00	49.00
Nsukkayellow	0.00	0.00	0.00	7.43	16.20	18.82	24.13	32.90	28.52	18.07	34.37	26.15	74.67	70.00	72.23
Shombo pepper	1.33	0.67	0.33	28.93	37.70	33.32	32.20	45.23	38.72	25.40	34.37	30.08	40.33	31.33	35.67
Tatase pepper	0.67	0.00	0.33	6.77	16.40	11.68	12.83	26.87	19.85	12.40	32.33	22.47	46.33	37.00	41.67
Mean	0.67	0.33		12.65	21.36		19.75	30.40		17.32	27.91		52.48	42.71	
LSD for Fert	0.81			1.25			1.31			0.81			0.79		
LSD for Var	1.52			2.34			2.45			1.52			1.47		
LSD for Fert x var	2.15			3.30			3.47			2.150			2.08		

4.1.6.2 Days to First Harvest

The effect of fertilizer significantly affected the number of days to first harvest (Table 10). Results show that plots that had 200 kg ha^{-1} attained the earlier (100.57 days) to first harvest. While it took some 31days more for the varieties on the plots that received 0 kg ha^{-1} fertilizer to attain days to first harvest. Among the varieties, days to first harvest was earliest in Shombo (94 DAP), compared to other varieties. Nsukka yellow pepper was harvested latest (138.50 DAP). ANOVA showed that interaction of fertilizer with varieties was significant on the number of days to first harvest with Green pepper having the earliest days to first harvest at 0 kg ha^{-1} and Shombo at 200 kg ha^{-1} fertilizer rates, while the days to first harvest was delayed in Nsukka yellow pepper (142-145 DAP).

4.1.6.3 Mean Number of Fruits per Plant

Fertilizer application significantly affected the mean number of fruit per plants (Table 10). Plots that received 200 kg ha^{-1} NPK fertilizer had pepper plants with (109.43 fruits per plant) compared to 97.29 fruit per plant produced in plots that received 0 kg ha^{-1}. The effect of varieties was significant on the mean number of fruit per plant with Local pepper having significantly the higher number of fruit per plants (214.50), compared to other varieties. The interaction of fertilizer with varieties was significant on the mean number of fruit per plant with Local pepper having significantly more fruits (222.33 per plant) at 200 kg ha^{-1}NPK fertilizer application.

4.1.6.3 Mean Fruit Weight g)

In table 10, NPK fertilizer application significantly affected the mean fruit weight. Fresh fruits with plots that received 200 kg ha^{-1} NPK fertilizer produced more (10.95 g), while plots that received 0 kg ha^{-1} produced fewer (7.09 g).

Table 10: Effect of fertilizer and Varieties on fruiting

		Days to 50% fruiting			**Days to first harvest**			**Mean number of fruits**			**Mean fruits Weight(g)**		
Capsicum	Varieties	0	200	Mean	0	200	Mean	0	200	Mean	0	200	Mean
Danjarawa	Pepper	87.00	75.67	81.33	117.33	99.00	108.17	55.33	67.00	61.17	7.16	9.20	8.19
Green	Pepper	67.33	58.00	62.67	103.33	87.33	95.33	10.33	20.67	15.50	11.37	14.23	12.80
Local	Pepper	81.33	72.00	76.67	108.00	99.00	103.50	206.67	222.23	214.50	0.50	1.10	0.80
Ngwa	Pepper	88.33	72.67	80.50	118.00	100.33	109.17	79.00	92.33	85.67	6.08	13.23	9.66
Nsukka	Yellow	112.33	105.00	108.67	142.00	135.00	138.50	73.67	86.33	80.00	6.24	12.10	9.17
Shombo	Pepper	71.33	62.33	66.83	99.00	89.00	94.00	203.00	214.00	208.50	9.68	12.51	11.09
Tatase	Pepper	77.33	68.67	73.00	106.33	94.33	100.17	53.00	63.33	58.17	8.67	14.27	11.47
Mean		83.57	73.48		113.43	100.57		97.29	109.43		7.09	10.95	
LSD for	Fert	1.49			2.12			2.13			0.15		
LSD for	Var	2.80			3.96			3.98			0.28		
LSD for	Var x fert	3.96			5.60			5.63			0.39		

