Effect of Spacing and Chemical Fertilization on growth, yield and nutritive quality of ravaya

(*Solanum melongena* cv Baby Aubergine).

By

Alfred Kwasi Nsiah

JUNE, 2009.

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY (KNUST), KUMASI, COLLEGE OF AGRICULTURE AND NATURAL RESOURCES (CANR), FACULTY OF AGRICULTURE, DEPARTMENT OF HORTICULTURE

EFFECT OF SPACING AND CHEMICAL FERTILIZATION ON GROWTH, YIELD AND NUTRITIVE QUALITY OF RAVAYA (*SOLANUM MELONGENA* CV BABY AUBERGINE)

A THESIS SUBMITTED TO THE SCHOOL OF RESEARCH AND GRADUATE STUDIES, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI, GHANA

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE (OLERICULTURE) DEGREE.

BY

ALFRED KWASI NSIAH

JUNE, 2009.

DECLARATION

I do hereby declare that this work is my own original work and the results of my own investigations and that no such work has been presented in this University or elsewhere, in a previous application for MSc degree.

References made to the work of other authors which served as sources of information are duly acknowledged.

………………………………..   …………………………….

ALFRED KWASI NSIAH   DATE

(STUDENT)

………………………………   ……………………………..

PROF. P. Y. BOATENG   DATE

(SUPERVISOR)

…………………………….   …………………………..

DR. B. K. MAALEKUU   DATE

(HEAD OF DEPARTMENT)

DEDICATION

This thesis is dedicated to my brother Samuel Yaw Nsiah, my dear wife and children.

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ABSTRACT

A study on the effect of spacing and chemical fertilization on growth, yield and nutritive quality of ravaya (*Solanum melongena* cv Baby Aubergine) was conducted in a 3 x 4 factorial experiment on the experimental plot at the Department of Horticulture, Faculty of Agriculture, KNUST, Kumasi. In a Randomized Complete Block Design, spacing and fertilizer constituted the factors, spacing being the main plot factor with 3 levels and fertilizer, the subplot factor with 4 levels. Data were collected on nutrient status of soil sample before the start of the experiment, vegetative and reproductive growth, marketable and unmarketable yields, nutrient composition of fruits and cost benefit analysis. Soil analysis indicated that the soil was ideal for the production of aubergine since all the nutrients were within the production range. Spacing did not affect plant height and canopy spread however, fertilization significantly affected plant height but not canopy spread. Applying 12g NPK + 5g S/A (F_3) produced taller plants. Their interaction influenced plant height and canopy spread. Number of leaves and branches per plant were not influenced by spacing but were significantly affected by fertilization. Plants which received 12g NPK + 5g S/A (F_3) had more branches and leaves than the control (F_0). The interaction showed significant differences between some of them with the S_3F_1, S_3F_2 and S_3F_3 having more branches and leaves. Plant girth was neither affected by spacing, fertilization nor their interaction effect. Spacing had no influence on days from sowing to 50% flower bud appearance, neither on flower opening nor fruit set. Plants which were not fertilized (control – F_0) and those fertilized with 5g Sulphate of Ammonia (F_1) per plant produced flower buds, opened flowers and set fruits earlier than the F_2 and F_3 plants. On yield, the closest spacing (70cm x 50cm) S_1 produced the highest number and weight of fruits per hectare but the least fruit yield per plant. With fertilization, the F_3 plants produced more fruits per plant and per hectare. The interaction showed that the closest spaced plants (70cm x50cm), and the highest fertilizer rate 12g NPK+5g Sulphate of Ammonia (S_1F_3) had more number and weight of

fruits per hectare. The closest spacing S_1 (70cm x 50cm) and its interaction with fertilizer F_3 (12g NPK + 5g S/A), S_1F_3 recorded the highest total weight of export marketable and unmarketable fruits. Neither spacing nor fertilization influenced fruit length and diameter but for the interaction, the S_3F_0 plants had the least fruit length and diameter that significantly differed from the others. Total yield per harvest reached its peak at the fifth harvest and declined thereafter. The closest spacing (70cm x 50cm) produced the highest total number and weight of both marketable and unmarketable fruits per hectare while the widest spacing (70cm x 70cm) produced the least weight of unmarketable fruits per hectare. The highest fertilizer rate 12g NPK + 5g S/A (F_3) produced more marketable and the least unmarketable fruits per hectare. The analysis of fruit samples showed that ravaya was found to be similar in nutrients to garden egg. With the cost of production and profit margin, the S_1F_1

treatment (70cm x 50cm) and 5g of Sulphate of Ammonia recorded the highest net profit.

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CHAPTER ONE

1.0 INTRODUCTION

Ravaya also known as "Baby Aubergine" is a newly introduced Asian vegetable crop in Ghana. It belongs to the genus *Solanum* and family *Solanaceae*. The family contains many of the world's most popular garden and cash crops such as tomato, eggplant, peppers and potato (Williams *et al.*, 1991; Tweneboah, 1998).

Aubergine might have originated from the Indo-Burmese region and has been cultivated since prehistoric times and occurs with great variability. Secondary sources of diversity are China where it was grown for more than 1500 years ago and most probably Africa. It has now spread throughout the tropics, subtropics and the warm temperate regions and has become an important vegetable in the tropics and subtropics (Siemonsma and Kasem, 1993).

Aubergine is an erect, branching and polymorphous perennial herb up to 1.5m tall, grown as an annual with strong deeply penetrating taproot. The fruits are dark purple in colour and shinny. Plants are sometimes spiny and older ones may become woody (Siemonsma and Kasem, 1993).

Ravaya is grown for its immature fruits, which are used as a vegetable. They may be fried, roasted, stuffed, baked, cooked as curry or pickled, cut into pieces and used in stews and soups. In Indonesia and Malaysia, young fruits are eaten raw. Mature fruits are hard, seedy and bitter. Nutritionally the value of eggplant per 100g fresh edible portion contains 93% moisture, energy 20 cal, CHO 4g, Protein 1.1g, fat

0.1mg, fibre 1g, Ca 7mg, phosphorus 25mg, iron 0.4mg, Vitamin A70IU, thiamine 0.09mg, ascorbic acid

15mg, riboflavin 0.2mg, nicotinamide 0.6mg and niacin 0.6mg (Norman, 1992).

Ravaya is widely used in traditional medicine. The fruit helps to lower blood cholesterol levels and is suitable as part of the diet to help regulate high blood pressure. It is also used as an antidote to poisonous mushrooms. In Malaysia, the ashes of the fruit are prescribed in a dry hot poultice on hemorrhoids and the pounded root is applied inside the nostrils against ulceration. In India, ravaya is used in medicines to cure diabetes, asthma, cholera and bronchitis. In Papua New Guinea, the juice from the roots is used to cure toothache (Siemonsma and Kasem, 1993).

Although the local garden egg is more popular with West Africans than the aubergine types, several West African countries including Senegal, Niger and La Cote d'Ivoire export aubergines to Europe from December to May (Norman, 1992).

The introduction of aubergine in Ghana has increased the popularity of egg plant. Several cultivars have been tested in the country and have proved successful for growing both in the wet and dry seasons (MOFA, 2002).

It is however, more frequently cultivated in the forest and derived savanna zones than in the Guinea and Sudan savanna zones (Norman, 1992). Ravaya grown in the country for export is popular with some farmers in the Greater Accra, Eastern and Central regions. An example is individual members of the Vegetable Producers and Exporters Association of Ghana (VEPEAG), Accra.

According to MOFA report (2002), ravaya yield varies from place to place but an average of 15 – 20 t/ha is obtainable with good management practices such as adoption of optimum spacing and fertilizer application. About 60 – 70% of this is exported and the difference is sold on the local market.

The quantity in metric tonnes of aubergine exported from the years 1997 to 2008, with the exception of 2005, is as follows: 1010.35, 1184.34, 1337.49, 1080.23, 1294.6, 1511.93, 1866.73, 6975.77, 926.67, 923.73 and 2486.59 respectively. Its contribution to the agricultural sector as a non – traditional export crop is between 0.58 and 0.71% (Ghana Export Promotion Council, 2008).

Aubergine is spaced 90cmx90cm during the major wet season(April –July) and 90cmx60cm in the minor wet season(September – November) (Norman, 1992), and from 60cmx75cm to 75cm to 90cm x 90cm depending on the variety (Tweneboah, 1998).

It is of great importance to know the best plant population and spacing, for, these have great effects on the yield of vegetables, though their effects are conditioned by other factors (Fordham and Biggs, 1985).

Knowledge of crops response to population density is also useful for management decisions and provides basis to assess the effects of interspecific competition (Jollife, 1989).

General fertilizer recommendation for aubergine is a preplant application of 250 – 400kg/ha of NPK 15 – 15 -15. For maximum yield, the crop may be side dressed about four times with nitrogen fertilizer at the rate of 80 – 100kg/ha (Norman, 1992)

A number of researchers (Abutiate, 1988; Nandekar and Sawarkar, 1990; Reddy *et al*., 1990 and Kusemee 2004) have undertaken studies into the effects of fertilizer and spacing on eggplant and aubergines for maximization of profit and have come out with varying results. Reddy *et al.* (1990) observed that the highest yields of bringal were obtained at a closer spacing and highest fertilizer rate whilst Kusemee (2004) observed no significant differences on the vegetative growth and yield parameters studied on ravaya.

The objectives of the study were:

a) to determine the optimum spacing that would achieve good growth and higher yield of ravaya.
b) to find out an optimum NPK 15 -15 15 and Sulphate of ammonia fertilizer rates for good growth, high yield and nutritive quality of ravaya.

Figure 1: Ravaya plant with fruits

Figure 2: Ravaya fruits

CHAPTER TWO

2.0 LITERATURE REVIEW

The performance of crops depends on how soil and climatic conditions are manipulated. The adoption of good management practices such as optimum spacing and fertilizer application play significant roles in the performance of crops.

2.1 Effect of spacing on the growth and yield of aubergines

Studying the effect of spacing and weeding frequency on growth and yield of ravaya, Kyeraa (2003) reported that although spacing did not affect plant height, closer spacing produced taller plants, wider canopy and the highest total number of fruits per plant and per hectare.

The effects on the yield, plant height and canopy spread of aubergines were investigated by Kogbe (1983) and Abutiate (1988). These authors reported separately that closer spacing significantly out yielded all other treatments in terms of number and weight of marketable fruits. According to Abutiate (1988), the yield of unmarketable fruits increased sharply with closer spacing whilst the widest spacing gave the lowest yields of both marketable and unmarketable fruits. Total yields however, increased from the first to the fourth harvest and declined thereafter.

A research on the effect of plant density on yield and losses caused by fungus and insects in bringal at Karnataka, India was carried out by Shukla and Prabhakar (1987). They observed that the highest yield (154 t/ha) was recorded with a density of 50,000 plants /ha (50cm x 40cm). The crop was sprayed twice with phytolon (copper oxychloride) but 7.9 to 21.2% damage caused by fungi was recorded. Damage caused by *Leucinodes obonalis* during the monsoon season ranged from 26.8 to 45% despite regular spraying with Decis (deltamethrin).

Barbieri and Deveronino (1989) studied the yield responses of aubergine (*Solanum melongena* L) to irrigation and plant density. In the experiment, aubergine cultivar Violetta Lunga di Napoli planted at densities of 1.6, 3.1, 4.6, 6.2, 7.8 or 9.4 plants / m² were irrigated at rates of 50, 100 or 150% of estimated evapotranspiration (Ete, Class A pan). They observed that there were significant interaction between plant densities and irrigation regime. The best results (marketable yield of 656t/ha) were obtained with plant density of 4.6 plus or minus 1.5 plant /m² with an irrigation rate of 100% Ete.

