UNIVERSITY OF EDUCATION, WINNEBA

EFFECT OF DIFFERENT PLANTING DISTANCE ON PERFORMANCE OF TWO CULTIVARS OF COWPEA (*Vigna unguiculata*)

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EFFECT OF DIFFERENT PLANTING DISTANCE ON PERFORMANCE OF TWO CULTIVARS OF COWPEA *(Vigna unguiculata)*

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A DISSERTATION IN THE DEPARTMENT OF CROP AND SOIL SCIENCES EDUCATION, FACULTY OF AGRICULTURE EDUCATION, SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES, UNIVERSITY OF EDUCATION, WINNEBA, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF EDUCATION IN AGRICULTURE (CROP SCIENCE)

OCTOBER, 2022

DECLARATION

Student's Declaration

I, EDWARD DAVOROH, declare that with the exception of quotations and references contained in published works which have all been identified and acknowledged, this dissertation is entirely my own work and it has not been submitted either in part or whole for another degree elsewhere.

SIGNATURE…………………………………………

DATE……………………………………………

SUPERVISOR'S DECLARATION

I hereby declared that the preparation and presentation of this dissertation was supervised in accordance with the guidelines for supervision of dissertation as laid down by the University of Education Winneba (UEW)

PROF. (MRS.) MARGARET ESI ESSILFIE (Principal Supervisor)

SIGNATURE…………………………………………..

DATE……………………………………………

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DEDICATION

This work is dedicated to the Almighty God for His guidance and protection. I also dedicate this work to my late brother, Charles Woo. May He Rest in Perfect Peace.

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ABSTRACT

The field experiment was conducted at the Multipurpose crop nursery, College of Agriculture Education, of the Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development Mampong-Ashanti from July to September, 2022. The study was conducted to determine the effect of different planting distance on performance of two cultivar of cowpea *(Vigna unguiculata*). The experimental design used was 2 x 3 factorial, arranged in Randomized Complete Block Design (RCBD) with three (3) replications. The treatments were made up of 2 varieties of Cowpea (*Tona and Zamzam*) and 3 planting distance (60 cm x 10 cm, 60 cm x 20 cm and 60 cm x 30 cm). The results revealed that Zamzam planted on 60 cm x 30 cm interaction, emerged earliest (4.67 days), Tona planted on 60 cm x 10 cm, Zamzam planted on 60 cm x 10 cm and 60 cm x 10 cm spacing emerged at the same period (5.33 days) whilst Zamzam planted on 60 cm x 20 cm interaction emerged late (6.33 days). Tona planted on 60 cm x 20 cm and Zamzam planted on 60cm x 30 cm were earliest to flower (41.00 days) whilst Tona planted on 60 cm x 10 cm were earliest to pod (45.3 days).Tona produced wider canopy width and higher number of leaves per plant than zamzam from 6 to 8 WAP, whilst Tona planted on 60 cm x 30 cm interaction produced significantly ($P \leq 0.05$) wider canopy width than on 60 cm x 10 cm interaction. Zamzam planted on 60 cm x 10 cm produced significantly ($P \leq 0.05$) taller plants than Tona planted on 60 cm x10 cm and on 60 cm x 30 cm interaction which produced shortest plants at 4 WAP and 6 WAP respectively. Planting distance 60 cm x 10 cm produced significantly heaviest root fresh weight at 8 WAP. Tona planted on 60 cm x 30 cm interaction produced significantly greatest number of branches per plant at 8WAP. It is therefore recommended that for high yield of cowpea, farmers are to plant Tona using 60 cm inter row spacing and either 10 cm, 20 cm or 30 cm intra row spacing for maximum number of branches per plant.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the Study

Cowpea [(*Vigna unguiculata* (L.)Walp) is an important crop in many countries of tropical Africa, Asia and South America. Both grain and leaves are edible products of cowpea that are rich and cheap sources of high-quality protein. The crop supplements to the lower quality cereal and grown extensively in the low lands and mid-altitude regions of Africa (particularly in the dry savanna).The crop is sometimes grown as sole crop but more often intercropped with cereals such as sorghum or millet (Agbogidi, 2015). Cowpea is of major importance to the livelihoods of millions of relatively poor people in less developed countries of the tropics (FAO, 2015). Islam *et al.*, (2016) emphasized that all parts of the plant used as food are nutritious providing protein and vitamins, immature pods are used as vegetables while several snacks and main dishes are prepared from the grains. Among the legumes, cowpea is the most extensively grown, distributed and traded food crop consumed. (Agbogidi, 2015).

This is because the crop has considerable nutritional and health value to man and livestock (Agbogidi, 2015). They form a major staple in the diet in Africa and Asian continents (Awe, 2018). The seeds makeup the largest contributor to the overall protein intake of several rural and urban families. Agbogidi (2015) reported that cowpea is regarded as the poor man's major source of protein. Their amino acid complements those of cereals (Asumugha, 2014). Their mineral contents (calcium and iron) are higher than that of meat, fish and egg and the iron content equates that of milk; the vitamins-thiamin, riboflavin, niacin (water soluble) and their levels compare with that found in lean meat and fish Adaji *et al.* (2017) reported that daily consumption of 100-135gm of dry cowpea reduces cholesterol level by 20 % there by, reducing the risk for coronary heart diseases by 40%. Besides its health related benefits cowpea are inexpensive, considerably cheaper than rice or any other dietary fiber type (Ayenlere *et al.,* 2012). It is a good food security items as it mixes well with other recipe (Muoneke *et al*, 2016). Cowpea fixes atmospheric nitrogen through symbiosis, with nodule bacteria (Shiringani and Shimcles, 2011). It does well and most popular in the semi-arid region of the tropics where other food legumes do not perform well (Sank1e *et al.,* 2018). lt is an extremely resilient crop and cultivated under some of the most extreme agricultural conditions in the world (Owolade *et al.,* 2016). The crop is well adapted to stress and has excellent nutritional qualities (El-Ameen, 2018).Cowpea is an important grain legume in West Africa and in many part of the tropics (Singh *et al.,* 2019), thereby supplementing the low protein menus due to high cost or animal protein (Ojeinlukwe. 2020). Its relatively high protein content (22%) makes it highly valuable items of food in the local diet.

1.2 Problem statement and justification

Already established by most researchers, Ghana has adequate land and stable climatic condition for cowpea production. Besides large farms, cowpea has been established in many parts of the country by individual and government agencies. In spite of all these, Ghana's production of cowpea fall under expectation of the internal demand as annual population growth increase at the rate of 3 % whilst food production increases at the rate of 2%.This means that the required yield per area or land is not obtained due to a number of factors such as plant density (Free *et al.,* 2016). Although yield may vary from cultivar but with good and appropriate management, yield may reach 600kg/ha (Tindal, 2016). Plant Spacing determines the size of an area available to each plant and the larger the plant the greater the area required for the plant to perform well. The spacing between stands determines the number or plants per hectare or density. The spacing given to the plant in the field varies greatly, depending on the fertility of' the soil, variety grown, method use and disease and pest control method use. The choice of the two new cowpea varieties being selected is mainly due to the fact that they have recently been released by the crop research Institute (CRI) of the Council for Scientific and Industrial Research (CSIR). The new varieties are early maturing, high yielding, fast – cooking, nutritious and exhibit tolerance to drought and common insect- pests and diseases of cowpeas. The zamzam variety, particularly, is rich in mineral iron and has the potential to reduce iron deficient illness, especially children and women.