However, varieties significantly affected the mean fruit weight of pepper where Green pepper significantly produced the highest (12.80 g) mean fruit weight, compared to the mean fruit weight of other varieties, followed by Tatase (11.47 g). The mean fruit weight was lowest in Local pepper (0.80 g), which was significantly different from the mean fruit weight of other pepper varieties. Analysis of variance (ANOVA) also showed that the interaction of fertilizer by varieties was significant on the mean fruit weight. ANOVA shows that the Green pepper (11.37 g) at 0 kg ha $^{-1}$and Tatase (14.27 g) and Ngwa pepper (13.23 g) at 200 kg ha^{-1} fertilizer rates produced higher mean fruit weight compared to other varieties.

4.1.6.5 Mean Fruit Length

The effect of species was significant on the mean fruit length (Table 11), Results show that significantly longer fruits (8.69 cm) were produced in plots that received 200 kg ha^{-1} NPK fertilizer compared to when no fertilizer was applied (6.02 cm). Varieties, significantly affected fruit length with Shombo having significantly longer (11.15 cm) fruits, although it was significantly different from Green pepper fruit length (9.44 cm). Mean separation shows that within the interaction of fertilizer with varieties results to the increase in length of fruit, but the fruit length of Local pepper (1.97 cm), was significantly shorter compared to other varieties.

4.1.6.6 Mean Fruit Diameter

The application of fertilizer had a significant effect on mean fruit diameter. The results in Table 11 shows that application of 200 kg ha^{-1} NPK fertilizer produced significantly bigger (4.71 cm) fruits compared to when no fertilizer was applied (3.8 cm). Varieties were significantly different in their mean fruit diameter, with Green pepper having the significantly bigger fruits (7.34 cm) compared to other varieties. Fruit diameter was significantly smaller (0.71 cm) in Local pepper compared to other varieties.

4.1.7 Effects of Fertilizer Application and Varieties on Incidence of Disease.

ANOVA shows that at 7 WAT, application of fertilizer was significantly different on disease incidence. Results in Table 11 show that plots that had no fertilizer application, produced significantly more disease incidence (2.19 %) compared to (1.86 %) produced when 200 kg ha^{-1} NPK fertilizer was applied. Varieties also significantly affected the number of disease incidence, With Nsukka yellow pepper having significantly more disease incidence (2.83 %) compared to other varieties. Among all the varieties, (1.00 %) produced by Green pepper was significantly least. The interaction of fertilizer with varieties was significant on the disease incidence. Mean separation shows that the interaction effect was due to the response of Nsukka yellow pepper (4.00 %) at 0 kg ha^{-1} to fertilizer application with varieties while Green pepper produced significantly least disease incidence compared to other varieties at 200 kg ha^{-1}.

At 9 WAT, NPK fertilizer application had significant effect on the disease incidence. Results show that plots that received 200 kg ha^{-1} (2.62 %), while the plots that received 0 kg ha^{-1} produced (3.90 %). Varieties, however, the incidence of disease with Nsukka yellow pepper having the highest number of diseased plants (5.50 %).which was significantly different from other varieties. Disease incidence was low in Green pepper at 1.50 % which was equally significantly different from other varieties. Results equally show that interaction effect was significantly different with Nsukka yellow pepper having the highest disease incidence (7.67 %) at 0 kg ha^{-1}, followed by Local pepper at 0 kg ha^{-1}. The effect of fertilizer was significant on plant disease incidence at 13 WAT in (Table 11), plots that received 200 kg ha^{-1} produced less (4.19 %), while plots that received 0 kg ha^{-1} produced more (6.81 %). Varieties were equally significantly different on plant disease incidence with Nsukka yellow pepper having significantly the highest diseased plant (9.67 %), it was significantly different from other varieties. Although disease incidence was least in Green pepper which was equally significantly different from other varieties. Analysis of variance (ANOVA) also showed that fertilizer by varieties interaction was significant on disease incidence. Mean separation, however showed that significant interaction effect was attributable to the response of Nsukka yellow pepper at 0 kg ha^{-1} (13.33 %), and followed by Local pepper at 0 kg ha^{-1} (8.67 %).