2.2 Effect of fertilizer levels on the growth and yield of aubergines

Ghanaian soils are found to contain considerable amounts of N, P and K for crop growth. Afari (1999) in a preliminary evaluation of fertilizer application on garden egg and cowpea intercropped system, observed that on the average, N, P and K levels in the soil after harvest were 0.12%, 5.8Cmol/kg and 0.9 Cmol/kg respectively.

On phosphorus contents, ranges of 0-10 mg/kg are considered low, 10-20 mg/kg medium and greater than 20 mg/kg as high (Anonymous, 1978).

Compared to Phosphorus and Potassium, Nitrogen has received more attention in studies related to plant nutrition. This is because in addition to its role in the formation of proteins, nitrogen is an integral part of the chlorophyll molecule. An adequate supply of nitrogen is therefore associated with vigorous vegetative growth and a deep green colour of plants. Except in virgin and very fertile soils where significant responses may not be obtained, nitrogen applied at the correct levels together with adequate amounts of phosphorus and potassium has beneficial effect on productivity of crops (Bellester *et al.*,1964). The effect of N applied in split doses on the growth of different varieties of aubergines was investigated by Nandekar and Sawarkar (1990) and Naik *et al*. (1996). The full rate of P and K and one third of the N rate were applied before planting. The remaining N was applied in 2 equal doses at 30 and 60 DAP (Nandekar and Sawarka, 1990). They observed however, that NPK application significantly increased plant height and spread, the number of leaves per plant, the number of branches per plant and fruit length, diameter and weight compared with the unfertilized control. The highest NPK rate gave the highest yield. Similarly, investigating into the effects of application of high rates of mineral fertilizers on capsicum and egg plant, Ludilov and Ludilova (1976) stated that on heavy clayed chernozem, N, $P2\ O_5$ and $K2\ O$ at 120:120:120kg/ha increased capsicum and egg plant yields by 54% and 75.8% respectively compared with the unfertilized control. Yield increase was due mainly to greater fruit set as mean fruit weight was only affected slightly by the high N, $P2\ O_5$ and $K2O$ rates. The nutrients also improved fruit quality. Increasing the rate to 180:180:180kg/ha gave no advantage.

Investigating into egg plant nutrition on irrigated land, Babich (1975) observed that egg plant receiving nitrogen and phosphorus each at 180kg/ha yielded on the average 49 centners per hectare, that is 35% more than the control. Further fertilizer increases with nitrogen at 180 and phosphorus at 240 kg/ha augmented yield by 53 to 64 centners. Malayskina (1976) in an experiment on the effects of different combinations of mineral fertilizers on egg plants yield showed that among the various combinations tested, plants receiving N, $P2O_5$ and $K2O$ at

120:180:60kg/ha yielded 604.8 centners/ha, 97.8% more than the unfertilized control. Of the different N, $P2O_5$ and K2O combinations, N and $P2O_5$ at 120 and 180kg/ha gave the best results.

High nitrogen level (89.6kg/ha) greatly increased vegetative growth of two local varieties of egg plant (*Solanum integrifolium* L). On the other hand, egg plant yield was doubled from 1.33 to 3.3 kg per plant in an experiment conducted in Allahabad region in India by merely increasing nitrogen application up to 89kg/ha plus 45kg/ha each of P2 O_5 and K2 O (Nertia and Chauhan, 1970).

Addae – Kagya and Norman (1977) observed that the effect of different nitrogen levels of 44.8, 67.2 and 89.6kg/ha on flowering, fruit set and yield was however not significant. Nitrogen fertilization did not affect fruit size and pH but significantly influenced the titrable acidity content of the fruits, with low and medium nitrogen rates giving the best results. Kalyanasundaram and Sambandam (1979) studied the performance of three varieties of bringal (*Solanum melongena* L) to various levels of nitrogen. In trials with the egg plant varieties, the plants received nitrogen at 100, 150 or 200kg/ha. They noticed that the variety Annamalai showed the best response to nitrogen followed by SM-2 and SM-50A. The number of fruits per plot increased with increasing nitrogen rate, except in SM -2 at 150kg/ha. A similar trend was noted with regard to fruit weight per plot. The bearing pod of Annamalai was appreciably longer than in the other two varieties. Studies on the response of egg plant variety Trakeits to rates of mineral fertilization and method of application was carried out by Doikova (1978). He reported that on a three year average, mineral fertilizers raised the yield by 52%. The increases were significant in all years at $P2O_5$, 120 and K2O, 240kg/ha basic treatment, plus a single dressing at the onset of flowering with 240kg N/ha as the most economic combination.

In another experiment, EL–Shal *et al*. (1986) studying the effects of nitrogen fertilizer on the characteristics of four egg plant (*Solanum melongena* L) cultivars reported that in a two season trial with aubergine cultivars, Black Beauty, Florida Market, Local Long Black and Local Long White, the plants received nitrogen at 30 to 120kg/feddan (0.42ha). Yield increased with nitrogen rates up to a maximum at 90kg/feddan and in the summer season from 13.8 to 21.5t/feddan. Local long white was the highest yielding cultivar followed by Black Beauty.

The effect of varying levels of organic and inorganic fertilizers on the yield and nutrient uptake in bringal was experimented by Subbiah *et al*. (1983). They stated that in trials with the aubergine cultivar Co.1, the plants received farmyard manure (FYM) at 12.5 to 37.5 t/ha or N, P2O_5 and K2O (standard rate) or half or double the standard rate. The highest FYM and NPK rates gave 53t/ha and the control plot yielded 29.7t/ha.

Egg plant occupies the soil for a long period hence the plants should be side dressed at 4, 8, 12 and 16 weeks after planting (WAP) with sulphate of ammonia or calcium ammonium nitrate at the rate of 80 to 100kg/ha (Norman, 1992).

2.3 Effect of spacing and fertilizer levels on the growth and yield of aubergines

Investigating into the effect of spacing and fertilization on growth and yield of ravaya, Kusemee (2004) observed that no significant differences existed in the parameters studied, that is, plant height, canopy spread, stem girth, number and weight of fruits harvested, fruit length and diameter.

Studying the response of bringal to varying levels of fertilizers and spacing, Sulikeri (1978) and Reddy *et al*. (1990) observed that the highest yields were obtained at a closer spacing and highest fertilizer rate.

Reddy *et al*. (1990) using four spacings (75cmx60cm (S_1), 60cmx60cm (S2), 60cmx45cm (S_3) and 60cm x

30cm (S_4)) and three rates of NPK fertilizer application 62:50:25 (F_1), 125:100:50 (F2) and 187:150:75 (F_3) in kg/ha, stated that the highest mean fruit yield (17.5t/ha) was obtained with a closer spacing (60cm x30cm) and highest fertilizer rate of 187:150:75kg/ha NPK (S_4F_3).

In their study into the effect of different levels of nitrogen and spacing on fruit yield of egg plant grown in the Mid-hill region of Himachal Pradesh, Rastogi *et al*. (1980) concluded in a 2 –years trials with the variety Pusa Purple Long that the highest average yields were obtained from plots receiving 45kgN/ha compared with higher N rates (60, 75 or 90kg/ha) and spacing of 45cmx30cm or 60cmx30cm.

The response of bringal cultivars to spacing, nitrogen and phosphorus nutrition using aubergine cultivars Pusa Purple Long and Pant Samrat was studied by Srivastova and Singh (1985). The plants were spaced at 75cm x 40cm, 75cm x 60cm or 75cm x 80cm and received nitrogen at 50 or 100kg/ha and P2 O_5 at 0 or 60kg/ha. They observed on the average that Pant Samrat yielded 54% more than Pusa Purple Long. With Pant Samrat maximum net profit was obtained from plants spaced at 75cm x 60cm and N, $P2O_5$ at

100kg/ha whiles with that of Pusa Purple Long, maximum net profit was obtained at a spacing of 75cmx60cm and N, P_2O_5 at 50kg/ha. The experiment thus showed that different cultivars of the crop respond differently to various levels of spacing and fertilizers.

Conducting a research into the response of egg plant to various N, P and K levels and densities on an Oxisol, Mangul –Crespo (1981) used a fertilizer yield equation fitted with yield data from egg plant cultivar Rosita, spaced at 90cmx90cm and 60cmx60cm and each receiving various levels of

N, P and K. The equation indicated that maximum yields of between 38 to 40t/ha marketable fruits could be obtained at both densities with 398kg N, 200kg P2 O_5 and 253kg K2 O/ha. On the influence of mother crop nutrition and spacing on yield and quality of aubergine, a fertilizer rate of 50kg N + 25kg P + 15kg K/ha or twice, 4 or 6 times this rate of NPK fertilizer was used. The report indicated that estimated yields were highest with 200kg N + 100kg P + 60kgK/ha. Of the three spacings tested (90cm x 70cm, 90cm x 60cm and 75cm x 60cm), 75cm x 60cm produced the highest yield (Vijayakumar *et al.*, 1995).

Similarly, studying the effect of nitrogen fertilizer and spacing on two varieties of aubergine, Vadivel *et al.* (1988) also reported that in both varieties the highest yields were obtained with 300kgN/ha applied to plants spaced at 90cm x 60cm.

2.4 Effect of spacing on the growth and yield of other vegetables

Investigating the effect of spacing and date of sowing and plant spacing on the growth and yield of okro (*Abelmoscus esculentus* L) Gorachand and Mallik (1990) and Raghan (1996) respectively, reported that closer spacing produced taller plants of okro.

Studying the effect of planting distances on tomato, Bustelaar and Elhart (1986), Pyzik and Dabrowska (1989) and Saggam and Yazgan (1995) observed separately that wider spacing gave more fruits per plant and heavier fruits than closer spacing but yield per unit area increased with closer spacing.

Similar results were obtained by Ahmed (1984), Metwally *et al.* (1987), Leskovar *et al.* (1992), Petreuska (1993), Decoteau and Graham (1994) and Motsenbocker (1996) who also worked on capsicum found out that plants grown at the highest density produced fewer fruits per plant but more fruits per hectare than those grown at lower densities. In trials with okro variety Pusa Sawani, Gupta (1990) studied the effect of levels of irrigation (20, 40, 60 or 80mm cumulative pan evaporation) and 4 plant densities (spacings of 50cmx10cm, 60cmx10cm, 50cmx20cm and 60cmx20cm). Irrigation at 20mm resulted in the highest mean yield of 147.7q/ha and the closet plant spacing (50cmx10cm) gave the lowest mean fruit weight of 11.6g/fruit and the highest yield/ha (150.8q). Studying the effect of the spacings (45cmx30cm, 45cmx45cm, 60cmx30cm and 60cmx45cm) on the yield of okro, Bisen *et al*. (1996) also reported that the best fruit yield per plant was observed from plants at a spacing of 60cmx45cm.

Wider spacing resulted in higher number of leaf blade and larger foliage (dry and fresh) per plant than close spacing in bulb yield of shandwell 1 onion grown from setts (Korem *et al.*, 1991). On the other hand Bleasdale (1991) reported that high populations are used to produce small bulb onions for pickling with yield slightly less than the maximum. He further reported that some crops such as carrots hold their maximum yields as populations are further increased. Petreuska (1993) and Motsenbocker (1996) realised that wider spacing gave the heaviest seedlings but the narrowest spacing was best for production of capsicum. According to Saggam and Yazgan (1995), number of days to maturity as well as harvesting period was not significantly affected by plant density in tomato.