Even though early maturing varieties have been developed to mitigate the maturity period yet no conscious attempt has been made to establish the possibility of cultivating these new varieties for high yielding and, especially the rich iron content in grains. Considering the importance of these new cowpea varieties and the possibility of several cropping and harvests in both minor and major cropping seasons, this study was undertaken to find suitable cowpea varieties and also explore their yield potential through appropriate planting distance for maximum yield. Although there have been some reports elsewhere on cowpea response to planting spacing (Jallow and Fergusson, 2018) there is little information on the performance of current cowpea cultivars when grown in the transition agro-ecological zone of Ghana (Ati *et al.,* 2016). Thus, an understanding of how the modern cowpea cultivars will respond to different planting spacing is very important. This will help cowpea growers to select appropriate planting distance that will increase grain yield in their locations.

1.3 Objectives of the study

1.3.1 Main Objective

The main objective of the study was to determine the effect of different planting distance on performance (growth and development) of two varieties of cowpea *(Vigna unguiculata*).

1.3.2 Specific Objectives

The specific objectives were to**:**

1. Determine the effect of different planting distance on the growth of two varieties of cowpea (Zamzam and Tona)
2. Compare the development of two cowpea varieties as influenced by different planting distance
3. Assess the interactive effect of different planting distance on growth and development of two varieties of cowpea.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Origin and Distribution

Cowpea (*Vigna unguiculata* (L.)Walp) is one of the most ancient human food sources and has probably been used as a crop plant since Neolithic times. A lack of archaeological evidence has resulted in contradicting views supporting Africa, Asia and South America as origin. Some literature indicates that cowpea was introduced from Africa to the Indian subcontinent approximately 2000 to 3500 years ago, at the same time as the introduction of sorghum and millet, while others state that before 300 BC, cowpeas had reached Europe and possibly North Africa from Asia. Speculations are that the Northern part of the Republic of South Africa (former Transvaal region) was the centre of speciation of *Vigna unguiculata,* owing to the presence of most primitive wild varieties. Sankle *et al.* (2018) further hypothesized that the species moved northwards from the Transvaal to Mozambique and Tanzania, where the subspecies pubescens evolved. Cowpea is now grown throughout the tropics and subtropics and has become a part of the diet of about 110 million people. According to Angessa, (2016), Africa is the origin of cowpea where domestication took place as well Centers of diversity have been identified in both Africa and Asia, however, the exact region of domestication is still under speculations.

2.2 Botany

Cowpea is herbaceous, short day plant existing in various forms. The plant may be erect, prostrate or twining, with determinate or indeterminate growth habit. It has trifoliate leaves of various shapes and sizes. The leaf petiole is 5 to 25 cm long. The leaves may be lanceolate or hastate. There is a main tap root with several rootlets. On the root are present nodules which vary in their distribution, size, number and shape. The flowers have various shades of colour ranging from purple, white, pink, and blue, to yellow and occur on long penduncles (Onat *et al.,* 2017). Pods may be 25cm long with variation in colour and shape. The commonest pod colour are purple cream and black. Number of seeds per pod varies between six to twenty. Seed coat colour can be white, red, cream, black, brown, or mottled. Germination is epigeal and seeds take two to three days to emerge. The seeds are oblong to globose (spherical) 0.5-1 cm long and can be black, brown, pink or white. The fruit has cylindrical seed, pod 8-30 cm long (in some cases 120 cm long), is pale brown when ripe and bears 8-30 seeds (Jaiswa *et al.,* 2015).

2.3 Varieties

Varieties of cowpea in Ghana include *Boafo* and *soronko,* new Era, local white, Vallenga, Red Nkwanta, Amantin, Asontem. Besides these there are numerous other local varieties. Recently Ghana has released three varieties of cowpeas, which comprises IT93K-192-4 with the local name, Hewale; meaning strength; IT93K-410-2 or Asomdwee ;meaning ;peace and IT95K-142-20 also known as videfulu (vode le enjufuu) which means; profitable.(MoFA 2012). However, the introduction of new, recommended and improved varieties of cowpea has helped boost the yield of farmers.

2.4 Uses and Nutritional Value

Cowpeas are a major staple food in many parts of Africa where every part of the plant is eaten. Green seeds are roasted and used like peanuts. Dried seeds may be boiled and used in soups or stews, or ground and made into cakes. Scorched seeds are sometimes used as a coffee substitute. Immature pods are steamed or boiled and eaten whole. The green leaves are boiled and eaten like spinach. According to Appiah *et al.* (2011), cowpea is cultivated for its leaves, green pods, grain and haulm for livestock feed. It is a major source of protein. Legumes are important because they supplement soil nitrogen through atmospheric fixation thus improving soil fertility (Tian *et al*., 2017). Cowpea is a valuable component of farming systems in many areas because of its ability to restore soil fertility for succeeding cereal crops grown in rotation with it (Sanginga *et al.*, 2013). Cowpea plays a critical role in the lives of millions of people in Africa and other parts of the developing world, where it is a major source of dietary protein that nutritionally complements staple low-protein cereal and tuber crops, and is a valuable and dependable commodity that produces income for farmers and traders. Cowpea leaves can be used as spinach. The grain can be boiled and eaten with stew.

The flour can be used to prepare *koose, tubani* and fortified foods (e.g. porridge) for adults and children (Martey *et al.,* 2015). An added advantage of cowpea is that the plants can be harvested as fodder for livestock (Kebe and Sembene, 2011). Cowpea (*Vigna unguiculata*) is a dual leguminous plant grown in most areas for its leaves and seeds. Although the leaf protein content is lower than that of the grain its dietary contribution is not negligible (Wang *et al.,* 2017). Vitamin C and pro-vitamin are abundant in this vegetable leaves and it is also high in calcium, phosphorous and Iron. It is an important crop especially in the tropical and subtropical belt, where protein deficiency and malnutrition is a major problem (Abukutsa, 2011). Cowpea is considered nutritious with a protein content of about 23%, fat content of 1.3%, fiber content of 1.8%, carbohydrate content of 67% and water content of 8-9% (Quinn and Myers, 2016). It also contains B vitamins such as folic acid which is important in preventing birth defects and essential micronutrients such as iron, calcium and zinc (Kebe and Sembene, 2011). Although a significant amount of cowpea is commercialized, it plays a critical subsistence role in the diets of many households in Africa, Latin America and Asia, providing nutrients that are deficient in cereals (Kebe and Sembene, 2011)

2.4 Production Estimate

Production of the cultivar group a Sesquipedialis (or yardlong) bean is widespread throughout Asia and is thought to be grown on about 300,000 ha. Dry grain production is the only commodity of cowpea formerly estimated on a worldwide basis. The United Nations Food and Agricultural Organization (FAO, 2014) estimates that nearly 4 million metric tons (mt) of dry cowpea grain is produced annually on about 10 million ha worldwide. Cowpea grain production estimates by (Singh *et al*, 2016) are slightly higher than FAO 2014 estimates, with worldwide production of 4.5 million (mt) on 12 to 14 million ha. About 70% of this production occurs in the drier Savanna and Sahelian zones of West and Central Africa.