Table 11: Effect of fertilizer and Varieties on Fruit length, diameter and disease incidence (%)

Capsicum	Fertilizer Rate (kg ha-1)														
	0	200		0	200		0	200		0	200		0	200	
Varieties							3 WAT			7 WAT			9 WAT		
	Fruit Length		Mean	Fruit Diameter		Mean	Disease Incidence		Mean	Disease Incidence		Mean	Disease Incidence		Mean
Danjarawa Pepper	6.23	8.27	7.25	4.29	4.80	4.55	2.67	1.33	2.00	3.67	2.67	3.17	5.33	3.67	4.50
Green Pepper	6.83	12.00	9.41	6.57	8.12	7.34	2.00	0.00	1.00	2.00	1.00	1.50	2.33	2.00	2.17
Local Pepper	1.60	2.33	1.97	0.54	0.89	0.71	2.00	2.33	2.17	5.00	3.67	4.33	8.67	6.67	7.67
Ngwa Pepper	5.69	8.98	7.34	4.27	5.13	4.70	2.33	2.67	2.50	3.33	3.00	3.17	5.67	4.00	4.87
Nsukka Yellow Pepper	5.47	8.16	6.82	4.23	4.37	4.30	4.00	1.67	2.83	7.67	3.33	5.50	13.33	6.00	9.67
Shombo pepper	9.70	12.59	11.14	2.34	3.30	2.82	2.67	1.67	2.17	4.33	2.33	3.33	7.00	3.67	5.33
Tatase pepper	6.61	8.47	7.54	4.34	6.32	5.34	1.67	1.33	1.50	2.33	1.33	1.83	5.33	3.33	4.33
Mean	6.02	8.69		3.80	4.71		2.19	1.86		3.90	2.62		6.81	4.19	
LSD for Fert	0.14			0.08			0.49			0.53			0.74		
LSD for var	0.25			0.16			0.92			1.00					
LSD for var X Fert	0.36			5.34			1.31			1.41					

4.2 DISCUSSION

The soil of the experimental site was sandy loam with moderate acidic pH (5.2), low organic matter content (1.29 %), low total nitrogen (0.23 %), and potassium (0.10 c mol kg^{-1}) but high in phosphorus (11.76 mg kg^{-1}). This agrees with the report of Ohiri and Ano (1985) and Ohiri (1992), who reported that soils in Rivers, Abia, Akwa Ibom and Imo States are characterized by low pH, low organic and low exchangeable cations.

The results obtained in this study showed that plant height and number of leaves in all the species evaluated were initially depressed when inorganic fertilizer was applied. These responses were clearly shown in the data collected at 3 WAT. This agrees with the work of Idowu- Agida *et al*. (2012) who reported that transplanting disturbances can have adverse effects on plants growth especially during the early stages. Subsequently, however, the application of NPK fertilizer had significant effect on plant height and number of leaves. The increase in plant height and number of leaves may be due to greater availability of soil nutrients, especially Nitrogen and Phosphorus as a result of the application of fertilizer which have enhancing effect on the vegetative growth of plants by increasing cell division and elongation and the varietal variability to absorb the nutrients from the soil (Vos and Friking, 1997; El-Tohamy *et al*., 2006). The result of this study confirms the finding of Gonzalez *et al.,* (2001) who reported that inorganic fertilizer supplied most of the essential nutrients at growth stage resulting in increase of growth variables including plant height. NPK fertilizer contains essential nutrient elements associated with high photosynthetic activities and thus promoted vegetative growths (John *et al*., 2004). Such nutrient elements include nitrogen which is known to enhance physiological activities in crops thereby improving the synthesis of photo-assimilates (Aliyu, 2000).

Generally, branching in the pepper species evaluated showed the significant difference which is attributable to genetic variations among the species. In addition, results also show that branching was significantly enhanced by NPK fertilizer application.

Fewer flowers were obtained at the early stage of flowering, could be due to insufficient optimum soil moisture at the early flowering period of the crops. Although, flowering was not much in subsequent times, the primary cause of poor flowering and fruit set could be due to diseases, pests (birds) in the experimental plot. Wind and heavy rainfall during the later flowering period caused decrease in effective pollination that resulted in loss of potential flower and caused fruit damage and decrease in yield. The more number of flowers in plots that received 200 kg ha^{-1} was as a result of the nutrient availability of the study area. The decrease in number of flowers, on species with 200 kg ha^{-1} fertilizer rate at 3 weeks after transplanting, could be attributed to the function of nitrogen concentration. As a result, producing numerous and large pepper leaves, most of the plants energy was directed towards the leaves rather than flowering or fruiting.