2.5 Effect of fertilizer levels on the growth and yield of other vegetables

Reddy *et al*.(1984) and Kulvinder and Srivastova (1988) reported that the combination of N and P fertilizers at higher levels resulted in maximum yield being the most economic treatment for okro and capsicum respectively. Yield of fruits significantly increased with increasing rates of nitrogen

(Arora *et al*., 1991; Sharma *et al.*, 1996). Similarly Chaudhari *et al*. (1995) also studying the performance of okro varieties in relation to fertilizer application found that yields increased with the application of fertilizers. Sharma *et al*. (1996) found out that the highest yield and highest income invested was recorded at the highest nitrogen rate on chilli. They concluded that the best treatment to promote yield and profitability was 120kgN and 30kg $P2O_5$/ha. Yields ranged from 36.19kg/ha in the unfertilized control to 88.49kg/ha with application of NPK.

Kulvinder and Srivastova (1988); Arora *et al*. (1991); Naik and Srinivasa (1992) and Singh (1995) working on capsicum and okro realized that parameters such as plant height, number of branches, number of fruits/plant, fruit length and diameter and yield increased with increasing rates of fertilizer application.

Changes in leaf yield and nutritive quality of the black night shade *(Solanum nigrum*) as influenced by nitrogen application was studied by Murage *et al*. (1996). In a field trial *solanum nigrum* plants (widely eaten as a leafy vegetable in Kenya) were supplied with O, 5, 10 or 15gN (as calcium ammonium nitrate) per plant as a side dressing. With application of 5gN/plant, leaf yield after 10 and 12 weeks of growth and ascorbic acid content were more than doubled (the latter reaching > 400mg/100g FW), crude protein and B – Carotene contents were increased by about 60% (to 28.6g/100g DW and 103mg/100FW respectively) and crude fat content was increased from 5.0 to 6.8 per 100g DW compared with controls. For all these parameters application of 10 or 15g N/plant was little or no more effective than 5g N per plant. DM and crude fiber contents decreased with increasing N application rate. N application had little effects on leaf K, Ca and Mg concentrations or on phenolic compounds and oxalates, but nitrate was increased 10 fold by the application of 5g N/plant and continued to increase with increasing N application rate.

Working on the effect of different levels of fertilizer application on the growth of tomato seedlings grown in seedling trays, He and Chen (1996) observed that if rates were too high they retarded root and plant growth and delayed flower bud differentiation.

2.6 Effect of spacing and fertilizer on the growth and yield of other vegetables

Studying the effects of different spacing and fertilizer levels on the growth, yield and quality of okra, Lee *et al.* (1990) and Agyekum (1999) reported separately that closer spacing produced the highest number and weight of fruits per hectare but the least fruit yield per plant. Agyekum (1999) reported that the widest spaced plants had the widest canopy, produced the tallest plants with more leaves and nodes as well as producing more fruits per plant.For the total weight of marketable and unmarketable fruits, the closest spacing recorded the highest figures.

In a 2 –year trial on the effect of fertilizer rate, application timing and plant spacing on yield and nutrient content of bell pepper, *Capsicum annum* transplants were established at in – row spacing of 31cm or 46cm on bare soil and drip irrigated on a twice weekly schedule. A base rate of NPK was applied either in 1 (preplant application) or in 2 (preplant and at first flower set) or 3 (preplant, at first flower set and after midseason harvest) split applications. Additional fertilizer was applied in excess of the base rate on a predetermined schedule or after yield decline " as needed" Concentrations of 12 elements in leaf and fruit tissues were determined throughout the growing season. The 3 –part split application of the base fertilizer increased total yield over the other treatments. Plants spaced at 46cm had higher total and marketable yields in one year than those spaced at 31cm. Interactions of fertilizer treatment and plant spacing did not affect total yield. In one year when additional fertilizer was applied "as needed'', plants spaced at 31cm produced more marketable yield than plants spaced at 46cm. Levels of nutrients in leaves and fruits did not respond to fertilizer treatments or spacing (Russo, 1991). On the other hand, Dimri and Gulshan (1997) adopting N levels of (0, 60, 90 or 120kg/ha and spacing of 60cmx60cm, 60cx45cm, 60cmx30cm and 30cmx30cm) reported that increasing rates of nitrogen

fertilizer and plant spacing in tomato resulted in increase N and chlorophyll content in leaves at all three stages (preflowering, flowering and fruit ripening stages).

Working on tomato, pepper and green bean, (Nassar, 1986 and Mohammed and Ali, 1988; Man Chanda

and Bhopal, 1987; Ivanov *et al.*, 1988) respectively observed that the highest plant density and highest N levels gave the highest yield and quality of fruits.

When okro cultivar Pusa Sawani plants were grown at 3spacings (45cmx15cm, 45cmx10cm and 45cmx45cm) with 4rates of N fertilizer (0,30,60 and 90kg/ha) as sulphate of ammonia, Shrestha (1983) observed that spacing did not affect the number of days to first fruit per plant. It was further known that individual plant yields at each harvest and pod yield per hectare were maximum at spacing of 45cmx45cm. On the part of fertilizer, the study showed that nitrogen fertilizer advanced the first harvest by 4 -6 days compared with the control with pod yield being highest (9.3t/ha) for plants receiving 60kg N/ha. Studying the yield of okro as affected by spacing and nitrogen levels Birbal *et al*.(1995) adopting spacing of 30cmx30cm, 45cmx30cm, 45cmx45cm, 60cmx20cm or 60cmx30cm with nitrogen applied at

50, 100 and 150kg/ha observed that the tallest plants (109.2cm) were obtained with closer spacing 30cmx30cm and highest nitrogen application at 100 and 150kg/ha.

The number of branches per plant were also highest at 45cmx45cm and 100 and 150kgN/ha than at O and 50kgN/ha. Spacing had no effect on days to 50% flowering but nitrogen at 100 and 150kg/ha delayed it by 4.5 and 6.0 days respectively. Number of fruits per plant, individual fruit weight and yield per plant were highest with 45cmx45cm and 60cmx30cm compared to the control. Yields were highest with spacing at 60cmx20cm; 45cmx30cm also giving similar results.

3.0 MATERIALS AND METHODS

3.1 Location

The experiment was carried out at the Department of Horticulture, Faculty of Agriculture, Kwame Nkrumah University of Science and Technology, Kumasi (06 43’N, 01 36’ W) from July, 2004 to January, 2005.

The site falls within the rainfall pattern of the forest zone with a double maxima or bimodal rainfall regime of about 7 months and 5 months of dry period.

3.2 Soil and history of site

The soil of the experimental area which is Akroso series, is sandy loam in structure and belongs to the forest Ochrosol (Ablor, 1972). It is deep, well drained with good to moderately good water holding capacity.

The area had been previously cultivated to many vegetables including okro, lettuce, and spring onion.

Before the start of the experiment, soil samples were taken at a depth of 0 – 15cm and 15 - 30cm from various locations at the experimental site. These were bulked together and a sample was taken to analyse for pH, organic matter content, total nitrogen, available P_2O_5, water soluble K_2O, calcium, magnesium and cation exchange capacity (CEC).

3.3 Source of seeds

Ravaya seeds were obtained from previous cropping at the Department of Horticulture, KNUST.

3.4 Seed sowing and nursery practices

The seeds were sown on 14th July, 2004 in drills spaced at 15cm on seed beds which had been worked into a fine tilth, levelled and firmed. The beds were partially shaded with palm fronds and watered carefully everyday until seedling emergence one week after sowing.

The density of palm fronds was gradually reduced to expose the seedlings to sunlight and to avoid excessive dampness of the soil. Pricking out was done one week after germination. Spraying of the seedlings was done to control cotton stainers (*Dysdercus fasciantus*) using Karate at the rate of 2ml/litre of water. Hand picking of weeds, occasional stirring of the soil and watering were some of the cultural practices carried out.

3.5 Land preparation and field layout

The area was ploughed and harrowed on 23rd and 24th August, 2004 respectively. The experimental field measuring 41m x 11m (451m²) was divided into three blocks of 3m x 41m each. Each block was divided into twelve plots of 3m x 2.5m (7.5m²) each.

3.6 Experimental design

The experimental design was a 3x4 factorial in a Randomized Complete Block Design (RCBD). Spacing and fertilizer constituted the factors, spacing being the main plot factor with 3 levels and fertilizer, the sub plot factor with 4 levels.

The treatments were:

Spacings		Plants/Plot	Plants/ha
S1	70cm x 50cm	30	40,000
S2	70cm x 60cm	25	33,333
S3	70cm x 70cm	20	26,666

Fertilizer levels

NPK 15 -15 -15		Sulphate of Ammonia (S/A)
F0	0g	0g
F1	0g	5g/plant
F2	6g/plant	5g/plant
F3	12g/plant	5g/plant

The treatment combinations therefore were S1 F0, S1 F1, S1 F2, S1 F3, S2 F_o, S2F1, S2F2, S2F3, S3F_o, S3F1, S3F2 and S3F3. These were randomly allocated to the plots by picking pieces of paper with treatments written on them and replicated 3 times.

3.7 Transplanting and cultural practices

Vigorous and healthy seedlings were transplanted six weeks after seed sowing. Watering during the first week after transplanting was done everyday for quick recovery of transplants using a rubber hose.

However, subsequent watering was done every other day and in most cases with the help of the sprinkler irrigation. Dead seedlings and those destroyed by crickets were replaced during the first two weeks after transplanting. Regular weeding was done to avoid competition for nutrients, light and moisture with the main crop while some plants which were affected by Fusarium wilt as diagnosed at the Pathology laboratory of the Crop and Soil Sciences Department, KNUST, were removed and burnt.

3.8 Fertilizer application

Fertilizer was applied according to the treatment combinations and levels. NPK 15 -15 -15 was applied on 10th September, 2004, two weeks after transplanting at the rate of 0g/plant (F0 and F1), 6g/plant (F2) and 12g/plant(F3) by ring application method and incorporated into the soil by hoeing. With the exception of F_o which was the control, sulphate of ammonia was also applied to the other plots (F1, F2, F3) at the rate of 5g/plant at 5 weeks after transplanting and this was incorporated into the soil by hoeing.

3.9 Harvesting

Harvesting started six weeks after transplanting. Immature fruits were harvested since mature ones were hard, seedy and bitter. The fruits with the calyx were harvested with a sharp knife. Harvesting was done weekly for 12 weeks.

3.10 Parameters studied

Data on vegetative growth parameters were taken at fortnightly intervals starting from 3 weeks after

transplanting and these included the underlisted.

3.10.1 Plant height

Measurements were taken from the soil level to the terminal point with a meter rule from plants in the central row of each plot. The measurements started three weeks after transplanting with subsequent ones taken fortnightly until plants were 15weeks after transplanting (WAT).

3.10.2 Canopy spread

Fortnightly measurements of canopy spread were taken from 3 to 15 WAT. The widest spread of each sampled plant was measured.

3.10.3 Number of leaves/plant

The number of leaves per plant was taken three weeks after transplanting and at fortnightly intervals thereafter till 7 WAT. These were obtained by counting individual expanded and developing leaves on each plant on the sampled plants.

3.10.4 Number of branches/plant

The number of primary and secondary branches per plant was counted fortnightly from 3 to 15 WAT on the sampled plants.

3.10.5 Plant girth

The girth of plants was also taken fortnightly at the base 5 cm from the ground of each sampled plant from 3 to 15 WAT using veneer callipers.

3.11 Reproductive growth parameters

3.11.1 Days to flowering

These were recorded as the number of days from seed sowing to 50% visible flower bud appearance, 50% flower opening and 50% fruit set.

3.11.2 Fruit length and width ratio

Fruit length and width were obtained by measuring the length and width of fruits by the use of veneer callipers. Their ratio was determined by dividing the length by the diameter. This parameter shows the export standard of the fruit.

3.11.3 Number and weight of fruits/plant

Mean number and weight of fruits per plant were obtained by dividing the number and weight of fruits per treatment by the total number of plants per treatment.

3.11.4 Yield per number of harvest

The total yield per each harvest was recorded for the number of times that harvesting was done.

