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FACULTY OF AGRICULTURE

DEPARTMENT OF HORTICULTURE

EFFECT OF MOUNDING, STAKING AND FREQUENCY OF WEEDING ON GROWTH, YIELD AND QUALITY OF TINDA (*Praecitrullus fistulosus)*

A THESIS SUBMITTED TO THE SCHOOL OF RESEARCH AND GRADUATE STUDIES IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF A MASTER OF SCIENCE (OLERICULTURE) DEGREE

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JULY, 2009

UNIVERSITY OF SCIENCE AND TECHNOLOGY; KUMASI

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DECLARATION

I hereby declare that this submission is my own work towards the MSc (Olericulture) degree and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the awarded of any other degree of the University, except where due acknowledgement has been made in the text.

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DEDICATION

This thesis is dedicated to my lovely daughter, Josephine Dankwaa Twumasi and my dear wife; Mrs. Theresah Marfo Twumasi, my inspirer.

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ABSTRACT

A 2x2x3 factorial experiment in a Randomised Complete Block Design (RCBD) was undertaken on the field to investigate the effect of mounding, staking and frequency of weeding on growth, yield and quality of tinda (*Praecitrullus fistulosus*) at the Department of Horticulture, Kwame Nkrumah University of Science and Technology, Kumasi from 1st December, 2005 to 25th February, 2006. No significant differences existed in the number of leaves, nodes, branches and vine length per plant at two, four and six weeks after germination for mounding, staking and frequency of weeding. Significant interaction effects existed between the treatments (mounding, staking and frequency of weeding) for the number of leaves and nodes at six weeks after germination. With regard to number of branches and vine length significant interactive effects existed between the treatments at four and six weeks after germination respectively. Number of days from germination to flower bud appearance and fruit set were not significantly affected by mounding, staking or frequency of weeding. The treatments however, showed significant interactive effects in the number of days from germination to flower bud appearance but not in days to fruit set. Fruit length/diameter ratio was significantly increased from 0.747cm to 0.883cm for mounding, staking and frequency of weeding interaction but average number of fruits and average weight of fruits were not significantly affected by the treatments. Total number of fruits, marketable fruits and non exportable fruits were significantly increased from (5319–9775), (2281–4319) and (863– 2850) fruits per hectare for the treatments and their interaction. All the nutrients analysed for moisture, ash, protein, fats, carbohydrate, minerals (iron, calcium, potassium, sodium and phosphorus) were significantly affected by mounding, staking and frequency of weeding and their interactions. Cost-benefit analysis showed that plants that were mounded, staked and weeded three times had the highest income, the highest expenditure but a lower profit margin of Gh¢326.04. Plants that were not mounded, not staked and weeded once had the least

expenditure with the highest profit margin. Also plants that were not mounded, staked and weeded three times recorded the lowest profit margin.

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1.0 INTRODUCTION

Tinda (*Praecitrullus fistulosus*) belongs to the family Cucurbitaceae. It is one of the most important export vegetables in Ghana just like garden eggs, aubergines, peppers and green beans (MOFA, 2002; Norman, 2003).

Early evidence for the cultivation of this tropical plant comes from South America around 7000BC but it is thought to have originated in Africa, South of the Sahara or in India (Sujatha and Seshadri, 1989). According to Messiaen (1992) the crop which is distributed and grown throughout the Mediterranean was introduced into Egypt 1106 years ago. It was also introduced into India at an early stage, reaching China in the tenth or eleventh century AD and now widely spread throughout the tropics.

Tinda is an annual herbaceous plant with long creeping stems and curly tendrils (Appendix 2: Plate 1). The leaves are hairy usually deeply palmate with three to five lobes on long petioles. The flowers are monoecious, solitary on a pedicel up to 45cm long (Tindall, 1983). The fruit is round shaped and green in colour (Appendix 2: Plate 2).

The crop grows on well drained soil. The seeds require soil temperature of 21 – 35^{0}C to germinate. Excessive rainfall and high humidity reduce productivity by affecting flowering and encouraging development of leaf diseases (Rice *et al.*, 1987). The crop thrives only in hot weather and will not withstand frost (Thompson and Kelly, 1957).

The fruits are important source of water in the desert areas during dry months of the year when no surface water is available. It has a cooling effect and contains vitamin A

(Van Wyk and Gericke, 2000). The fruits can be cooked, pickled or candied. The seeds are roasted and eaten as snack. It is also used for medicinal purposes such as curing diabetes (Sujatha and Seshadri, 1989).