Evidently, number of days to 50 % flowering was enhanced by nutrient availability with soil analysis results showing that the soil of the experimental site was low in N, K and other nutrient elements. Consequently pepper plots that received NPK fertilizer flowered significantly earlier than those plots that received no fertilizer. This agrees with the report of Dauda (2002) that low soil content induces late flowering. On the other hand, Nsukka yellow pepper had the most number of days to 50 % flowering (72.33 DAP). This is attributable to inherent differences in the species. On the whole, days to 50 % flowering was 34 -72 DAP in the species evaluated. This compares to the 30 – 42 DAP which Gibbon and Pain (1985), Khah and Passam (1992), FAO (2013), reported for commencement of anthesis in pepper. As a result of the application of NPK fertilizer, significant increase in the number of fruits per plant, fruit length and fresh fruit yield were observed. These are attributable to increase in nutrient availability which enhanced productivity. This agrees with Gupta Shukla. (1977) Takahanci *et al*. (1979) and Dauda, (2002), who reported that adequate nutrient supply has the ability to promote vigorous foliage growths; increased meristematic and physiological activities in the plant resulting in production of more assimilate used in formation of fruits. Fruit yield in the pepper species were positively associated with branching in this study. The flower and fruits are borne on branches. As the number of number of primary, secondary and tertiary branches increased significantly due to the effects NPK application or species, more flowers and fruits were adequately produced.

Fruit size was largely dependent on pepper species and inversely correlated with number of fruits per plants. As a result, species with large fruits in terms of diameter and weight, produced fewer fruits compared with species that have smaller fruits for instance, although the number of fruits was significantly highest in Local pepper (215 fruit per plant), with each fruit weighing 0.8 g, this translated to a total of yield of 172 g. Shombo on the other hand produced 20 g fruit per plant, but with a mean fruit weight of 11g fruit per plant which resulted to a total yield of 2.3 kg. Generally with regards to number of fruits and mean fruit weight per plant, total fruit yield in the species was in the range of 172 –2300 g. Consequently upon having significantly more days to 50 % flowering and fruiting, Nsukka yellow pepper required significantly more days (138 DAP). Shombo and Green pepper which flowered and fruited earlier were the earliest to reach first harvest at 94 and 95 DAP respectively. The variation in days to first harvest (maturity) among the species could be due to the genetic make – up of the species. Abayomi *et al.* (2012) has similarly reported longer days to first harvest in Tatashe and Rodo compared Shombo. It was also evident from the result that improved soil nutrient significantly reduced days flowering and fruiting, and hence days to first harvest.

Among the species Nsukka yellow pepper and Local pepper were very severely attacked by bacterial wilt (*Pseudomonas solanacearum*) while the Green pepper was slightly infected. The occurrence of diseases on these species was attributed to the continous rainfall towards the maturation period of the fruits. Cutworms and the brown stink bugs (*Euschistus servus*) and Green stink bugs (*Acrosternum hilare*) were also a problem during the early seedling establishment on the field.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Summary

Pepper is one of the major Horticultural vegetable crops of importance in Nigeria. It serves as a source of income particularly for small holder farmers in many parts of the study area. The yield of pepper is affected by cultural practice, their genetic make-up and environmental. The objectives of this study were to assess the: agronomic performances of different cultivated species of *capsicum* in Owerri which is located in the rainforest agroecology of southeastern Nigeria. The effect of inorganic fertilizer on selected capsicum species in Owerri. Southeastern Nigeria. In this study, fourteen treatment combinations were laid out in a 7 x 2 factorial experiment in a randomized complete block design with three replications. The factors comprised: 7 pepper species and two fertilizer levels, (0 kg ha^{-1} and 200 kg ha^{-1}). The fertilizer materials used was NPK 20:10:10, and application at one week after transplanting. Green pepper and Shombo matured earliest (94 - 95 DAP). Other pepper species matured 100–138 DAP, with Nsukka yellow pepper maturing last at 138 DAP, number of fruits per plant was highest in Green pepper (16). The total fruit yield were in the range of 172-2300 g per plant with Shombo having the highest fruit yield (2300 g) and performed best among the species evaluated. Green pepper produced the least number of fruits per plants and had the total yield of 501 g, while Local pepper that produced the highest number of fruits per plant had the least yield of 171.6 g. Shombo pepper performed best among the species evaluated in growth and yield, followed by the Ngwa pepper that had 85.67 numbers of fruit per plant and had the fruit yield of 828 g. All the pepper species responded well to fertilizer application.