The large urban centers of coastal West Africa are huge markets for cowpea produced further inland where climates are drier and favorable for production of high-quality grain. The United States produces about 80,000 mt, in several southern states (Alabama, Arkansas, Georgia, Louisiana, Missouri, Tennessee and in Texas and California (Fery, 2017). In Ghana, cowpea is very important in the efforts of Ghanaian farmer to ensure a sustainable cropping system in Ghana. The crop is usually cultivated for its leaves, green pods, grain for human consumption, and the haulm for livestock feed. It is an important source of vegetable protein and minerals for over 70 % of Ghana population and it is the second most important grain legume (Hamakareem *et al.,* 2016). It is, therefore, important that activities regarding its cultivation such as the appropriate planting density should be seriously taken into consideration in an effort to produce the crop

2.6 Climatic and Soil Requirements

2.6.1 Climatic Requirements

Cowpeas grow best during summer. The best temperature for germination is 8.5 °C and for leaf growth 20 °C. Cowpea is a heat-loving and drought-tolerant crop. The optimum temperature for growth and development is around 30°C. Varieties differ in their response to day length, some being insensitive and flower within 30 days after sowing when grown at a temperature around 30 °C. Cowpea readily germinates and the young plants are robust. Planting dates and temperatures are roughly the same as soybean. Planting dates should be late May through mid-June. A daytime temperature of 80°F (FAO, 2015) and a consistent soil temperature of at least 65°C are best. Plants require well-drained, highly acidic to neutral soils, but can grow well in a range of soil types, including soils with low fertility. The plant is very drought resistant and does not survive flooded conditions. Cowpea can be grown under rain fed conditions as well as by using irrigation or residual moisture along river or lake floodplains during the dry season, Provided that the range of minimum and maximum temperatures is between 28^0C and 30^0C (night and day) during the growing season. Cowpea performs well in agro-ecological zones where the rainfall range is between 500 and 1200 mm/year. However, with the development of extra early and early maturing cowpea varieties, the crop can thrive in the Sahel where the rainfall is less than 500 mm/ year.

2.6.2 Soil Requirement

Cowpeas can be planted in a wide range of soils, from acidic (pH 4) to neutral, as long as they are well-drained but the plants are not well adapted to alkaline soil. Cowpeas can be produced successfully in areas where soil fertility and pH are not suitable for the production of maize. For normal production, soils must have a depth of 0.5m. For best results, plant cowpeas in a well-draining sandy loam with a pH between 5.5 and 6.5 in an area that receives full sun. Cowpeas are drought resistant and very heat tolerant which means they can be grown successfully in many areas (Gulluoglu et al., 2016). Cowpeas can be planted in soils that vary from sandy to clayey, but soil that is easily waterlogged must be avoided. Nitrogen fixation, which is a characteristic of legumes, is inhibited in waterlogged soils.

2.7 Crop Propagation

The main planting material of cowpea which is accepted or recognized is the seed (Nianget *al.,* 2016). However, Genetic Modified Organims (GMOs) is now been produced through tissue culture as a planting material (FAO, 2015). Every farmer has his/ her own ideology of planting pattern, in the rural areas, most farmers use scatter method. Some may choose to go for triangular pattern and so on. This means that there is no specific planting pattern and hence planting density for cultivation of cowpea (Porter *et al.,* 2016). For the spacing, a variety varies with their climatic conditions such as rainfall, temperature, humidity and a host of them. Sometimes early maturing varieties are planted between April to May at a spacing of 60 cm x 20 cm and the medium maturing varieties planted between April to May at the spacing of 70 cm x 20 cm (Tiradoet *al.,* 2015). Two seeds per hill are used for seeds that are free from diseases (Müller *et al.,* 2018). Planting date is an important cultural practice that results in the differences in growth and yield of grain legumes without involving additional costs such as addition of fertilizers. The optimum planting date varies according to cultivar planted. In South Africa, the optimal planting time for cowpea in cooler areas is mid-November and in the warmer areas mid-December (Republic of South Africa National Department of Agriculture, 2015). This report further explained that due to availability of adequate rainfall, planting during this period ensures good seedling establishment, and good flowering and pod filling stages for maximum seed yield.

2.7 Agronomic Practices

2.7.1 Weed Control

All plants require a certain amount of nutrients, water and space for growth, and when crowded they cannot thrive well. If the space needed for their development is to some extent occupied by weeds that rob the cultivated plants of nutrients, moisture and sunlight, then returns from the crop must be correspondingly less. Ghana Grain Development Project FAO/UNESCO (2008) stated that weeds have a competitive advantage over young cowpea seedlings and therefore it is necessary to keep fields free from weeds at least in the first 2-4 weeks after sowing. Yield losses of 40 -60% is due to weeds have been reported (Raemaekers, 2015). Weeds must never be allowed to out-grow cowpea plants before being controlled. According to Dogan*et al.* (2018), the best time to minimize the effect of weeds on maize yields is within 2 weeks after planting when cowpea is in the 2 to 3 branches-leaf stage. Prohibitive nosious weeds are very difficult to control and time consuming example *Striga*s pp. Chemical control is not needed as it need technical knowledge. Fertile soil has good effect on *Striga*s pp thus more fertile are less infested with Striga. Awuku*et al.*, (2011) stated that farmers can use organic or chemical fertilizer on continuously or previously used land in southern and central Ghana and place where *Striga*spp are the mojor weeds. It is also advisable to add small amount of fertilizer to spray the field before seeds sowing. Annual weeds such as *Ageratum conyzoides, Amaranthus spinocus, Boerhavia diffusa* and among others have ability to produce large quantities of seeds, a tendency to occur in/ high density and efficient method of seed dispersal and need to be control manually or pre tillage can assist to arrest these weeds pressure (Ndiaga, 2019). Biological method of control weeds in cowpea production for field experiments or researchers only since most organisms prefer the leaves of cowpea for their source of food.

2.7.2 Fertilizer Application

The process of nitrogen fixation takes place in the root nodules and the bacteria usually makes use of sugars produced by the plant. It has been discovered that cowpea *Rhizobium* is widespread however, seed inoculation with *Rhizobium* that is specific to cowpea would be very relevant and beneficial in areas where it is not present. It is also very important and necessary to use the right *Rhizobium* regarding the cowpea variety (Saglam*et al.*, 2020). Cowpea, as a legume, usually forms a symbiotic relationship with a specific soil bacterium (*Rhizobium* sp.) which makes atmospheric nitrogen available to the plant via nitrogen fixation (Shiringani, 2011). The plant will perform well under low nitrogen conditions due to a high capacity for nitrogen fixation. In most cases, a starter nitrogen rate of 27 $kgha^{-1}$ is required for early plant development on low-nitrogen soils (Wills, 2016).

2.7.3 Pest Control

Pests are the main problems which significantly cause low yields on farmers' farms where serious control measures are lacking. Pest of vegetative stage includes *Zonocerus variegatus*. Some of the pest at the floral and pod stage is *Melanagromy zavignalis.* This insect pest is mainly controlled with recommended insecticides. Four applications are necessary. First application should be done at flower initiation and ten days intervals thereafter. This enables the researchers to apply fungicide. Chemicals were used to control insect pest Insect pests cause maximum damage to cowpea from seedling stage to grain storage (Ajeigbe and Singh, 2016). Cowpea cultivars resistant to Empoascu have been identified (Keller *et al.*, 2015). Foliage beetle (*Oothecamutabilis*.) is a known pest that causes harm to cowpea and it is widely distributed in Africa where it is an important foliage feeder on cowpea seedlings.

In East Africa a related species, *bennigseni*, is also found. Adults are about 6 mm long, oval, and normally shiny reddish brown, although this varies considerably and black or; brown adults may occur. Yellow egg masses are laid in soil, and there are three larval instars. Adults feed internally on the leaves, later enlarging damage into feeding holes. High beetle populations can totally defoliate cowpea seedlings and kill them. The larvae feed on cowpea roots but seldom cause serious damage. Adult beetles are effective vectors of cowpea (yellow) mosaic virus (Ojiem*et al.,* 2017). Striped Foliage Beetle *Medythiaquaterna* (= *uperodeslineata* = *Paraluperodusquaternus*) M. quaterna is known from the forest zone of West and Central Africa where it is a sporadic pest. Its distribution is less wide than *Oothecamutabilis*. The adult, who is about mm long and striped longitudinally with white and light brown markings, attacks young cowpea seedlings by feeding on newly emerged leaves, mostly at the margins. Eggs are laid in the soil, where the larvae and pupae develop. Other beetles, which are minor pests of cowpea include *Lagriavillosa* and the related *Chlysolagrianairobana*. Cowpea seedlings can withstand a substantial amount of defoliation by these beetles without effect on subsequent seed yield (Schipps*et al.,* 2015). Cowpea aphid (*Aphis craccivora*) is an important legume pest of Asia and recent observations suggest that aphids may also be seasonally important in parts of Africa. This species of aphid not only causes direct damage to its hosts (including groundnut as well as cowpea) but also transmits cowpea aphid-borne mosaic virus. A. *craccivora* is a medium sized, shiny black aphid whose biology varies depending on climate and soil.