3.11.5 Number and weight of fruits/ha

The number of fruits per treatment was counted and together with their weight expressed in tonnes per hectare.

3.11.6 Weight of export marketable fruits/ha

Fruits devoid of disease and pest infestation, or malformation and uniform in colour were sorted out as marketable and their weight calculated in tonnes /ha.

3.11.7 Weight of unmarketable fruits/ha

All diseased and pest infested, malformed and over mature fruits were taken as unmarketable for export.

3.12 Nutrient composition of fruits

Samples of fruits from each treatment were taken at the fifth harvest for fruit nutrient analysis of N,P,K, Ca, Mg, Crude fibre, Protein, Fats, Oils, at the Biochemistry Department of KNUST.

3.13 Cost benefit analysis

Cost benefit analysis was carried out for all treatments for all cultural practices starting from transplanting through to watering, weeding, fertilization and harvesting in order to assess the profitability of the various treatment combinations.

3. 14 Statistical analysis

All parameters studied were statistically analysed and the differences between means determined by the Duncans Multiple Range Test (DRMT)

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4.0 RESULTS

4.1 Soil sample analysis

Analysis of the soil sample (Appendix 1) taken from the field prior to fertilizer application showed that with the exception of Carbon: Nitrogen ratio (C/N) the top soil (0-15cm) had higher concentrations of all the macro and micro nutrients than the subsoil (15-30cm). The analysis also showed that soil pH of 6.2 and 6.1 for the topsoil and subsoil respectively were normal for the production of the crop. Phosphorus availability was very high in both top and subsoils.

4.2 Plant height and canopy spread

Table 1 shows the effects of spacing and fertilizer application on plant height and canopy spread of ravaya from 3 weeks after transplanting to 15 weeks after transplanting.

Even though there was an increase in plant height with time, spacing did not significantly affect it but was affected by fertilization. Applying 12g NPK + 5g S/A significantly ($P<0.05$) produced taller plants than the unfertilized control.

The interaction effect of spacing and fertilization on plant height showed significant differences between

S_3F_3 and S_3F_2, S_3F_1, S_3F_0, S_2F_0, S_2F_1 and S_1F_0. The S_3F_3 plants were the tallest and the S_3F_0 the shortest. Canopy spread was not significantly affected by both spacing and fertilization. The interaction of the

factors affected canopy spread with the S_3F_3 canopy being larger than that of S_3F_0, S_1F_3 and S_1F_0. Larger canopies were produced by plants fertilized with 12g NPK + 5g S/A and spaced at 70cm x 70cm (S_3F_3) than plants spaced at 70cm x 50cm and no fertilizer, the control (F_0).

4.3 Number of leaves and branches

The number of leaves produced was not significantly affected by the spacings (Tables 2a-c) but fertilizer application significantly affected the number of leaves (Tables 2b & c) with the F_3 plants producing significantly more leaves ($P<0.05$) than the F_1 and F_0 plants. The F_2 plants also had significantly more leaves than the F_0 plants but produced similar number of leaves as the F_3 plants. The interaction of the factors significantly affected number of leaves (Table 2c) with the S_3F_2 producing the highest number of leaves.

Data on mean number of branches of ravaya showed that no significant differences existed amongst the spacings. On fertilization, significant difference existed only between the F_3 and F_0 plants. (Tables 2a – e) The interaction showed some level of significance with the S_3F_3 producing the highest number of branches. (Tables 2a – e)

4.4 Plant girth

Tables 3a to d indicate that there were no significant differences in plant girth with respect to the spacings and fertilization. The interaction did not show any significant differences either.

Table 1a Effect of spacing and chemical fertilization on plant height and canopy Spread of ravaya at 3 WAT

Parameters Treatments	Plant height (cm)	Canopy spread (cm)
Spacings		
S_1 70cm x 50cm	19.3a	32.5a

S_2 70cm x 60cm	20.1a	31.6a
S_3 70cm x70cm	19.7a	33.8a
Fertilizer levels		
F_0 control	19.3a	30.3a
F_1 5g S/A	18.7a	31.5a
F_2 6g NPK + 5g S/A	20.7a	34.5a
F_3 12g NPK + 5g S/A	20.1a	34.4a
Interactions		
S1F0	19.3a	32.7ab
S1F1	18.3a	29.4b
S1F2	22.6a	35.2ab
S1F3	17.1a	32.8ab
S2F0	19.9a	29.0b
S2F1	18.3a	31.1ab
S2F2	19.9a	32.5ab
S2F3	22.4a	33.6ab
S3F0	18.9a	29.1b
S3F1	19.6a	33.9ab
S3F2	19.7a	35.7ab

S3F3	20.5a	36.6a

Means with similar letters in a column are not significantly different at DMRT p<0.05 **Table 1b**

Effect of spacing and chemical fertilization on plant height and canopy spread of ravaya at 5 WAT

Parameters	**Plant height (cm)**	**Canopy spread (cm)**
Treatments		
Spacings		
$S_1$70cm x50cm	36.7a	44.9a
$S_2$70cm x 60cm	31.1b	44.4a
$S_3$70cm x 70cm	37.9a	45.2a
Fertilizer levels		
F_0 control	33.8a	42.4a
F_1 5gS/A	34.4a	42.9a
F_2 6q NPK+ 5g S/A	37.6a	47.4a
F_3 12g NPK + 5g S/A	34.9a	46.7a
Interactions		
S_1F0	36.1ab	43.9ab
S_1F_1	33.3bc	40.1ab

S_1F_2	36.5ab	46.9ab
S_1F_3	40.8a	48.8a
S_2F0	27.8cd	43.6ab
S_2F_1	34.6ab	43.4ab
S_2F_2	37.9ab	45.7ab
S_2F_3	23.8d	44.9ab S_3F_2 37.5ab
39.6b		
S_3F_1	35.3ab	45.1ab
S_3F2	38.5ab	49.7a
S_3F_3	40.2a	46.4ab

Means with similar letters in a column are not significantly different at DMRT, $P<0.05$

Table 1c Effect of spacing and chemical fertilization on plant height and canopy spread of ravaya at 7 WAT

Parameters	**Plant height (cm)**	**Canopy spread (cm)**
Treatments		
Spacings		

$S_1$7ocm x 50cm	49.9a	61.3a
$S_2$70cm x 60cm	50.9a	62.5a
$S_3$70cm x 70cm	47.7a	60.4a
Fertilizer levels		
Fo control	44.0c	52.8b
F_1 5g S/A	47.4bc	63.3a
F_2 6g NPK+5g S/A	51.9ab	64.3a
F_3 12q NPK+5g S/A	54.7a	65.2a
Interactions		
S1F0	45.2bc	53.9cd
S_1F_1	47.6bc	63.3ab
S_1F_2	52.0ab	62.0ab
S_1F_3	54.9ab	66.3a
S1Fo	46.5bc	56.1bcd
S2F1	46.3bc	61.0abc
S2F2	53.1ab	65.3a
S2F3	42.6c	67.7a

S_3F_o	40.2c	48.6d
S3F1	48.4b	65.7a
S_3F_2	50.7ab	65.8a
S3F3	51.7ab	61.7abc

Means with similar letters in a column are not significantly different at DMRT, P<0.05

Table 1d Effect of spacing and chemical fertilization on plant height and canopy spread of ravaya at 9 WAT

Parameters	Plant height (cm)	Canopy spread (cm)
Treatments		
Spacings		
S_1 70cm x 50cm	57.3a	63.4a
S_2 70cm x 60cm	56.1a	65.3a
S_3 70cm x 70cm	54.2a	63.4a
Fertilizer levels		

Fo control	50.2b	57.4b
F_1 5g S/A	55.3ab	64.7ab
F_2 6g NPK + 5g S/A	57.4 ab	66.2a
F_3 12g NPK + 5g S/A	61.3a	67.6a
Interactions		
S_1F_O	52.1ab	57.4bc
S_1F_1	55.3ab	64.4ab
S_1F_2	58.4a	64.4ab
S_1F_3	60.6a	67.3ab
S_2F_1	54.0ab	62.6abc
S_2F_2	53.6ab	62.4abc
S_1F_3	59.2a	66.8ab
S_2F_3	52.8ab	69.4a
S_3F_O	46.3b	52.2c
S_3F_1	53.5ab	67.4ab
S_3F_2	54.4ab	67.4ab
S_3F_3	58.2a	66.3ab

Means with similar letters in a column are not significantly different at DMRT, $P<0.05$

Table 1e Effect of spacing and chemical fertilization on plant height and canopy spread of ravaya at 11 WAT

Parameters	Plant height (cm)	Canopy spread (cm)
Treatments		
Spacings		
S_1 70cm x 50cm	61.4a	69.7a
S_2 70cm x 60cm	59.6a	69.6a
S_3 70cm x 70cm	57.5a	68.9a
Fertilizer levels		
F_O control	55.7b	65.6a
F_1 5g S/A	58.9b	66.4a
F_2 6g NPK + 5g S/A	61.4ab	71.5a
F_3 12g NPK + 5g S/A	66.1a	74.1a
Interactions		
S_1F_O	57.3abc	64.4bc
S_1F_1	58.7abc	70.1abc
S_1F_2	64.9ab	72.1abc
S_1F_3	64.5ab	72.1abc

S_2F_O	58.6abc	70.4abc
S_2F_1	59.2ab	63.3c
S_2F_2	63.1ab	72.3ab
S_2F_3	66.4ab	75.7ac
S_3F_0	51.3c	62.2bc
S_3F_1	55.4bc	68.9abc
S_3F_2	56.7abc	70.2abc
S_3F_3	66.9a	74.6a

Means with similar letters in a column are not significantly different at DMRT, $P<0.05$

Table 1f Effect of spacing and chemical fertilization on plant height and canopy spread of revaya at 13 WAT

Parameters	Plant height (cm)	Canopy spread (cm)
Treatments		
Spacings		
S_1 70cm x 50cm	66.6a	76.3a
S_2 70cm x 60cm	65.4a	78.3a
S_3 70cm x 70cm	62.3a	79.6a
Fertilizer levels		
Fo control	60.2b	70.9a
F_1 5g S/A	61.6ab	78.2a
F_2 6g NPK +5g S/A	66.1ab	80.2a
F_3 12g NPK +5g S/A	71.2a	82.9a
Interactions		

S_1Fo	62.2 bc	67.8c
S_1F_1	63.6bc	79.1b
S_1F_2	73.1ab	83.0ab
S_1F_3	67.7ab	75.4bc
S_2Fo	61.5bc	78.3bc
S_2F_1	63.1bc	71.7b

S_2F_2	66.4abc	77.3bc
S_2F_3	70.6ab	81.2ab
S_3Fo	56.9c	70.7bc
S_3F_1	58.2c	79.9b
S_3F_2	58.8c	74.4bc
S_3F_3	75.4a	92.2a

Means with similar letters in a column are not significantly different at DMRT, $P<0.05$

Table 1g Effect of spacing and chemical fertilization on plant height and canopy spread of ravaya at 15 WAT

Parameters	Plant height(cm)	Canopy spread(cm)
Treatments		
Spacings		
S_1 70cm x 50cm	71.1a	79.6a
S_2 70cm x 60cm	70.7a	82.3a
S_3 70cm x 70cm	67.5a	85.2a
Fertilizer levels		
F_0 control	64.0b	76.6a
F_1 5g S/A	66.8ab	78.2a
F_2 6g NPK + 5g S/A	71.3ab	86.5a
F_3 12g NPK + 5g S/A	77.0a	88.1a
Interactions		
S1F0	64.6b	73.5b
S1F1	69.2ab	86.6ab
S1F2	78.7ab	88.4ab
S1F3	71.8ab	80.8b
S2F0	65.5b	84.5ab
S2F1	68.8b	87.6ab
S2F2	71.7ab	82.6ab