5.2 Conclusion

In conclusion, exotic species of pepper can thrieve well in the study area using inorganic fertilizer (NPK fertilizer 20:10:10).

The pepper species of Shombo performs well in the study area in growth and yield.

5.3 Recommendations

Farmers can equally grow pepper species in dry season for better yield.

Exotic species of pepper can grow well in the Owerri southeastern, Nigeria.

Pepper species can be grown in the study area using NPK fertilizer 20: 10: 10, for better production.

Shombo pepper is the variety that is recommended for farmers in Owerri for optimum yield

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APPENDICES

Appendix I: Plant height of pepper at 3 Weeks After Transplanting (WAT)

Sources of variation	d.f	S.S	m.s	v.r	f.pr
Replication	2	7.669	3.834	2.53	
Fertilizer	1	95.794	95.794	63.33	0.001
Cultivar	6	207.858	34.643	22.90	0.001
Fertilizer x cultivar	6	183.982	30.664	20.27	0.001
Residual	26	39.329	1.513		
Total	41	534.632			

Appendix II: Plant height of pepper at 7 Weeks After Transplanting (WAT)

Sources of variation	d.f	S.S	m.s	v.r	f.pr
Replication	2	3.366	1.683	0.49	
Fertilizer	1	1142.972	1142.9672	333.42	0.001
Cultivar	6	2637.907	439.651	128.25	0.001
Fertilizer x cultivar	6	79.913	13.319	3.89	0.007
Residual	26	89.128	3.428		
Total	41	3953.285			

Appendix III: Plant height of pepper at 11 Weeks After Transplanting(WAT)

Sources of variation	d.f	S.S	m.s	v.r	f.pr
Replication	2	9.824	4.912	1.46	
Fertilizer	1	11.35.680	1135.680	337.04	0.546
Cultivar	6	4976.556	829.426	241.15	0.001
Fertilizer x cultivar	6	111.818	18.636	5.53	0.001
Residual	26	87.609	3.370		
Total	41	6321.486			

Appendix IV: Plant height of pepper at 15 Weeks After Transplanting (WAT)

Sources of variation	d.f	S.S	m.s	v.r	f.pr
Replication	2	33.104	16.552	6.09	
Fertilizer	1	1174.4866	1174.486	432.19	0.001
Cultivar	6	9135.385	1522.564	560.28	0.001
Fertilizer x cultivar	6	140.246	23.374	8.60	0.001
Residual	26	70.656	2.718		
Total	41	10553.876			

Appendix V: Number of leaves per plant of pepper at 3 Weeks After Transplanting(WAT)

Sources of variation	d.f	S.S	m.s	v.r	f.pr
Replication	2	2.672	1.336	0.38	
Fertilizer	1	110.419	110.419	31.35	0.001
Cultivar	6	1041.246	173.541	49.27	0.001
Fertilizer x cultivar	6	25.809	4.302	1.22	0.327
Residual	26	91.575	3.522		
Total	41	1271.721			

Appendix VI**:** Number of leaves per plant of pepper at 7 Weeks After Transplanting(WAT)

Sources of variation	d.f	S.S	m.s	v.r	f.pr
Replication	2	1.903	0.952	0.18	
Fertilizer	1	1996.861	1996.861	384.12	0.001
Cultivar	6	34406.626	5734.438	1103.08	0.001
Fertilizer x cultivar	6	207.606	34.601	6.66	0.001
Residual	26	135.163	5.199		
Total	41	36748.159			

Appendix VII**:** Number of leaves per plant of pepper at 11 Weeks After Transplanting (WAT)