Under favourable conditions a generation may take only 13 days. Adults live from 6-15 days and may produce more than 100 progeny. On cowpea aphids normally feed on the under surface of young leaves, on young stem tissue and on pods of mature plants.

When present in large numbers, they cause direct feeding damage. The plants become stunted, leading to leaf distortion, premature defoliation and death of seedlings. An indirect and generally more harmful effect, even of small populations, is the transmission of cowpea aphid-borne mosaic virus. Control by planting resistant varieties and old harvested plants must be removed from the field, as these often host the aphids (Ajeigbe*et al.,* 2015). Pod Sucking Bug (*Anoplocnemiscurvipes*) is a major pest in tropical Africa; yield losses vary from 30 to 70 percent. Full grown bugs are black and are about 3 cm long. Eggs are laid in chains and are grey to black. They hatch in about 7-11 days. There are five *nymphal*instars, and the early instars resemble ants. The total *nymphal*period varies from 29-54 days; the life of an adult from 24-84 days. Eggs are usually laid on leguminous trees or weeds, but seldom on cowpeas. Adults are strong fliers. They suck the sap from green pods, causing them to shrivel and dry prematurely with resulting loss of seed. Several commercial pesticides are available to control pod sucking bug (Asanti *et al.*,2016).

2.7.4 Disease Control

In cowpea production the most destructive disease is *Pythium* stem rot which is cause by *Pythiumaphaniderinatum*. Distribution and Importance: Worldwide. In Nigeria, field incidence in cowpea normally ranges between 0.5 - 10.0 percent, although occasional incidences of up to 30 percent have been observed. Symptoms and Diagnosis: *Pythium*stem rot is characterized by a grey-green water soaked girdle of the stem extending from soil level Lip to and sometimes including the lower portions of the lower branches. During periods of high humidity copious growth of white, cottony Mycelia occurs at the stem base. Infected plants quickly wilt and lie. The presence of oospores of the causal fungus in the stem curtical tissue distinguishes this disease from *Sclerotiurn* stem rot and *Fusarium*collar rot which superficially resemble it. Cowpea stem rot caused by *Phytophtihora* spp., fungi closely related to *Pythium,* is of local importance in North America, Australia and India.

Control: Probably not seed transmitted. Principally soil-borne. Bi-weekly applications of captafol effectively control the disease, but benomyl may increase its incidence (Ajeigbe *et al.,* 2015). The pathogen is widespread in moist tropics and warm temperate areas but the disease is of minor importance on cowpea. The causal fungus infects the bases of stems producing a fan of silky white mycelium and large round *sclerotia* which are initially white and gradually darken. Infected plants wilt and die. The mycelium and presence of *sclerotia* serve to distinguish this disease from Pythium stem rot which it otherwise resembles. Occasionally, concentrie leaf spots are also induced by C. rolfsi. The *sclerotia* are disseminated by cultivation, wind and water, and occasionally as contaminants among seed. Control may be achieved by cultural means (Smart *et al.,* 2020). Root Knot Nematodes (*Meloidogyne incognita, M.lavanica and M. arenaria*). All three species of nematode are widespread throughout the tropics. M. incognita can cause severe crop loss. A4. javanica may make cowpea more susceptible to fusarium wilt. Affected plants die prematurely as a result of extensive damage to the root system which may be heavily galled. Root knot galls are easily distinguished from the nodules containing Rhizobium which are usually small, spherical, and pink inside.

Numerous species of non-gall-rorming nematodes are parasitic on cowpeas throughout the subtropics and tropics. The nematodes survive in soil and on alternate hosts. This disease can be control by using Nematodes, Crop rotation and host plant resistance (Smart, 2017). Bacterial Blight (Canker) Cause by *Xanthomonasvignicola,*is a widespread and important disease of cowpea in tropical Africa, America and India. Seedling mortality resulting from seed-borne infection may be up to 60 percent. Yield losses from field infection have not been estimated. The initial symptoms of bacterial blight are tiny water soaked dots on leaves. These dots remain small and the surrounding tissue dies, developing a tan to orange coloration with a yellow halo. On heavily infected leaves the dead spots merge so that large areas of leaf are affected. The pathogen also infects the stem, causing cracking (stem canker), and causes water soaking of pods from where the pathogen enters the seed. The disease spreads rapidly during heavy rainfall, and during overhead irrigation. The pathogen is seed borne, and probably survives on diseased crop residues. Methods of control include the use of clean seed and of resistant varieties El Awad (2020). Cowpea (Yellow) Mosaic Virus (CYMV) Knownfrom East (Kenya, Tanzania) and West (Nigeria, Togo) Africa; essentially an African virus though occasionally reported from America CYMV Causes yield losses of 80 -100 percent; the earlier the infection the greater the yield loss.

2.8 Harvesting

The harvesting time for cowpea depends on the purpose for which the crop is cultivated. If it is grown for seed yield, harvesting period is reached when 90 % of the pods are dried. If the crop is grown purposely for hay, then, the harvesting is reached as soon as the pods start to change colour. However, if the cowpea is to be used as a vegetable then, the leaves and young pods can be picked by hand when the leaves are big enough and the pods are formed (Knezevirc *et al.,* 2013)

2.9Effect of planting distance on growth and development of cowpea

Spacing is an important factor governing the plant population, the development of individual plants and ultimately crop yield. Thus the effect of plant population on yield is needed to design proper management practices (Fadlalla, 2017). Spacing trails in many countries, worldwide, have generally shown varying differences in yield within different plant species. Plant density and spacing have great influence on the growth of cowpea. This is because, plant density affects individual plant size and the time taken to reach maturity and this requirement influence the density at which crops are grown. On the contrary, Hatam *et al.* (2015) reported that plants in close spacing took minimum days to 50% flowering. Whereas wide spacing enhances vegetative growth and causes a delay in maturity. Days to flowering in cowpea are considered a variety characteristic, which is genetically controlled. Previous studies, however, showed that the differential response to flowering among cowpea varieties was distinct. El Awad (2018) reported that all cultivars introduced to Sudan significantly grows earlier than the local varieties. The introduced cultivars attained 50% flowering between 44-53 days from effective planting, while the local varieties flowered in 71 days. In contrast, Idris (2018) found that the number of seeds per pod was significantly affected by plant spacing. The author attributed this result to the fact that widely spaced plants suffer less from competition than closely spaced plants and was thus expected to grow better. Cowpea cultivars with varying growth habits have high yield potential, resistance to pest and tolerant to water stress (IITA, 2019).