S2F3	77.0ab	86.1ab
S3F0	61.9b	72.0b
S3F1	62.3b	85.3ab
S3F2	63.7b	83.7ab
S3F3	82.2a	97.3a

Means with similar letters in a column are not significantly different at DMRT, $P<0.05$

Table 2a Effect of spacing and chemical fertilization on mean number of leaves and branches of ravaya at 3 WAT

Parameters	Mean number of leaves	Mean number of branches
Treatments		
Spacings		
S_1 70cm x 50cm	14a	3a S_2
70cm x 60cm	13a	3a
S_3 70cm x 70cm	16a	4a
Fertilizer levels		
Fo control	12a	2a
F_1 5g S/A	13a	3a
F_2 6g NPK +5g S/A	15a	4a
F_3 12g NPK +5g S/A	17a	4a
Interactions		
S_1Fo	13b	3bcd
S_1F_1	11b	2cd
S_1F_2	17ab	5ab S_1F_3
13b	3bcd	

S_2Fo	10b	2cd
S_2F_1	12b	3bcd
S_2F_2	13b	4abc
S_2F_3	15ab	3bcd
S_2F_o	12b	1d
S3F1	16ab	4abc
S_3F_2	16ab	4abc
S3F3	21a	6a

Means with similar letters in a column are not significantly different at DMRT, $P<0.05$ **Table 2b Effect of spacing and chemical fertilization on mean number of leaves and branches of ravaya at 5WAT**

Parameters	Mean number of leaves	Mean number of branches
Treatments		
Spacings		
S_1 70cm x 50cm	37a	6a
S_2 70cm x 60cm	36a	
6a S_3 70cm x 70cm	42a	
6a		
Fertilizer levels		
Fo control	32c	5a
F_1 5g S/A	35bc	6a
F_2 6g NPK + 5g S/A	42ab	6a
F_3 12g NPK + 5g S/A	45a	
7a		
Interactions		
S_1Fo	33de	5b
S_1F_1	27e	5b
S_1F_2	42abcd	6ab
S_1F_3	46ab	7ab
S_2Fo	31de	7ab

S_2F_1	35 cde	6ab
S_2F_2	36bcd	6ab
S_2F_3	43abcd	7ab
S_3Fo	32de	5b
S_3F_1	44abc	6ab
S_3F_2	48a	8a
S_3F_3	46ab	7ab

Means with similar letters in a column are not significantly different at DMRT, P<0.05.

Table 2c Effect of spacing and chemical fertilization on mean number of leaves and branches of ravaya at 7WAT

Parameters	**Mean number of leaves**	**Mean number of branches**
Treatments		
Spacings		
S_1 70cm x 50cm	80a	10a
S_2 70 x 60cm	82a	10a
S_3 70cm x 70cm	88a	12a
Fertilizer levels		

Fo control	76c	9b
F_1 5g S/A	82bc	11ab
F_2 6g NPK + 5g S/A	89ab	11ab
F_3 12g NPK + 5g S/A	95a	12a
Interactions		
S_1Fo	76de	10bc
S_1F_1	74e	8c
S_1F_2	88abcd	10cc
S_1F_3	92ab	11b
S_2Fo	72e	8c
S_2F_1	78cde	12ab
S_2F_2	80bcde	10bc
S_2F_3	90abc	11b
S_3Fo	72e	8c
S_3F_1	90abc	12ab
S_3F_2	100a	12ab
S_3F_3	92a	14a

Means with similar letters in a column are not significantly different at DMRT, $P<0.05$

Table 2d Effect of spacing and chemical fertilization on mean number of branches of ravaya at 9, 11 and 13 WAT

Parameters	Number of branches	Number of branches	Number of branches
Treatments	**9 WAT**	**11 WAT**	**13**
WAT Spacings			
S_1 70cm x 50cm	11a	12a	15a
S_2 70 x 60cm	12a	13a	16a
S_3 70cm x 70cm	13a	14a	
18a **Fertilizer levels**			
Fo control	10b	10b	13b
F_1 5g S/A	12ab	14ab	16b
F_2 6g NPK + 5g S/A	13ab	13ab	15b
F_3 12g NPK + 5g S/A	14a	15a	20a
Interactions			
S_1Fo	10cd	12bc	15cdef
S_1F_1	11bcd	12bc	13ef
S_1F_2	10cd	13bc	14def
S_1F_3	13abc	13bc	17bcdef
S_2Fo	9d	10c	13ef

S_2F_1	15a	15ab	20abc
S_2F_2	11bcd	12bc	14def
S_2F_3	13c	13b	19abcd
S_3Fo	8d	9c	12f
S_3F_1	14ab	15ab	17bcdef
S_3F_2	15a	15ab	18bcde
S_3F_3	16a	18a	24a

Means with similar letters in a column are not significantly different at DMRT, P<0.05

Table 2e Effect of spacing and chemical fertilizer on mean number of branches of ravaya at 15

WAT

Parameters	**Number of branches**
Treatments	
Spacings	
S_1 70cm x 50cm	16a
S_2 70cm x 60cm	17a
S_3 70cm x 70cm	20a

Fertilizer levels	
F_0 control	14b
F_1 5g SA/plant	19ab
F_2 6g NPK + 5g S/A	17ab
F_3 12g NPK + 5g S/A	20a
Interactions	
S1F0	15def
S1F1	15def
S1F2	13ef
S1F3	18bcde
S2F0	16cdef
S2F1	20abcd
S2F2	15def
S2F3	17bcdef
S3F0	12f
S3F1	22ab

S3F2	22ab
S3F3	24a

Means with similar letters in a column are not significantly different at DMRT, P<0.05

Table 3a Effect of spacing and chemical fertilization on mean plant girth of ravaya at 3 and 5 WAT

Parameters	Plant girth (cm)	Plant girth (cm)
Treatments	**3 WAT**	**5 WAT**
Spacings		
S_1 70cm x 50cm	0.55a	0.86a
S_2 70cm x 60cm	0.53a	0.83a
S_3 70cm x 70cm	0.56a	0.89a
Fertilizer levels		
Fo control	0.52a	0.82a
F_1 5g S/A	0.53a	0.80a
F_2 6g NPK + 5g S/A	0.55a	0.91a
F_3 12g NPK +5g S/A	0.57a	0.92a
Interactions		
S_1Fo	0.58a	0.82a
S_1F_1	0.50a	0.76a
S_1F_2	0.55a	0.87a
S_1F_3	0.57a	1.00a
S_2Fo	0.49a	0.82a
S_2F_1	0.59a	0.81a
S_2F_2	0.53a	0.90a

S_2F_3	0.55a	0.81a
S_3F_0	0.50a	0.81a
S_3F_1	0.56a	0.82a
S_3F_2	0.58a	0.97a
S_3F_3	0.60a	0.96a

Means with similar letters in a column are not significantly different at DMRT, $P<0.05$ **Table 3b**

Effect of spacing and chemical fertilization on mean plant girth of ravaya at 7 and 9 WAT

Parameters	Plant girth (cm)	Plant girth (cm)
Treatments	**7 WAT**	**9 WAT**
Spacings		
S_1 70cm x 50cm	1.19a	1.33a
S_2 70cm x 60cm	1.13a	1.17b
S_3 70cm x 70cm	1.10a	1.44a
Fertilizer levels		
Fo control	0.95	1.16a
F_1 5g S/A	1.20a	1.36a
F_2 6g NPK + 5g S/A	1.23a	1.40a
F_3 12g NPK +5g S/A	1.17a	1.32a
Interactions		
S_1Fo	1.04a	1.11a
S_1F_1	1.19a	1.31a
S_1F_2	1.19a	1.38a
S_1F_3	1.35a	1.53a
S_2Fo	0.91a	0.93a
$S2F_1$	1.17a	1.45a

S_2F_2	1.26a	1.41a
S_2F_3	1.19a	1.21a
S_3Fo	0.91a	1.43a
S_3F_1	1.25a	1.33a
S_3F_2	1.25a	1.43a
S_3F_3	0.98a	1.56a

Means with similar letters in a column are not significantly different at DMRT, $P<0.05$

Table 3c Effect of spacing and chemical fertilization on mean plant girth of ravaya at 11 and 13 WAT

Parameters	Plant girth (cm)	Plant girth (cm)
Treatments	**11 WAT**	**13 WAT**
Spacings		
S_1 70cm x 50cm	1.33a	1.34a
S_2 70cm x 60cm	1.29a	1.32a
S_3 70cm x 70cm	1.50a	1.52a
Fertilizer levels		
Fo control	1.31a	1.33a
F_1 5g S/A	1.43a	1.45a
F_2 6g NPK + 5g S/A	1.44a	1.49a
F_3 12g NPK +5g S/A	1.40a	1.41a
Interactions		
S_1Fo	1.19a	1.21a
S_1F_1	1.44a	1.44a
S_1F_2	1.39a	1.49a
S_1F_3	1.55a	1.51a
S_2Fo	1.29a	1.32a
S_2F_1	1.49a	1.52a
S2F2	1.49a	1.52a

S2F3	1.23a	1.25a
S_3Fo	1.47a	1.52a
S3F1	1.36a	1.39a
S3F2	1.46a	1.50a
S3F3	1.62a	1.67a

Means with similar letters in a column are not significantly different at DMRT, $P<0.05$

Table 3d Effect of spacing and chemical fertilizer on mean plant girth of ravaya at 15 WAT

Parameters	**Plant girth(cm)**
Treatments	
Spacings	
S_1 70cm x 50cm	1.38a
S_2 70cm x 60cm	1.37a
S_3 70cm x 70cm	1.54a
Fertilizer levels	
F_0 control	1.34a

F_1 5g S/A	1.49a
F_2 6g NPK + 5g S/A	1.53a
F_3 12g NPK + 5g S/A	1.43a
Interactions	
S1F0	1.21a
S1F1	1.45a
S1F2	1.53a
S1F3	1.59a
S2F0	1.36a
S2F1	1.59a
S2F2	1.54a
S2F3	1.27a
S3F0	1.55a
S3F1	1.41a
S3F2	1.52a
S3F3	1.70a

Means with similar letters in a column are not significantly different at DMRT, P<0.05

4.5 Reproductive parameters

4.5.1 Days to 50% Flower Bud Appearance, Flower Opening and Fruit Set

Table 4 shows that days from sowing to 50% flower bud appearance, flower opening and fruit set of ravaya were significantly ($P<0.05$) affected by fertilization but not the spacings. The F_0 and F_1 (5g S/A) exposed their flower buds, opened their flowers and set fruits earlier compared to the other treatments. For the interactions, the S_1F_0 and S_1F_1 exposed their flower buds, opened their flowers and set fruits earlier than the other interactions.

4.6 Effect of spacing and chemical fertilization on yield parameters

4.6.1 Mean number of fruits per plant and per hectare

Total number of fruits harvested per plant and per hectare were significantly affected by the spacings and fertilizer application (Table 5). The S_3 (70cm x 70cm) plants yielded more in terms of number of fruits per plant than the S_2 (70cm x 60cm) and S_1 (70cm x 50cm) plants. However, in terms of number of fruits/ha, the S_1 and S_3 yielded more than the S_2.

With fertilization, the F_3 (12g NPK 15-15-15 + 5g S/A/plant) produced more fruits per plant and per hectare than the rest of the fertilizer applications. There were significant differences among the interactions. The S_3F_3 produced more fruits per plant than the rest whilst in terms of per hectare, the S_1F_3 had the highest number of fruits.