Sources of variation	d.f	S.S	m.s	v.r	f.pr
Replication	2	2780.0	1390.0	1.76	
Fertilizer	1	47699.0	47699.0	60.28	0.001
Cultivar	6	562105.2	93684.2	118.40	0.001
Fertilizer x cultivar	6	20830.1	3471.7	4.39	0.003
Residual	26	20571.9	791.2		
Total	41	653986.2			

Appendix VIII**:** Number of leaves at 15 Weeks After Transplanting(WAT)

Sources of variation	**d.f**	**S.S**	**m.s**	**v.r**	**f.pr**
Replication	2	69.51	34.75	1.82	
Fertilizer	1	16664.28	16664.28	874.65	0.001
Cultivar	6	1138213.18	189702.20	9956.85	0.001
Fertilizer x cultivar	6	6656.21	1109.37	58.23	0.001
Residual	26	495.36	19.05		
Total	41	1162098.54			

Appendix IX**:** Number of flowers at 3 Weeks After Transplanting(WAT)

Sources of variation	**d.f**	**S.S**	**m.s**	**v.r**	**f.pr**
Replication	2	1.8571	0.9286	1.71	
Fertilizer	1	1.1667	1.1667	2.14	0.155
Cultivar	6	16.6667	2.7778	5.11	0.001
Fertilizer x cultivar	6	0.6667	0.1111	0.20	0.972
Residual	26	14.1429	0.5440		
Total	41	34.5000			

Appendix X**:** Number of flowers per plant of pepper at 7 Weeks After Transplanting(WAT)

Sources of variation	**d.f**	**S.S**	**m.s**	**v.r**	**f.pr**
Replication	2	126.99	64.99	4.19	
Fertilizer	1	796.312	796.312	204.12	0.001
Cultivar	6	3317.497	552.916	141.73	0.001
Fertilizer x cultivar	6	138.235	23.039	5.91	0.001
Residual	26	109.235	3.901		
Total	41	4361.278			

Appendix XI**:** Number of flowers per plant of pepper at 11 Weeks After Transplanting (WAT)

Sources of variation	d.f	S.S	m.s	v.r	f.pr
Replication	2	1.424	0.712	0.17	
Fertilizer	1	1190.404	1190.404	278.44	0.001
Cultivar	6	4565.116	760.853	177.97	0.001
Fertilizer x cultivar	6	183.446	30.574	7.15	0.001
Residual	26	111.156	4.275		
Total	41	6051.546			

Appendix XII**:** Number of flowers per plant of pepper at 15 Weeks After Transplanting (WAT)

Sources of variation	d.f	S.S	m.s	v.r	f.pr
Replication	2	8.785	4.392	2.68	
Fertilizer	1	1176.602	1176.602	717.18	0.001
Cultivar	6	2883.773	480.629	292.96	0.001
Fertilizer x cultivar	6	418.543	69.757	42.52	0.001
Residual	26	42.655	1.641		
Total	41	4530.358			

Appendix XIII**:** Number of primary branches at 3 WAT After Transplanting

Sources of variation	d.f	S.S	m.s	v.r	f.pr
Replication	2	0.0119	0.0060	0.05	
Fertilizer	1	0.3810	0.3810	3.31	0.080
Cultivar	6	13.9524	2.3254	20.23	0.001
Fertilizer x cultivar	6	1.2857	0.2143	1.86	0.125
Residual	26	62.9881	0.1149		
Total	41	18.6190			

Appendix XIV**:** Number of primary branches at 7 WAT After Transplanting

Sources of variation	d.f	S.S	m.s	v.r	f.pr
Replication	2	0.3776	0.1888	0.76	
Fertilizer	1	365.5050	365.5050	1470.53	0.001
Cultivar	6	327.7781	54.6297	219.79	0.001
Fertilizer x cultivar	6	109.9267	18.3211	73.71	0.001
Residual	26	6.4624	0.2486		
Total	41	810.0498			

Appendix XV**:** Number of primary branches at 11 WAT After Transplanting

Sources of variation	d.f	S.S	m.s	v.r	f.pr
Replication	2	3.3162	1.6581	3.34	
Fertilizer	1	825.4867	825.4867	1661.56	0.001
Cultivar	6	924.2381	154.0397	310.06	0.001
Fertilizer x cultivar	6	104.4067	17.4011	35.03	0.001
Residual	26	12.9171	0.4968		
Total	41	1870.3648			