These cowpea cultivars were however, developed mainly under sole-cropping. Many studies showed that the appropriate row spacing affected growth of the plant. Morrison *et al. (*2012) attested that narrow row spacing had more yield. Plant population can be increase through different plant pattern and spacing. Plant spacing varies from one plant species to another and thus must strictly be controlled to prevent over-crowding which may in turn affect growth, development of cultivated crops. Adequate spacing of crop is important for good yield. Widely spaced crops may produce shorter plants as a result of reduced competition for growth factors. A number of studies have shown that increased crop density due to close spacing would decrease the magnitude effect of weed competition with crops (Adigun, 2019). Biswan *et al.* (2012) reported that plant spacing had significant effect on cowpea plant establishment. The maximum yield of a legume crop depends upon its vegetative growth, such as the number of branches, shoot fresh weight, and root fresh weight. Plant spacing is an important factor that affects flowering and podding of legumes. The reflex of legume plants to different planting distance had been studied by other researchers (Ayaz *et al.,* 2014). Planting distance is one of the important and effectual factors in the fixation of crop growth and is not stable for one variety in different climate conditions. Kobata (2018), reported on increase in number of branches per plant and the higher number of leaves per plant due to close planting distance. Several authors reported that plant height increased with decrease planting distance. In addition Shahein *et al.* (2015), Hussein et *al*. (2019) and Mokhtar (2016), reported that decreasing planting distance influenced number of branches negatively.

CHAPTER THREE

3.0MATERIALS AND METHODS

3.1Experimental site and location

The experiment was conducted at the Multipurpose crop nursery, College of Agriculture Education of the Akenten Appiah-Menka University of Skills Training and Entrepreneural Development, Mampong-Ashanti. Mampong-Ashanti lies at the transitional zone between the forest and northern Savanna Zone of Ghana. Mampong-Ashanti is 57.6 km from Kumasi on the latitude 01ºC, 024ºC west of the equator and it is 457.5m above sea level (Ghana Meteorological Service Department, 2008). Mampong-Ashanti has a bimodal rainfall pattern with annual rainfall between 1094.4 mm and 1200 mm and monthly mean rainfall of about 91.2 mm. The major rainy season occurs from March to July whilst the minor rainy season occurs from September to November (Meteorological Services Department, 2018). Between the two seasons is a short dry spell in August (Meteorological Services Department, 2018). Mampong-Ashanti has a daily temperature of about 30.5 ºC.

3.2 Soil and vegetation at the experimental site

The soil at the experimental site is derived from the voltain sandstone of Afram plains. It belongs to the savanna ochrosol class and is characterized by deep sandy loam; free from pebbles. It is well drained and contains moderate organic matter. The soil has a good water-holding capacity. The p^H ranges from 6.0 to 6.5. It has been classified by FAO/UNESCO (2008) legend as chromic luvisol and locally as Bediesi series. It is good for tuber, cereal, and legumes crops production. The experimental site had been used for the cultivation of various crops such as carrot, tomatoes, maize, cowpea, okra and sweet potato. Grasses such as nut grass (*Cyperus rotundus*), giant star grass (*Cynodonplectostachus*) and guinea grass (*Panicum maximum*) are the most common grass species found in the study area.

3.3 Experimental Design, Treatments and Field layout

3.3.1 Experimental Design

The experimental design used was a 2 x 3 factorial, arranged in Randomized Complete Block Design (RCBD) with three (3) replications.

3.3.2 Treatments

There were six (6) treatment combination, these were:

Table 3.1 Treatments combinations

Treatments	Cowpea Cultivar	Planting Spacing
T1	Zamzam	60 cm x 10 cm
T2	Zamzam	60 cm x 20 cm
T3	Zamzam	60 cm x 30 cm
T4	Tona	60 cm x 10 cm
T5	Tona	60 cm x 20 cm
T6	Tona	60 cm x 30 cm

3.3.3 Field layout

Each experimental plot measured 3.0 m x 2.4 m in size with 0.5 m between plots and 1.0 m between blocks. The field size was 16.9 m x 11 m (185.9 m^2).

3.4 Planting material

The cowpea cultivars used as planting materials were Zamzam and Tona. These were obtained from Crop Research Institute of CSIR, Fumesua near Kumasi. These cultivars (Zamzam and Tona) were used because both were early and medium maturing cowpeas respectively (Zamzam and Tona), drought tolerant, and high yielding and most liked by the local people.

3.5 Land preparation and planting

The land was ploughed, harrowed, lined and pegged on July 15, 2022 at the Multipurpose crop nursery. Sowing was done on the 16th July, 2022; seeds were sown 2-4 per hole at a spacing of 60 cm x 10 cm, 60 cm x 20 cm and 60 cm x 30 cm and at the depth of 2 cm to 4 cm. Each experimental plot contained four (4) rows with ten (10), fifteen (15) and thirty (30) plants respectively within each row. Seedling emergence started four (4) days after sowing and ten (10) days later vacant hills were refilled. Seedlings were thinned to two (2) plants per hole or stand fourteen (14) days after emergence.

3.6 Cultural practices

3.6.1 Weed control

Weed control was manually done using hoe, cutlass as well as hand picking. The first weeding was done on the 24th July, 2022 after planting. Weeding was also carried out anytime the weeds appeared until the field work came to an end. The most common weed species found in the area of study was *Cyperus* spp.

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3.6.2 Pest and Disease control

Incident of cowpea pest and disease were monitored periodically by frequent visit to the experimental field to check for cowpea pest such as; Aphid, Trips and Pod borers. Diseases such as; Blight, Powdery mildew, stem rot, wet root rot and cowpea mosaic were also checked. Insecticide (Rain top-M) (70 WP) at the rate of 150- 80g/ 16L was applied to the crop using a 15 litre knapsack sprayer and applied four weeks after planting. However, no disease was encountered in the field throughout the experimental period on the cowpea crop.

3.7Data collection and statistical Analysis

3.7.1 Data collection

Data were collected on phenology and vegetative growth of plants. The following records were taken;

3.7.1.1Phenological Data

3.7.1.2 Days to 50% Emergence

The number of days to 50% emergence from planting per plot was counted on plants from the two central rows and the mean recorded.

3.7.1.3 Days to 50% flowering

The number of days to 50% flowering from seedling emergence is defined as the number of days to an thesis from seedling emergence until half the plants within the two central rows had flowered and the mean computed.

3.7.1.4 Days to 50% podding

The number of days to 50% podding per plant was counted for the selected plants and the mean recorded.

3.7.2 Vegetative Growth Data

3.7.2.1 Plant height

The plant height was measured from the base to the tip of the four (4) plant tagged from the two central rows four weeks after planting (4WAP)and at 14 days intervals using a meter rule and the mean recorded.

3.7.2.2 Number of leaves per plant

The total number of leaves per plant was counted separately on four (4) plants four weeks after planting (4WAP) and at every 14 days interval and the mean recorded.

3.7.2.3 Number of branchesper plant

The total number of branches per plant was counted separately on four (4) plants four weeks after planting (4WAP) and at every 14 days interval and the mean recorded.

3.7.2.4 Canopy Width

This was obtained by measuring the canopy spread on the four tagged plants from the two central rows using a meter rule and the mean recorded.

3.7.2.5 Dry Matter accumulation

Three plants were uprooted from the border and separated into roots and shoot. The fresh root and shoot weight were determined, oven dried at 70°C to constant weight. The dry biomass was weighed and the mean recorded.

3.8 Statistical Analysis of Data

The data collected was subjected to statistical analysis. Analysis of variance (ANOVA) was carried using Genstat statistical package (Genstat, 2011), and where significant differences were obtained, least significant difference (LSD) was used to separate means at 5% probability.

CHAPTER FOUR

4.0 RESULTS

4.1Phenology

4.1.1 Days to 50 % emergence

There was no significant (P ≥ 0.05) difference between variety and planting distance in days to 50 % emergence (Table 4.1). Tona planted on 60 cm x 10 cm and Zamzam planted on 60 cm x 10 cm interactions produced the same mean value of (5.33 days) while Zamzam planted on 60cm x 30 cm emerged two days earlier than zamzam planted on 60 cm x 30 cm spacing.