Table 4 Effect of spacing and chemical fertilization on number of days to 50% flower bud appearance, flower opening and fruit set of ravaya

Parameters	Flower bud Appearance	Flower opening	Fruit set
Treatments			
Spacings			
S_1 70cm x 50cm	54.6a	59.5a	65.4a
S_2 70cm x 60cm	54.8a	59.7a	65.5a
S_3 70cm x 70cm	55.0a	60.2a	66.0a
Fertilizer levels			
F_0 control	53.2b	58.0b	64.1b
F_1 5g S/A	54.0b	58.2b	64.2b
$F_2$6g NPK + 5g S/A	55.1a	59.4a	65.2a

F_3 12g NPK+5g S/A	55.6a	60.1a	66.1a
Interactions			
S1FO	54.0b	58.2d	64.3bc
SIF1	54.2b	58.4d	64.3bc
SIF2	55.3a	59.2bc	65.3ab
SIF3	55.8a	60.2a	66.2a
S2FO	54.1b	58.5c	64.2c
S2FI	54.2b	58.6c	64.4bc
S2F2	55.4a	59.1bc	65.3abc
S2F3	55.9a	60.3a	66.3a
S3FO	54.3b	59.1bc	65.1bc
S3F1	54.4b	59.2bc	65.2abc
S3F2	55.2a	60.1a	65.3ab
S3F3	55.4a	60.2a	66.2a

Means with similar letters in a column are not significantly different at DMRT, P<0.05 **Table 5 Effect of spacing and chemical fertilization on mean number of fruits per plant and per hectare of ravaya**

Parameters	Number of fruits/plant	Number of fruits/ha

Treatments		
Spacings		
S_1 70cm x 50cm	5.40b	216000a
S_2 70cm x 60cm	5.72b	190664b
S_3 70cm x 70cm	7.75a	206661a
Fertilizer levels		
F_0 control	5.14b	171331c
F_1 5g S/A	5.76a	191998b
F_2 6g NPK + 5g S/A	5.50ab	183331b
F_3 12g NPK + 5g S/A	7.30a	243330a
Interactions		
S1F0	4.03b	161200b
S1F1	4.47b	178800b
S1F2	4.40b	176000b
S1F3	6.13ab	245000a
S2F0	4.86b	161998b
S2F1	5.18ab	169998b

S2F2	5.0b	166665b
S2F3	6.66ab	221997a
S3F0	6.10ab	162663b
S3F1	8.13ab	216795a
S3F2	7.66ab	204262a
S3F3	9.10a	242661a

Means with similar letters in a column are not significantly different at DMRT, $P<0.05$

4.6.2 Mean weight of fruits per plant and per hectare

Weight of fruits per plant and per hectare as affected by the spacings (Table 6) followed a pattern similar to that of number of fruits produced per plant and per hectare (Table 5). The weight of the S_3 fruits per plant was significantly higher than those of S_1 and S_2. The S_1 plants however produced 16.1t/ha as the highest and the S_2 plants with 14.1 t/ha as the lowest. The total weight of fruits per plant and per hectare (Table 6) were affected by fertilizer application. Applying 12g NPK + 5g S/A/plant resulted in heavier fruits per plant and per hectare than the other treatments.

The interaction shows significant differences in both weight of fruits per plant and per hectare (Table 6). On per plant basis, fruits from the S_3F_3 plants were heavier than the rest whilst in terms of per hectare, the S_1F_3 plants gave 17.4 t as the highest as against 11.3 t for S_3F_0 which was the least.

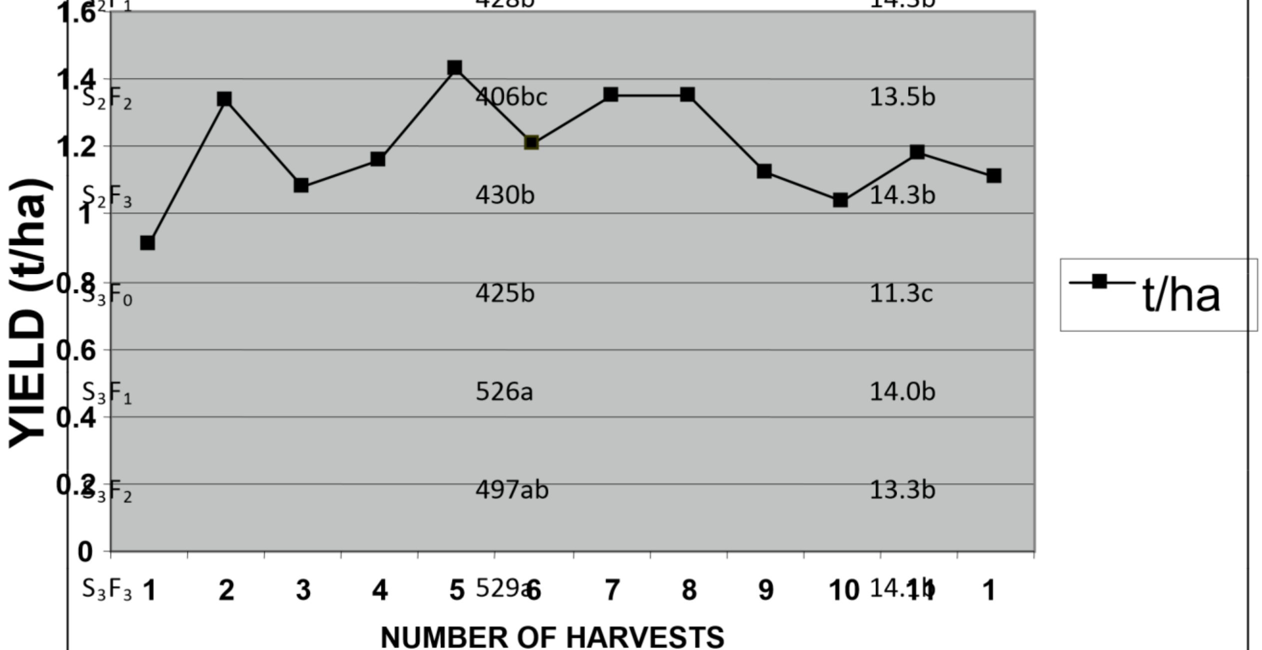
4.6.3 Yield per number of harvest

Figure 3 shows the composite yield of ravaya at twelve harvesting intervals. It rose sharply at the second harvest, dropping at the third and fourth, reaching its peak at the fifth harvest. It dropped at the 6^{th} and rose slightly at the 7^{th} and 8^{th} reaching a plateau at that level and declining again at the 9^{th} and 10^{th} harvests. There was a slight increase at the 11^{th} harvest and finally dropped at the 12^{th} and final harvests.

Table 6 Effect of spacing and chemical fertilization on mean weight of fruits per plant and per hectare of ravaya

Parameters	Mean weight of fruits per plant (g)	Mean weight of fruit per hectare t/ha
Treatments		
Spacings		
S_1 70cm x 50cm	403b	16.1a
S_2 70cm x 60cm	423b	14.1b
S_3 70cm x 70cm	545a	14.5b
Fertilizer levels		
F_0 control	343b	11.4b
F_1 5g SA/plant	421a	14.0a
F_2 6g NPK + 5g S/A	377ab	12.6b
F_3 12g NPK + 5g S/A	427a	14.2a
Interactions		
S1F0	352c	14.1b
S1F1	410bc	16.4a
S1F2	402bc	16.1a
S1F3	434b	17.4a

S_2F_0	417bc	13.4b
S_2F_1	428b	14.3b
S_2F_2	406bc	13.5b
S_2F_3	430b	14.3b
S_3F_0	425b	11.3c
S_3F_1	526a	14.0b
S_3F_2	497ab	13.3b
S_3F_3	529a	14.1b



Means with similar letters in a column are not significantly different at DMRT, P<0.05

Figure 3: Trend of composite yield (t/ha) as affected by number of harvests

4.6.4 Mean weight of marketable and unmarketable fruits per hectare

Table 7 shows that total weight of marketable and unmarketable fruits/ha were significantly affected by both the spacings and fertilizer treatments. The S_1 and F_3 plots yielded more marketable fruits/ha than the rest of the spacings and fertilizer applications. However, the weights of unmarketable fruits/ha were higher in the $S_1$and F_0 plots than the other treatments (Table 7).

For the interaction, significant differences existed between treatments in both the marketable and unmarketable yields per hectare. The S_1F_3 produced the highest in both marketable and unmarketable
yield in t/ha.

Table 7 Effect of spacing and chemical fertilization on mean weight of marketable and unmarketable fruits of ravaya per hectare

Parameters	Weight of marketable fruits per hectare (t/ha)	Weight of unmarketable fruits per hectare (t/ha)
Treatments		
Spacings		
S_1 70cm X 50cm	15.2a	0.9a
S_2 70cm x 60cm	13.6b	0.5b
S_3 70cm x 70cm	14.2ab	0.3b
Fertilizer levels		
F_0 control	10.6c	0.8a
F_1 5g SA/plant	13.7a	0.3b
F_2 6g NPK+5g S/A	12.2b	0.4b
F_3 12g NPK + 5g S/A	13.9a	0.3b
Interactions		
S1F0	13.1c	1.0a
S1F1	15.2b	0.8ab
S1F2	15.2ab	0.9a
S1F3	16.3a	1.1a
S2F0	13.1c	0.8ab

S2F1	13.9bc	0.4bc
S2F2	13.0c	0.5bc
S2F3	14.0bc	0.3c
S3F0	10.9c	0.4bc
S3F1	13.8bc	0.2c
S3F2	12.8c	0.5bc
S3F3	13.8c	0.3c

Means with similar letters in a column are not significantly different at DMRT, P<0.05

4.6.5 Mean fruit length and diameter ratio of ravaya

Table 8 shows that neither the spacings nor fertilization significantly affected fruit length and diameter ratio of ravaya. The interaction showed that the S_3F_0 produced the least in terms of fruit length and diameter and were significantly different from the rest but the ratio was not affected.

Table 8 Effect of spacing and chemical fertilization on mean fruit length and diameter ratio of ravaya

Parameters	Fruit length (cm)	Fruit diameter (cm)	L/D Ratio

Treatments			
Spacings			
S_1 70cm X 50cm	6.91a	4.75a	1.45a
S_2 70cm x 60cm	7.13a	4.63a	1.53a
S_3 70cm x 70cm	6.28a	4.14a	1.51a
Fertilizer levels			
F_0 control	6.43a	4.24a	1.51a
F_1 5g S/A	7.13a	4.65a	1.53a
F_2 6g NPK + 5g S/A	6.90a	4.56a	1.51a
F_3 12g NPK + 5g S/A	6.76a	4.57a	1.47a
Interactions			
S1F0	7.56a	5.00a	1.51a
S1F1	6.93a	4.56a	1.51a
S1F2	7.06a	4.73a	1.49a
S1F3	6.10b	4.73a	1.28a
S2F0	6.83a	4.63a	1.47a
S2F1	7.03a	4.60a	1.52a

S2F2	6.96a	4.53a	1.53a
S2F3	7.70a	4.76a	1.61a
S3F0	4.90c	3.10b	1.58a
S3F1	7.43a	4.80a	1.54a
S3F2	6.55a	4.43a	1.47a
S3F3	6.35a	4.23a	1.50a

Means with similar letters in a column are not significantly different at DMRT, P<0.05

4.7 Nutrient analysis of fruit samples of ravaya

Appendix 2 shows the nutrient analysis of fruit samples as affected by the spacings and fertilization. Even though there were slight differences in some of the values obtained they did not differ significantly from each other.

4.8 Cost benefit analysis

Tables 9a and b show the cost benefit analysis of production of ravaya as affected by the spacings and fertilization. With regard to profit, the highest net returns was obtained from the S_1F_1 plots followed by S_1F_3 plots with the S_3F_0 plots recording the least net returns and was significantly different from the other interactions. Cost of production also showed significant differences with the S_1F_3 as the highest ($P<0.05$) followed by the S_2F_3 which did not differ significantly from each other while the lowest cost of production was recorded from the S_2F_0 treatment.