Appendix XVI**:** Number of primary branches at 15 WAT After Transplanting

Sources of variation	d.f	S.S	m.s	v.r	f.pr
Replication	2	0.6176	0.3088	0.68	
Fertilizer	1	1377.1488	1377.1488	3038.93	0.001
Cultivar	6	1407.5148	234.5858	517.66	0.001
Fertilizer x cultivar	6	230.4662	38.4110	84.76	0.001
Residual	26	11.7824	0.4532		
Total	41	3027.5298			

Appendix XVII**:** Number of secondary branches at 3 WAT After Transplanting

Sources of variation	d.f	S.S	m.s	v.r	f.pr
Replication	2	0.6343	0.3171	0.62	
Fertilizer	1	0.0952	0.0952	0.19	0.670
Cultivar	6	42.4229	7.0705	13.78	0.001
Fertilizer x cultivar	6	0.5714	0.0952	0.19	0.978
Residual	26	13.3390	0.5130		
Total	41	57.0629			

Appendix XIX**:** Number of secondary branches at 7 WAT After Transplanting

Sources of variation	d.f	S.S	m.s	v.r	f.pr
Replication	2	0.1183	0.0591	0.15	
Fertilizer	1	1184.3424	1184.3424	2919.60	0.001
Cultivar	6	212.8714	35.4786	87.46	0.001
Fertilizer x cultivar	6	73.6669	12.2778	30.27	0.001
Residual	26	10.5470	0.4057		
Total	41	1481.5459			

Appendix XX**:** Number of secondary branches at 11 WAT After Transplanting

Sources of variation	d.f	S.S	m.s	v.r	f.pr
Replication	2	1.9805	0.9902	1.26	
Fertilizer	1	2130.0193	2130.0193	2701.55	0.001
Cultivar	6	840.7914	140.1319	177.73	0.001
Fertilizer x cultivar	6	133.6390	22.2732	28.25	0.001
Residual	26	20.4995	0.7884		
Total	41	3126.9298			

Appendix XXI**:** Number of secondary branches at 15 WAT After Transplanting

Sources of variation	d.f	S.S	m.s	v.r	f.pr
Replication	2	11.550	5.775	2.53	
Fertilizer	1				0.001
Cultivar	6	1950.249	1950.249	853.89	0.001
Fertilizer x cultivar	6	1992.840	332.140	145.42	0.001
Residual	26	162.971	27.167	11.89	
Total	41	4176.993	2.284		

Appendix XXII**:** Number of tertiary branches at 3 WAT After Transplanting

Sources of variation	d.f	S.S	m.s	v.r	f.pr
Replication	2	3.2248	1.6124	5.43	
Fertilizer	1	326.4860	326.4860	1099.29	0.001
Cultivar	6	134.7314	22.4552	75.61	0.001
Fertilizer x cultivar	6	22.9657	3.8276	12.89	0.001
Residual	26	7.7219	0.2970		
Total	41	495.1298			

Appendix XXIII: Number of tertiary branches at 7 WAT After Transplanting

Sources of variation	d.f	S.S	m.s	v.r	f.pr
Replication	2	0.9348	0.4674	1.39	
Fertilizer	1	1443.2010	1443.2010	4303.83	0.001
Cultivar	6	390.4957	65.0826	194.09	0.001
Fertilizer x cultivar	6	41.4090	6.9015	20.58	0.001
Residual	26	8.7186	0.3353		
Total	41	1884.7590			

Appendix XXIV**:** Number of tertiary branches at 11 WAT After Transplanting

Sources of variation	d.f	S.S	m.s	v.r	f.pr
Replication	2	2.8343	1.4171	1.57	
Fertilizer	1	990.8571	990.8571	1097.25	0.001
Cultivar	6	1282.7667	213.7944	236.75	0.001
Fertilizer x cultivar	6	209.2029	34.8671	38.61	0.001
Residual	26	23.4790	0.9030		
Total	41	2509.1400			