4.1.3 Days to 50 % flowering

There was no significant (P ≥ 0.05) difference between cowpea variety, planting distance and variety × planting distance interaction in days to 50 % flowering although Tona planted on 60cm x 20 cm was the earliest to flower (41.00 days) (Table 4.1). However, Tona planted 60 cm x 10 cm.Tona planted on 60cm x 30 cm, Zamzam planted 60 cm x 10 cm and Zamzam planted on 60 cm x 20 cm flowered the same day (41.67 days)

4.1.4 Days to 50 % podding

There was no significant (p ≥ 0.05) difference between variety, planting distance and variety × planting distance interaction in days to 50 % podding although Zamzam planted on 60 cm x 10 cm was late to pod (51.0 days) whilst Tona planted on 60 cm x 10 cm interaction was earliest to pod with mean value of 45 days (Table 4.1).

Table 4.1 Days to 50 % emergence, days to 50 % flowering, and days to 50 % podding as influenced by variety and planting distance

Treatment	Days to 50% Emergence	Days to 50% flowering	Days to 50% podding
Variety			
Tona	5.56a	41.61a	48.1a
Zamzam	5.44a	41.78a	49.7a
LSD (0.05)	NS	NS	NS
Planting distance			
60 cm x 10 cm	5.33a	41.67a	48.3a
60 cm x 20 cm	6.00a	41.83a	49.5a
60 cm x 30 cm	5.17a	41.33a	48.8a
LSD (0.05)	NS	NS	NS
Variety X Planting distance			
Tona X 60 cm x 10 cm	5.33ab	41.67a	45.3a
Tona X 60 cm x 20 cm	5.67ab	41.00a	49.7a
Tona X 60cm x 30 cm	5.67ab	41.67a	49.3a
Zamzam X 60 cm x 10 cm	5.33ab	41.67a	51.3a
Zamzam X 60 cm x 20 cm	6.33b	42.67a	49.3a
Zamzam X 60cm x 30 cm	4.67a	41.00a	48.3a
LSD (0.05)	1.48	NS	NS
CV (%)	4.8	2.5	12.4

4.2 Vegetative Growth

4.2.1 Canopy width (cm)

There was no significant ($p \geq 0.05$) difference between variety and planting distance in canopy width from 4 WAP to 8 WAP (Table 4.2). There was no significant ($p \geq 0.05$) difference between variety x planting distance interactions in canopy width from 6 WAP to 8 WAP except at 4 WAP in which significant difference exist in canopy width. Tona planted on 60 cm × 30 cm interaction produced significantly (p≤0.05) wider canopy width than Tona planted on 60 cm × 10 cm which had the least canopy width.

Table 4.2 Canopy width (cm) as influenced by variety and planting distance from 4 WAP to 8 WAP

	Canopy width (cm)		
Treatment	4 WAP	6 WAP	8 WAP
Variety			
Tona	28.81a	50.60a	57.40a
Zamzam	28.95a	49.10a	53.00a
LSD (0.05)	NS	NS	NS
Planting distance			
60 cm x 10 cm	27.76a	52.30a	61.00a
60 cm x 20 cm	29.09a	44.80a	49.60a
60 cm x 30 cm	29.79a	52.40a	55.00a
LSD (0.05)	NS	NS	NS
Variety X Planting distance			
Tona X 60 cm x 10 cm	26.50a	51.60a	64.00a
Tona X 60 cm x 20 cm	29.50ab	46.30a	52.10a
Tona X 60cm x 30 cm	30.44b	53.90a	56.20a
Zamzam X 60 cm x 10 cm	29.02ab	53.00a	58.00a
Zamzam X 60 cm x 20 cm	28.68ab	43.20a	47.20a
Zamzam X 60cm x 30 cm	29.14ab	50.90a	53.70a
LSD (0.05)	3.92	NS	NS
CV (%)	7.5	12.1	20.1

4.2.2 Number of leaves per plant

There was no significant (P ≥ 0.05) difference between cowpea variety (Tano and Zamzam) and planting spacing (60 cm × 10, 60 cm × 20 and 60 cm × 30 cm) in number of leaves per plant from 4 to 8 WAP (Table 4.3). There was no significant (P ≥0.05) difference between variety × planting distance interaction in number of leaves per plant from 4 WAP to 8 WAP (Table 4.3).

Table 4.3 Number of leaves per plant as influenced by variety and planting distance from 4 WAP to 8 WAP

	Number of leaves per plant		
	4 WAP	6 WAP	8 WAP
Variety			
Tona	18.33a	51.2a	61.9a
Zamzam	17.94a	50.5a	58.0a
LSD (0.05)	NS	NS	NS
Planting distance			
60 cm x 10 cm	18.05a	52.9a	61.9a
60 cm x 20 cm	17.94a	47.0a	56.6a
60 cm x 30 cm	18.41a	52.7a	61.3a
LSD (0.05)	NS	NS	NS
Variety X Planting distance			
Tona X 60 cm x 10 cm	16.21a	44.5a	58.6a
Tona X 60 cm x 20 cm	19.55a	49.1a	58.9a
Tona X 60cm x 30 cm	19.22a	60.0a	68.3a
Zamzam X 60 cm x 10 cm	19.89a	61.2a	65.3a
Zamzam X 60 cm x 20 cm	16.33a	44.8a	54.3a
Zamzam X 60cm x 30 cm	17.61a	45.4a	54.3a
LSD (0.05)	NS	NS	NS
CV (%)	15.9	22.8	19.0

4.2.3 Plant height (cm)

There was no significant (p ≥ 0.05) difference between variety and planting distance in plant height from 4 WAP to 8 WAP (Table 4.4). However, a significant (p≤0.05) difference existed between variety × planting distance interaction from 4 WAP to 6 WAP except at 8 WAP (Table 4.4). Zamzam planted on 60 cm x 10 cm produced significantly ($p \leq 0.05$) taller plant than Tona planted on 60 cm x 10 cm and Zamzam planted on 60 cm x 20 cm at 4 WAP. Zamzam planted on 60 cm x 30 cm interaction produced significantly ($p \leq 0.05$) taller plants than Tona planted on 60 cm x 10 cm interaction which produced the shortest plant height at 6WAP (Table 4.4).

Table 4.4 Plant height (cm) as influenced by variety and planting distance from 4 WAP to 8 WAP

	Plant height (cm)		
Treatment	4 WAP	6 WAP	8 WAP
Variety			
Tona	12.54a	22.74a	25.85a
Zamzam	12.76a	24.28a	27.13a
LSD (0.05)	NS	NS	NS
Planting distance			
60 cm x 10 cm	12.60a	22.97a	26.94a
60 cm x 20 cm	12.45a	23.19a	25.83a
60 cm x 30 cm	12.90a	24.37a	26.70a
LSD (0.05)	NS	NS	NS
Variety X Planting distance			
Tona X 60 cm x 10 cm	11.43a	21.16a	25.32a
Tona X 60 cm x 20 cm	13.36ab	23.49ab	25.71a
Tona X 60cm x 30 cm	12.84ab	23.57ab	26.51a
Zamzam X 60 cm x 10 cm	13.78b	24.78ab	28.56a
Zamzam X 60 cm x 20 cm	11.54a	22.90ab	25.94a
Zamzam X 60cm x 30 cm	12.96ab	25.17b	26.90a
LSD (0.05)	1.95	3.97	NS
CV (%)	8.5	9.3	9.3

4.2.4 Number of branches per plant

There was no significant ($P \geq 0.05$) difference between variety in number of branches per plant from 4 WAP to 8 WAP. However, a significantly ($p \leq 0.05$) higher number of branches per plant was produced by 60 cm x 10 cm than 60 cm x 30 cm (Table 4.5).