Table 9a Cost benefit analysis of production of ravaya

Activity	Quantity/ha (GH¢)	Cost/ha (GH¢)
	(S1)	
Land preparation	GH¢25.00/ha by 2 times	50
Seeds	-	5
Transplanting	6 persons at GH¢2/person/manday by 3 times	36
Fertilizer	5 bags NPK/ha at GH¢12/bag	60
	10 bags NPK/ha at GH¢ 12/bag	120
	4 bags S/A/ha at GH¢13/bag	52
Fertilizer application	4 persons at GH¢2/person/manday by 2 times	16
Irrigation	3 persons at GH¢2/person/manday by 7 times	42
Weeding	20 persons at ¢2/person/manday by 4 times	160
Harvesting	5 persons at GH¢2/person/manday by 12 times	120
	(S2)	
Land preparation	GH¢25/ha by 2 times	50
Seeds	-	5

Transplanting	6 persons at GH¢2/person/manday by 2.5 times	30
Fertilizer	4 bags NPK/ha at GH¢12/bag	48
	8 bags NPK/ha at GH¢12/bag	96
	3.5 bags S/A/ha at GH¢13/bag	45.5
Fertilizer application	3 persons at GH¢2/person/manday by 2 times	12
Irrigation	3 persons at GH¢2/person/manday by 7 times	42
Weeding	20 persons at GH¢2/person/manday by 4 times	160
Harvesting	5 persons at GH¢2/person/manday by 12 times	120
	(S3)	
Land preparation	GH¢25/ha by 2 times	50
Seeds	-	5
Transplanting	6 persons at GH¢2/person/manday by 2 times	24
Fertilizer	3.5 bags NPK/ha at GH¢12/bag	42
	7 bags NPK/ha at GH¢12/bag	84
	2.5 bags S/A/ha at GH¢13/bag	32.5
Fertilizer application	2 persons at GH¢2/person/manday by 2 times	8

Irrigation Weeding Harvesting	3 persons at GH¢2/person/manday by 7 times 20persons at GH¢2/person/manday by 4.5 times 5 persons at GH¢2/person/manday by 12 times	42 180 120

Table 9b Cost, Revenue and Profit

Treatments	Cost/ha (GH¢)	Revenue/ha (GH¢)		Profit (GH¢)
		Bags	Income	
S1F0	413b	485	2182.5	1,769.5bc
S1F1	481b	562.9	2,533.05	2,052.05a
S1F2	557ab	562.9	2,533.05	1,976.05ab
S1F3	617a	603.7	2,716.65	2,099.65a
S2F0	407b	470	2,115.0	1,708.0bc
S2F1	464.5b	514.8	2,316.6	1,852.1ab
S2F2	524.5ab	481.4	2,166.3	1,641.8c
S2F3	572.5ab	518.5	2,333.25	1,760.75b
S3F0	421b	403.7	1816.65	1,395.65d
S3F1	561.5ab	511	2,299.5	1,838ab
S3F2	511.5ab	474	2,133	1,621.5c
S3F3	553.5ab	511		1,746bc

			2,299.5	

A bag of 27kg Ravaya = GH¢4.50

5.0 DISCUSSION

Soil sample analysis

The result of the soil analysis indicated that N, P and K levels, organic matter content and the other soil nutrients before the experiment were ideal for the growth of aubergine. The nitrogen levels ranged between 0.140% and 0.154%, phosphorus levels between 60mg /kg and 70mg/kg and potassium levels between 0.09 Cmol/kg and 0.18 Cmol/kg for subsoil and topsoil respectively. This compares with the findings of Afari (1999) that on the average, N,P and K levels in the soil after harvest of garden eggs and cowpea in an intercropped system were 0.12%, 5.8Cmol/kg and 0.9Cmol/kg respectively.

On phosphorus content, ranges of 0-10mg/kg are considered low, 10-20mg/kg medium and greater than 20mg/kg as high (Anonymous, 1978) whilst Ulysses, (1982) observed potassium content to be 0.2meq/100kg (175kg/ha). A pH of 6.2 and 6.1 top and subsoils respectively were also ideal for the production of aubergine. Norman (1992) reported that a pH of 5.5 to 6.8 is desirable for successful production of egg plant.

Vegetative growth

There were no significant differences between the treatment mean height as far as spacing was concerned. This shows that there was little or no competition for light and space among the treatments. This collaborates with the findings of Kyeraa (2003) and Kusemee (2004) who worked on the effects of spacing and weeding frequency on growth and yield of ravaya and the effect of spacing and fertilizer on growth and yield of ravaya in separate experiments reported that spacing did not affect plant height. Similar results were observed by Gorachand and Mallik (1990) and Raghan (1996) on okra.

The application of fertilizer affected plant height. Plants that received 12g NPK 15-15-15 + 5g SA/plant (F_3) were found to be significantly taller than the control (F_0). This might be due to the presence of the nitrogen since N is known to promote growth. Nandekar and Sawarkar (1990) and Naik *et al.* (1996) observed that increasing NPK application significantly increased plant height of aubergines. Similarly,

Kulvinder and Srivastova (1988), Arora *et al*. (1991); Naik and Srinivasa (1992) and Singh (1995) working on *Capsicum* and okra realized that plant height increased with increasing rate of fertilizer application. Addae-Kagya and Norman (1977) also reported that high nitrogen levels (89.6kg/ha) greatly increased vegetative growth of two local cultivars of egg plant (*Solanum integrifolium L).*

The interaction between spacing and fertilization showed significant differences between some of the treatment combinations in plant height. The widest spacing and highest fertilizer rate (S_3F_3) plants were significantly taller than the S_3F_2, S_3F_1, S_3F_0 and S_1F_0 plants. This is similar to the findings of Agyekum (1999) who worked on the effects of different spacings and fertilizer levels on the growth, yield and nutritive quality of okra variety 'Asontem white' and reported that the widest spacing significantly produced the tallest plants. This however, is in contrast with the findings of Birbal *et al*. (1995) on the effects of spacing and nitrogen levels on okra that the tallest plants (109.2cm) were obtained with closer spacing and highest nitrogen application.

Neither spacing nor fertilizer application significantly influenced canopy spread although wider spacing and higher fertilizer application rate had wider canopies than the other treatments. This is attributed to little or no competition for space, nutrients and light among the treatments. This supports the results of Kusemee (2004) that spacing and fertilizer had no significant effect on canopy spread of aubergines.

The interaction however, showed significant differences between S_3F_3 and S_3F_0 and S_1F_0 but between the rest there were no significant differences. Nandekar and Sawarkar (1990) and Naik *et* *al.* (1996) reported that increasing NPK application increased the spread of aubergines with wider spacing. Similarly, Agyekum (1999) working on the effect of different spacings and fertilizer levels on the growth and yield of okra reported that the widest spaced and highest fertilizer rate plants had the widest canopy.

Number of leaves and branches were not significantly affected by spacing. However, the widest spacing had more leaves and branches per plant than the other spacings. This may be due to the fact that there was less competition for nutrient, air, light, water and space among the treatments. This is similar to the work of Korem *et al*. (1991) who reported that although spacing did not affect number of leaves and branches, wider spacing resulted in higher number of leaf blade and larger foliage (dry and fresh) per plant than closer spacing in bulb yield of onion grown from sett. In a similar trial, Agyekum (1999) also reported that wider spacing produced more leaves and nodes per plant of okra.

Fertilizer application had significant effect on the number of leaves and branches produced per plant. The F_3 plants had significantly more leaves than the F_1 and F_0 plants but for number of branches, significant difference existed only between F_3 and F_0 plants. This is an indication that NPK application is associated with vegetative growth. This collaborates with the results of Afari (1999), Nandekar and Sawarka (1990) and Naik *et al*. (1996) that increasing NPK application significantly increased the number of leaves and branches per plant of egg plant and aubergine respectively compared with the unfertilized control.

The interaction showed significant differences between some of them. Applying 6g NPK + 5g SA to S_3 plants produced the highest number of leaves per plant (S_3F_2). On the other hand however, applying 12g NPK + 5g SA to S_3 plants resulted in the highest number of branches per plant (S_3F_3).

Studying the yield of okra as affected by spacing and nitrogen levels, Birbal *et al*. (1995) adopting spacings of 30cm x 30cm, 45cm x 30cm, 45cm x 45cm, 60cm x 30cm or 60cm x 45cm with nitrogen applied at 0, 50, 100 and 150kg/ha observed that the number of leaves and branches per plant were highest at 45cm x 45cm and 100 and 150kg/ha than at 0 and 50kg/ha.

Results from the experiment indicated that plant girth was not significantly affected by spacing, fertilization and the interaction effect of spacing and fertilization . This is due to an insignificant level of competition among the treatments. This is similar to the findings of Kusemee (2004) who investigated into the effect of spacing and fertilization on growth and yield of ravaya and observed that no significant difference existed on stem girth.

Reproductive parameters

Days to 50% flower bud appearance, flower opening and fruit set

Spacing did not affect days to 50% flower bud appearance, flower opening and fruit set. This suggests that there was no competition for space among the treatments. This is similar to the work of Shrestha (1983), Birbal *et al*. (1995) and Agyekum (1999) on spacing and fertilization of okra that spacing had no effect on the number of days to first fruit per plant and 50% flowering respectively. Saggam and Yazgan (1995) also reported that number of days to maturity as well as harvesting period was not significantly affected by plant density in tomato.

However, fertilizer application significantly affected days to 50% flower bud appearance, flower opening and fruit set. Plants receiving 6g NPK 15-15-15 + 5g SA and 12g NPK 15-15-15 + 5g SA took longer periods to flower. This is attributed to the fact that fertilizer application is associated with vigorous vegetative growth.

Working on the effect of different levels of fertilizer application on the growth of tomato seedlings, He and Chen (1996) observed that if rates were high it delayed flower bud differentiation. Similarly, Birbal *et al*. (1995) studying the yield of okro as affected by spacing and nitrogen levels also reported that nitrogen at 100 and 150kg/ha delayed flowering.

Yield parameters

There were significant differences among the treatments with number of fruits per plant increasing with increasing spacing and fertilizer application but closer spacing yielded more per unit area.

Since the widest spaced plants had more leaves and branches, it was most likely that they would produce more fruits per plant but lower yield per hectare. Kyeraa (2003), Kogbe (1983) and Abutiate (1988) reported separately that closer spacing significantly out yielded all other treatments in aubergine per unit area. Bustelaar and Elhart (1996), Pyzik and Dabrowska (1989) and Saggam and Yazgan (1995) also reported separately that widest spaced tomato plants gave more fruits per plant than closer spacing but yield per unit area increased with closer spacing. Similar results were reported by Ahmed (1984), Metwally *et al*. (1987), Leskovar *et al*. (1992), Petreuska (1993), Decoteau and Graham (1994) and Motsenbocker (1996) on *Capsicum* and Lee *et al*. (1990) and Agyekum (1999) on okro.

On fertilizer, increasing the rate resulted in increased yield per plant and per hectare. This is as a result of the improvement of the soil nutrients. This compares favourably with the work of Nandekar and Sawarkar (1990), Naik *et al*. (1996) and Kalyanasundaram and Sambandam (1979) that yield increased with increasing rate of fertilizers in aubergine and eggplant respectively.

Similarly, Reddy *et al.* (1984), Kulvinder and Srivastova (1988) and Sharma *et al*. (1996) found out that the highest yield and highest income invested was recorded at the highest N,P and K rates for okro, *Capsicum* and chilli respectively. It was observed that the S_3 plants (70cm x 70cm) produced more fruits per plant than the rest of the spacings. It was also observed that increasing rate of fertilizer increased yield per plant. It is therefore not uncommon that the S_3F_3 plants produced more fruits per plant. However, in terms of yield per hectare the S_1F_3 plants had more fruits than the rest of the interactions. Sulikeri (1978), Reddy *et al*. (1990) and Vijayakumar *et al*. (1995) observed that the highest yields of bringal and aubergine were obtained at a closer spacing and highest fertilizer rates.