Appendix XXV**:** Number of tertiary branches at 15 WAT After Transplanting

Sources of variation	d.f	S.S	m.s	v.r	f.pr
Replication	2	0.373	0.187	0.18	
Fertilizer	1	958.104	958.104	922.39	0.001
Cultivar	6	2766.070	461.012	443.83	0.001
Fertilizer x cultivar	6	252.780	42.130	40.56	0.001
Residual	26	27.007	1.039		
Total	41	4004.333			

Appendix XXVI**:** Number of days to 50% flowering

Sources of variation	**d.f**	**S.S**	**m.s**	**v.r**	**f.pr**
Replication	2	0.762	0.381	0.25	0.01
Fertilizer	1	1000.595	1000.595	651.94	0.01
Cultivar	6	6031.619	1005.270	654.98	0.01
Fertilizer x cultivar	6	83.238	13.873	9.04	
Residual	26	39.905	1.535		
Total	41	7156.119			

Appendix XXVII**:** Number of days to 50% fruiting

Sources of variation	**d.f**	**S.S**	**m.s**	**v.r**	**f.pr**
Replication	2	21.762	10.881	1.95	0.001
Fertilizer	1	1070.095	1070.095	192.01	0.001
Cultivar	6	8054.810	1342.462	240.88	0.102
Fertilizer x cultivar	6	66.905	11.151	2.00	
Residual	26	144.905	5.573		
Total	41	9358.476			

Appendix XXVIII**:** Number of days to first harvest

Sources of variation	**d.f**	**S.S**	**m.s**	**v.r**	**f.pr**
Replication	2	31.48	15.74	1.41	0.001
Fertilizer	1	1722.88	1722.88	154.54	0.001
Cultivar	6	8174.14	1362.36	122.20	0.034
Fertilizer x cultivar	6	182.62	30.44	2.73	
Residual	26	289.86	11.15		
Total	41	10400.98			

Appendix XXIX**:** Mean Fruit Length

Sources of variation	**d.f**	**S.S**	**m.s**	**v.r**	**f.pr**
Replication	2	0.25226	0.12613	2.80	
Fertilizer	1	74.66667	74.66667	1657.84	0.001
Cultivar	6	281.29131	46.88186	1040.93	0.001
Fertilizer x cultivar	6	23.93040	3.98840	88.56	0.001
Residual	26	1.17100	0.04504		
Total	41	381.31165			

Appendix XXX**:** Mean Fruit Diameter

Sources of variation	d.f	S.S	m.s	v.r	f.pr
Replication	2	0.15000	0.07500	4.41	
Fertilizer	1	8.59524	8.59524	505.07	0.001
Cultivar	6	153.53686	25.58948	1503.69	0.001
Fertilizer x cultivar	6	3.88180	0.64697	38.02	0.001
Residual	26	0.44246	0.01702		
Total	41	166.60636			

Appendix XXXI**:** Mean fruit weight

Sources of variation	d.f	S.S	m.s	v.r	f.pr
Replication	2	56.73	28.36	0.69	
Fertilizer	1	155.67475	155.67475	2804.35	0.001
Cultivar	6	559.67976	93.27996	1680.36	0.001
Fertilizer x cultivar	6	50.72955	8.45492	152.31	0.001
Residual	26	1.55433	0.0551		
Total	41	767.63839			

Appendix XXXII**:** Disease incidence at 5 WAT

Sources of variation	d.f	S.S	m.s	v.r	f.pr
Replication	2	0.9048	0.4524	0.69	
Fertilizer	1	1.1667	1.1667	11.60	0.177
Cultivar	6	13.4762	2.24460	0.06	0.009
Fertilizer x cultivar	6	17.6667	2.9444	0.43	0.002
Residual	26	`15.7619	0.6062		
Total	41	48.9762			

Appendix XXXIII: Disease incidence at 9 WAT

Sources of variation	D.F	S.S	M.S	V.R	F.PR
Replication	2	0.3333	0.1667	0.24	
Fertilizer	1	17.3571	17.3571	24.62	0.001
Cultivar	6	67.9524	11.3254	16.06	0.001
Fertilizer x cultivar	6	24.1429	4.0238	5.71	0.001
Residual	26	`18.3333	0.7051		
Total	41	128.1190			