There was a significant (p ≤ 0.05) difference between variety × planting distance in number of branches per plant at 4 WAP and at 8 WAP except at 6 WAP. Zamazm planted on 60 cm x 10 cm produced significantly (p≤0.05) higher number of branches per plant than Tona planted on 60cm x 30 cm at 4 WAP (Table 4.5). Tona planted on 60 cm x 30 cm produced the greatest number of branches per plant at 8 WAP (Table 4.5)

Table 4.5 Number of branches per plant as influenced by variety and planting distance from 4 WAP to 8 WAP

	Number of branches per plant		
	4 WAP	6 WAP	8 WAP
Variety			
Tona	1.78a	3.64a	4.05a
Zamzam	1.84a	3.39a	3.64a
LSD (0.05)	NS	NS	NS
Planting distance			
60 cm x 10 cm	2.07b	3.58a	4.08a
60 cm x 20 cm	1.87ab	3.61a	3.58a
60 cm x 30 cm	1.49a	3.36a	3.88a
LSD (0.05)	0.57	NS	NS
Variety X Planting distance			
Tona X 60 cm x 10 cm	1.87ab	3.55a	3.94ab
Tona X 60 cm x 20 cm	2.16b	4.00a	3.72ab
Tona X 60cm x 30 cm	1.33a	3.38a	4.50b
Zamzam X 60 cm x 10 cm	2.28b	3.61a	4.22ab
Zamzam X 60 cm x 20 cm	1.59ab	3.22a	3.44ab
Zamzam X 60cm x 30 cm	1.66ab	3.33a	3.27ab
LSD (0.05)	0.81	NS	1.12
CV (%)	24.6	12.2	16.0

4.2.5 Root Fresh weight (g)

There was no significant (P ≥ 0.05) difference between both cowpea varieties and planting distance in root fresh weight from 4 to 8 WAP although 60 cm x 10 cm planting distance differed significantly from 60 cm x 20 cm in root fresh weight at 8 WAP (Table

4.6). There was no significant ($p \geq 0.05$) difference between variety × planting distance interaction in root fresh weight from 4 WAP to 6 WAP except at 8 WAP in which the interaction between Zamzam planted on 60 cm x 10 cm differed significantly from Tona planted on 60 cm x 20 cm in root fresh weight (Table 4.6).

Table 4.6 Root fresh weight as influenced by variety and planting distance from 4 WAP to 8 WAP

	Root fresh weight (g)		
Treatment	4 WAP	6 WAP	8 WAP
Variety			
Tona	8.56a	26.10a	30.60a
Zamzam	9.11a	24.80a	34.60a
LSD (0.05)	NS	NS	NS
Planting distance			
60 cm x 10 cm	8.50a	25.20a	36.70b
60 cm x 20 cm	8.67a	23.30a	28.80a
60 cm x 30 cm	9.33a	27.80a	32.20ab
LSD (0.05)	NS	NS	7.82
Variety X Planting distance			
Tona X 60 cm x 10 cm	8.00a	25.30a	33.00b
Tona X 60 cm x 20 cm	9.00a	23.30a	27.70a
Tona X 60cm x 30 cm	8.67a	29.70a	31.00ab
Zamzam X 60 cm x 10 cm	9.00a	25.00a	40.30b
Zamzam X 60 cm x 20 cm	8.33a	23.30a	30.00ab
Zamzam X 60cm x 30 cm	10.00a	26.00a	33.30ab
LSD (0.05)	NS	NS	11.06
CV (%)	23.5	24.4	18.7

4.2.6 Root dry weight (g)

There was no significant (P ≥ 0.05) difference between variety and planting distance in root dry weight across the cropping period (Table 4.7). There was a significant (P ≤ 0.05) difference between variety × planting distance in root dry weight at 4 WAP (Table 4.7). Tona planted on 60 cm x 30 cm produced significantly (p≤0.05) higher root dry weight than Tona planted on 60 cm x 10 cm and Tona planted on 60 cm x 20 cm interaction which recorded the same mean value (2.33g) at 4 WAP (Table 4.7).

Table 4. 7 Root dry weight as influenced by variety and planting distance from 4 WAP to 8 WAP

	Root dry weight (g)		
Treatment	4 WAP	6 WAP	8 WAP
Variety			
Tona	2.67a	5.78a	9.11a
Zamzam	2.78a	5.11a	8.78a
LSD (0.05)	NS	NS	NS
Planting distance			
60 cm x 10 cm	2.50a	5.33a	9.67a
60 cm x 20 cm	2.67a	5.17a	7.50a
60 cm x 30 cm	3.00a	5.83a	9.67a
LSD (0.05)	NS	NS	NS
Variety X Planting distance			
Tona X 60 cm x 10 cm	2.33a	5.67a	9.67a
Tona X 60 cm x 20 cm	2.33a	5.33a	8.33a
Tona X 60cm x 30 cm	3.33b	6.33a	9.33a
Zamzam X 60 cm x 10 cm	2.67ab	5.00a	9.67a
Zamzam X 60 cm x 20 cm	3.00ab	5.00a	6.67a
Zamzam X 60cm x 30 cm	2.67ab	5.33a	10.00a
LSD (0.05)	0.92	NS	NS
CV (%)	18.6	19.7	22.8

4.2 7 Shoot fresh weight (g)

There was no significant (p ≥0.05) difference between cowpea variety, planting distance and variety × planting distance interaction in shoot fresh weight from 4 to 8 WAP except at 8 WAP where a significant (p≤0.05) difference exist between 60 cm x 10 cm and 60 cm x 20 cm plantdistance (Table 4.8).

Table 4. 8 Shoot fresh weight as influenced by variety and planting distance from 4 WAP to 8 WAP

	Shoot fresh weight (g)		
	4 WAP	6 WAP	8 WAP
Variety			
Tona	167.9a	605.00a	733a
Zamzam	162.7a	536.00a	739a
LSD (0.05)	NS	NS	NS
Planting distance			
60 cm x 10 cm	158.0a	553.00a	896b
60 cm x 20 cm	152.7a	526.00a	632a
60 cm x 30 cm	185.2a	633a	681ab
LSD (0.05)	NS	NS	NS
Variety X Planting distance			
Tona X 60 cm x 10 cm	149.7a	572a	862a
Tona X 60 cm x 20 cm	166.0a	551a	644a
Tona X 60cm x 30 cm	188.0a	691a	694a
Zamzam X 60 cm x 10 cm	166.3a	534a	930a
Zamzam X 60 cm x 20 cm	139.3a	500a	620a
Zamzam X 60cm x 30 cm	182.3a	575a	669a
LSD (0.05)	NS	NS	NS
CV (%)	19.0	24.7	24.2

4.2.8 Shoot dry weight (g)

There was no significant (P≥0.05) difference between Tona and Zamzam in shoot dry weight at 4 WAP and 6 WAP (Table 4.9). Tona variety differed significantly from Zamzam in shoot dry weight at 8 WAP (Table 4.8). There was no significant (P ≥0.05) difference between plant distance in shoot dry weight from 6 to 8 WAP except at 4 WAP where significant difference existed between plant distance (Table 4.9). A significantly (p≤0.05) higher shoot dry weight occurred between 60 cm x 30 cm spacing from 60 cm x 20 cm at 4 WAP. There was a significant (p ≤ 0.05) difference between variety × planting distance interaction in shoot dry weight at 4 and 8 WAP. Zamzam planted on 60cm x 30 cm interaction produced significantly (p≤0.05) higher shoot dry weight than Zamzam planted on 60 cm x 20 cm at 4 WAP. Tona planted on 60 cm x 30 cm interaction produced significantly (p≤0.05) higher shoot dry weight than Zamzam planted on 60 cm x 20 cm interaction at 8 WAP (Table 4.9).