Nassar (1986) and Mohammed and Ali (1988), Man Chanda and Bhopal (1987), Ivanov *et al*. (1988) working on tomato, pepper and green bean respectively observed that the highest plant density and highest N levels gave the highest yield and quality fruits.

Spacing and fertilization had significant influence on weight of fruits per plant and per hectare. In this experiment, the widest spaced plants produced higher weight of fruits per plant since they had more fruits but in terms of per hectare, the closest spaced plants had more fruits and therefore higher weight.

Similar results were obtained by Bustelaar and Elhart (1996), Pyzik and Dabrowska (1989), Saggam and Yazgan (1995), Lee *et al*. (1990) and Agyekum (1999) that wider spacing gave more fruits and weight per plant of tomato and okro respectively than closer spacing but yield per unit area increased with closer spacing. Increasing the rate of fertilizer significantly influenced the weight of fruits per plant and per hectare. Nitrogen applied at the correct level together with adequate amount of phosphorus and potassium has beneficial effect on productivity of crops (Bellester *et al*., 1964). Nandekar and Sawarkar (1990) and Naik *et al*. (1996) also reported that

NPK application significantly increased fruit weight of aubergines compared with the unfertilized control and that the highest NPK rate gave the highest yield.

Similar reports were obtained by Reddy *et al.* (1984), Kulvinder and Srivastova (1988) and Sharma *et al.* (1996) on okro, *Capsicum* and chilli respectively.

Yield per number of harvests had two peaks. The first was two weeks after the application of Sulphate of ammonia and that was the second harvest (7WAT). The highest peak was observed at the fifth harvest that was five weeks after sulphate of ammonia application (10WAT) and declined thereafter. This may be because the plants after the sulphate of ammonia application had enough branches at the tenth week and also there was maximum use of fertilizer to produce more fruits.

Spacing, fertilization and their interaction had significant effect on both marketable and unmarketable yield. The S_1 plants produced more marketable and unmarketable fruits per hectare than the S_2 and S_3 plants. This collaborates with the findings of Kyeraa (2003), Kogbe (1983) and Abutiate (1988) that closer spacing significantly out yielded all other treatments in terms of number and weight of marketable fruits of aubergines. According to Abutiate (1988), the yield of unmarketable fruits increased sharply with closer spacing. Agyekum (1999) also reported that total weight of marketable and unmarketable fruits of okra per hectare were highest in closest spaced plants. On the part of fertilizer application, the F_3 plants (12g NPK + 5g SA) produced more marketable and the least unmarketable fruits per hectare than the unfertilized control since the presence of the nutrients improved fruit quality. Reddy *et al*. (1984), Kulvinder and Srivastova (1988) and Sharma *et al*. (1996) reported separately that the maximum yield and the highest income was recorded at the highest N, P and N rates respectively for okro, *Capsicum* and chilli.

The interaction resulted in the S_1F_3 producing more marketable and unmarketable fruits per hectare similar to that of the S_1 plants. This compares with the findings of a number of researchers that increasing plant density and fertilizer rates resulted in increased yield. Working on tomato, pepper and green bean, (Nassar, 1986 and Mohammed and Ali, 1988; Man Chanda and Bhopal, 1987; Ivanov *et al.*, 1988) respectively observed that the highest plant density and highest nitrogen levels gave the highest yield and quality of fruits.

Spacing and fertilization had no significant effect on fruit length and diameter although the S_1 and F_1 plants had the highest fruit length and diameter respectively. This may be due to less competition among plants to absorb light, water and nutrients for the production of assimilate and consequent production of almost equal size fruits.

Kusemee (2004) reported that neither spacing nor fertilization had significant effect on fruit length and diameter of aubergines. For the interaction, the S_3F_0 produced the least fruit length and diameter, which differed significantly from the other interactions.

Nutrient analysis of fruit samples

Even though the nutrient analysis of fruit samples of ravaya indicated that the spacings and fertilizer rates showed slight differences amongst them with a few of them having the same levels, they were not significantly different. This might be due to little or no competition among the crop plants for the nutrients. Nutritionally, the analysis also showed that the values of all the nutrients were similar to that of egg plant as reported by Norman (1992).

Cost benefit analysis

Tables 11a and b show that the S_1F_3 had the highest cost of production compared with the rest. This is attributed to the fact that it had the greatest number of labour to perform various activities such as transplanting, weeding, fertilizer application, irrigation and harvesting as well as having the highest cost of fertilizer applied. It therefore recorded the highest yield as a result of increased number of plants per unit area. This supports the findings of Vijayakumar *et al.* (1995) who worked on the influence of mother crop nutrition and spacing on yield and quality of aubergines that the closest spacing and highest fertilizer rate produced the highest yield. Similarly, Nassar (1986) and Mohammed and Ali (1988); Man Chanda and Bhopal (1987); Ivanov *et al.*, (1988) observed that the highest plant density and highest N levels gave the highest yield and quality of fruits of tomato, pepper and green bean respectively. However, in terms of cost of production and profit margin, the S_1F_1 treatment had the highest net profit.

6.0 SUMMARY, CONCLUSION AND RECOMMENDATION

An experiment to study the effect of spacing and chemical fertilization on growth, yield and nutritive quality of ravaya (*Solanum melongena* cv Baby Aubergine) was conducted at the Department of

Horticulture, Kwame Nkrumah University of Science and Technology, Kumasi from July, 2004 to January, 2005.

The experiment was a 3x4 factorial in a Randomized Complete Block Design (RCBD). Spacing and fertilizer constituted the factors, spacing being the main plot factor with three levels and fertilizer, the sub plot factor with four levels. There were twelve treatment combinations, which were replicated three times. Before the start of the experiment, soil samples were taken at a depths of 0-15cm and 15-30cm and analyzed for pH, organic matter content, total Nitrogen, available P_2O_5, Water soluble K_2O, Calcium and Magnesium. Other parameters studied included vegetative and reproductive growth, marketable and unmarketable yields, nutrient composition of fruits and cost benefit analysis. The result of the soil analysis indicated that the soil was ideal for the production of aubergine.

Plant height was not affected by spacing but was affected by fertilization with plants which received 12g NPK 15-15-15 + 5g SA/ plant (F_3) being significantly taller than those of the control. The interaction showed some differences. The S_3F_3 plants were significantly taller than the S_3F_2, S_3F_1, S_3F_0 and S_1F_0 plants. Spacing and fertilizer did not influence canopy spread but the interaction however showed significant differences between S_3F_3 and S_3F_0 and S_1F_0. Number of leaves and branches were not influenced by spacing. However, fertilizer application significantly affected the number of leaves and branches produced per plant. The F_3 plants had more leaves than the F_1 and F_0 plants. For the number of branches significant difference existed only between F_3 and F_0 plants. The interaction however, showed significant differences between some of them. Applying 6g NPK 15-15-15 + 5g SA to S_3 plants produced the highest number of leaves per plant (S_3F_2). On the other hand, applying 12g NPK 15-15-15 + 5g SA to S_3 plants resulted in the highest number of branches per plant (S_3F_3).

Plant girth was neither affected by spacing, fertilization nor by their interaction effect.

Spacing did not influence days to 50% flower bud appearance, flower opening and fruit set. However, the control and plants which received 5g Sulphate of Ammonia(F_1) produced flower buds, opened flowers and set fruits earlier than plants which received 6g NPK 15-15-15 + 5g of Sulphate of Ammonia and 12g NPK 15-15-15 + 5g Sulphate of Ammonia.

The numbers of fruits per plant and per hectare were significantly higher in the wider spacing and closer spacing respectively. On the part of fertilizer, applying 12g NPK 15-15-15 + 5g SA (F_3) resulted in more fruits being produced per plant and per hectare than any of the fertilizer treatments. For the interaction the S_3F_3 produced more fruits per plant but in terms of per hectare, the S_1F_3 plants had more fruits than the rest. Weights of fruits per plant and per hectare were influenced by spacing, fertilization and their interaction. The widest spaced plants and the highest fertilizer rate had more weight of fruits per plant but in terms of per hectare the closest spaced plants and highest fertilizer rate had greater weight of fruits.

Spacing, fertilization and their interaction had significant effect on both marketable and unmarketable yield per hectare. The S_1 and S_1F_3 plants produced more marketable and unmarketable fruits per hectare. While the F_3 plants produced more marketable and the least unmarketable fruits per hectare than the unfertilized control. Fruit length and diameter were not influenced by spacing and fertilization. However, their interaction, (S_3F_0) produced the least fruit length and diameter, which differed significantly from the others.

Yield per number of harvests had two peaks. The first was the second harvest that was two weeks after the application of sulphate of ammonia (7 WAT). The highest peak was the fifth harvest and that was five weeks after sulphate of ammonia application (10 WAT) and declined thereafter. Spacing and fertilization did not show significant differences as far as fruit nutrients were concerned although there were slight differences with a few of them having the same level of nutrients. The cost benefit analysis indicated that even though the S_1F_3 gave the highest yield, in terms of production cost and profit margin, the highest net profit was obtained from the S_1F_1 treatment.

Conclusion

It was found that the closest spacing (70cm x50cm) produced the highest total number and weight of both marketable and unmarketable fruits per hectare. It was also found that the widest spacing

(70cm x70cm) produced the highest number of fruits per plants and the least weight of unmarketable fruits per hectare. With fertilization, the highest fertilizer rate 12g NPK + 5g S/A (F_3) produced more marketable and the least unmarketable fruits per hectare. The results indicated that spacing and fertilization had a remarkable influence on yield and quality of ravaya fruits.

Recommendation

Closer spacing is recommended for the production of ravaya, but further study is suggested to be carried out to find the optimum fertilizer level for the production of the crop which will give the highest income to the farmer.

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LIST OF APPENDICES

Sample	**Moisture %**	**Ash**	**Protein**	**Fat**	**Fibre**	**CHO**	**N %**	**P**	**K**	**Ca**	**Mg**	**Fe**	**Na**
S_1	90.5	0.58	0.9	0.15	1.72	6.10	2.05	0.229	0.20	0.111	0.26	0.002	0.112
S_2	87.2	1.08	1.7	0.22	2.28	7.45	2.05	0.206	0.23	0.159	0.30	0.001	0.114

S_3	91.0	0.76	1.3	0.23	0.15	6.56	2.09	0.191	0.30	0.094	0.30	0.001	0.115
F_0	93.1	0.66	0.9	0.31	1.36	3.67	2.04	0.201	0.20	0.077	0.28	0.001	0.115
F_1	91.4	0.82	1.5	0.18	1.55	4.55	3.06	0.229	0.20	0.130	0.29	0.002	0.116
F_2	91.0	0.58	1.5	0.23	1.53	5.16	3.08	0.206	0.30	0.125	0.30	0.001	0.117
F_3	92.3	0.73	1.5	0.13	1.07	4.27	3.10	0.217	0.34	0.148	0.30	0.002	0.120

Appendix 1: Soil sample analysis of experimental area

Soil Depth (cm)	Percent			C/N Ratio	pH	Cmol/kg Extractable / Exchangeable Cations					Available P mg/kg
	C	O.M	N			Ca	Mg	K	Al	H	
0-15	0.75	1.29	0.154	4.57	6.2	6.0	1.2	0.18	1.0	2.2	70.0
15-30	0.72	1.24	0.140	5.14	6.1	5.2	0.8	0.09	0.6	2.0	60.0

Appendix 2: Proximate analysis of fruits