Table 4.9 Shoot dry weight as influenced by variety and planting distance from 4 WAP to 8 WAP

	Shoot dry weight (g)		
Treatment	4 WAP	6 WAP	8 WAP
Variety			
Tona	16.33a	25.8a	35.22b
Zamzam	16.22a	22.3a	31.89a
LSD (0.05)	NS	NS	2.11
Planting distance			
60 cm x 10 cm	15.67ab	26.3a	32.67a
60 cm x 20 cm	14.67a	24.0a	32.83a
60 cm x 30 cm	18.50b	21.8a	35.17a
LSD (0.05)	2.98	NS	NS
Variety X Planting distance			
Tona X 60 cm x 10 cm	15.67ab	29.7a	33.33ab
Tona X 60 cm x 20 cm	15.00ab	24.0a	34.67bc
Tona X 60cm x 30 cm	18.33ab	23.7a	37.67c
Zamzam X 60 cm x 10 cm	15.67ab	23.0a	32.00ab
Zamzam X 60 cm x 20 cm	14.33a	24.0a	31.00a
Zamzam X 60cm x 30 cm	18.67b	20.0a	32.67ab
LSD (0.05)	4.22	NS	3.66
CV (%)	14.3	24.2	6.0

CHAPTER FIVE

5.0 DISCUSSION

5.1Phenology of Cowpea as affected by variety and planting distance

The non-significant difference between variety and planting distance in days to 50% emergence might probably be that plant spacing had no effect on varieties. The same mean value of (5.67 days) days to 50% emergence produced by Tona planted on 60 cm x 20 cm, Tona planted on 60cm x 30 cm, Zamzam planted 60 cm x 10 cm and 60 cm x 10 cm could be due to closer intra row spacing. This disagrees with Koli (2014) and Dhital *et al* (2016) who reported that emergence increased with increase in planting distance. The earlier seedling emergence of 60 cm x 30 cm than others planted at closer spacing might be due to the variety response to less competition for space and soil nutrients (Yama et al., 2016).

The 60 cm x 30 cm took the advantage of less density, utilized the growth factors such as sunlight, soil nutrients and water to emerge. The significant difference in days to 50 % emergence between variety x planting distance interaction could probably be that plant spacing had effect on both varieties. The non- significant difference between variety, planting distance and variety × planting distance in days to 50 % flowering and days to 50 % podding might be that treatment effect on varieties were similar Wien *et al.,* (2014).

5.2 Vegetative growth as affected by variety and planting distance

The results on canopy width indicate that no significant ($P \geq 0.05$) difference occurred in canopy width in both varieties and planting distance treatments from 4 WAP to 8 WAP. This is an indication that none of the planting distance had superior effect in influencing the canopy width which probably suggests that any of the planting distance could provide proper growth of cowpea. It is however, worth stating that in spite of the lack of significant effect, plant spacing 60 cm × 10 cm provided cowpea with the widest canopies from 6 to 8 WAP. This might be due to close intra row planting spacing. The high number of plants per row might have led to high productivity per unit area of land, efficient use of water and nutrients for early canopy formation with subsequent high light interception. Canopy spread determines solar radiation interception and utilization and may impact positively on yield (Peksen *et al.,* 2015). The significantly wider canopy spread produced by Tona planted on 60 cm × 30 cm interaction spacing at 4 WAP could be due to wider intra row planting distance. The wider intra row planting distance might have provided enough space for horizontal growth coupled with efficient use of light interception. Light interception is highly influenced by different planting patterns (Mattera *et al.*,2013), since the canopy structure changes in response to planting distance.

The non-significant difference between variety, planting distance and variety × planting distance interaction across the cropping period in number of leaves per plant could be that the treatment had no effect on varieties of cowpea. The non-significant difference between variety and planting distance in plant height across the growing period might be that the treatments were similar and had no effect on variety. The significant difference that occurred between variety × planting distance interaction from 4 to 6 WAP in plant height could be due to differences in genetic characteristics of both varieties and their response to differences in plant spacing. Cowpea display morphological adaptations to its growth environment, such as plant spacing by modifying its canopy structure through leaves produced (Singh *et al.,* 2017).

The greater number of branches per plant produced by Tona planted on 60 cm x 30 cm interaction compared to other treatments at 8 WAP could be due to efficient use of soil nutrients and interception of solar radiation to enhance photosynthesis due to wide intra row spacing for early growth (Deng *et al.,* 2015). This agrees with Dwivedi *et al. (*2016) who observed better use of light and soil nutrients in legume-cereal intercrop. Similarly, Ajeigbe *et al.* (2015) opined that at close spacing the branches develop less in number than at wider spacing and that there is reduced vegetative and lateral development with closely spaced cowpea plants. The non- significant ($P \geq 0.05$) difference between variety and planting distance in root and shoot fresh weight from 4 to 8 WAP could probably be that planting distance had no effect on variety and its interaction. Plant dry matter accumulation increased linearly during the latter growth stage of plant. Hatfield and Prueger (2015) reported that favourable and soil conditions due to less competition potentially support the normal growth of plants. The reduction in dry matter accumulation with Zamzam planted on 60 cm x 20 cm at 4 WAP, might be attributed to competition for space, light and moisture in the soil among crops. Sterner (2014) attested to the fact that, closely spaced plants compete for nutrient and other growth factors thus produce low dry matter accumulation.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1Conclusion

. The result revealed that:

- Zamzam planted on 60 cm x 30 cm interaction, emerged earliest (4.67 days)
- Tona planted on 60 cm x 10 cm, Zamzam planted on 60 cm x 10 cm and 60 cm x 10 cm spacing emerged at the same period (5.33 days) whilst Zamzam planted on 60 cm x 20 cm interaction and Tona planted on 60 cm x 30 cm emerged late (6.33 days) and the same time.
- Tona planted on 60 cm x 20 cm and Zamzam planted on 60cm x 30 cm were earliest to flower (41.00 days) whilst Tona planted on 60 cm x 10 cm was earliest to pod (45.3 days) although no significant difference exist between treatments interactions.
- Tona produced wider canopy width and higher number of leaves per plant than zamzam from 6 to 8 WAP, whilst Tona planted on 60 cm x 30 cm interaction produced significantly ($P \leq 0.05$) wider canopy width than on 60 cm x 10 cm interaction.
- Zamzam planted on 60 cm x 10 cm produced significantly ($P \leq 0.05$) taller plants than Tona planted on 60 cm x 30 cminteraction and on 60 cm x 10 cm which produced shortest plants at 4 WAP and 6 WAP respectively.
- Planting distance 60 cm x 10 cm produced significantly heaviest root fresh weight at 8 WAP.
- Tona planted on 60 cm x 30 cm interaction produced significantly greatest number of branches per plant.

6.2Recommendations

From the results the following recommendations are made:

- For higher vegetative biomass only to serve as animal fodder, cowpea farmers should plant Tona using on 60cm x 30 cm planting distance.
- Farmers, are to plant Zamzam on 60 cm x 30 cm for earliest days to 50% seedling emergence and flowering.
- For high yield of cowpea, farmers are to plant Tona using 60 cm inter row spacing and either 10 cm, 20 cm or 30 cm intra row spacing for maximum number of branches per plant, since different levels of lateral and main stem branches have influence on plant yield.
- Further research should be carried out at different location and different climatic condition to validate these findings.

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