Although, widely spread in the tropics, it is now being introduced to Ghana as an export crop. According to the Ghana Export Promotion Council (GEPC, 2003), the quantity in metric tonnes of tinda exported from 2000 – 2003 with its equivalent value in US dollars were as follows; 2000 (1,126 metric tonnes – 474,315 US dollars), 2001 (1,256 metric tonnes – 532,015 US dollars), 2002 (1,135 metric tonnes – 636,361 US dollars) and 2003 (1,137 metric tonnes – 586,607 US dollars). It is appropriate to investigate into some of its agronomic practices that promote growth and subsequent yield.

The growth of a crop is directly influenced by timing and the quality of land preparation. Poor and untimely land preparation may cause serious weed problems and may lead to erosion (Agusiobo, 1984). Good land preparation is essential for cultivation of most vegetable crops. Soil surfaces that are fairly smooth and free from clods promote planting of seed at uniform depth and also give good soil coverage (Sinnadurai, 1992). Land preparation is a fundamental practice of crop production in working soil by hoeing, ploughing, harrowing and cultivation (Agusiobo, 1984). Land preparation in the form of mounding improves the tilth or granular conditions of the soil which facilitates aeration, water percolation and easy rooting of seedlings. Mounds are generally clustered to minimize run–off or spaced wide apart to permit drainage in poorly drained soils. Mounding helps to destroy some insect pests and pathogens present in the soil. Many insect pests which burrow underground are exposed to the surface during mounding and become desiccated (Youdeowei *et al*., 1994).

Staking brings about better ventilation (Amati *et al.*, 1995), less chance of spreading diseases (Hanna and Adams, 1987), cultivates more plants per hectare and makes weeding and harvesting easier. Creeping or trailing vegetable crops need to be supported or staked to prevent clusters of fruits from touching the ground either to rot or be attacked by insect pests (Tindall, 1983; Hanna and Adams, 1987).

Weeds act as host to pests and harbour many fungal, viral and bacterial diseases (Youdeowei *et al*., 1994). They are undesirable because they compete with crops for space, air, light, water and nutrients. While the International Institute of Tropical Agriculture (IITA, 1997) showed that uncontrolled weeds reduce yields of semi prostrate and erect crops by 68 and 78 percent respectively. Akobundu (1986) reported that all crops are sensitive to early weed interference and should be cleared within the first two to three weeks after planting.

There is therefore the need to research into tinda's agronomic practices like mounding, staking and weeding to improve upon its growth, yield and quality to attract many farmers to its cultivation because of its high returns in the world market (Norman, 2003).

The objectives of the study were therefore to determine the effect of:

i. Mounding on growth, yield and quality of tinda
ii. Staking on growth, yield and quality of tinda.
iii. Frequency of weeding on growth, yield and quality of tinda.
iv The interactive effects of the three factors on growth, yield and quality of tinda.

2.0 LITERATURE REVIEW

2.1 Botany of Tinda.

The root system of tinda is generally fibrous and shallow (Bates and Robinson, 1995). The growth of fibrous root system is impeded by compacted soil. The fibrous root system grows more or less horizontally within the soil and therefore lies close to the soil surface. Most of the roots occur within the top 30cm of the soil. The root system develops elaborately during the early part of the plant's life.

Stems of tinda are generally soft and hairy with curly tendrils. The stems trail with laterals branching from the nodes. Prolific vines grow 1.2 to 1.5m long (Sujatha and Seshadri, 1989).

The leaves are hairy, usually deeply palmate with 3-5 lobes on long petioles. The leaf edges are toothed and the leaf blade may grow to a very large size (Tindall, 1985).

The flowers are borne in the axils of the leaves and are usually unisexual with male and female flowers on the same plant (monoecious), solitary on a pedicel up to 45cm long (Tindall, 1985). The flowers have yellow or orange petals (Appendix 2: Plate 3) and fertilization of the flowers is by insects. Flowering begins at 30 to 35 days after planting.

The fruit is a berry that has a fleshy fruit with several seeds each with hard coat in which all parts of the pericarp are pulpy or fleshy except the exocarp which is often skin-light. They are green coloured, apple-sized fruits, spherical in shape and 50 to 60 grams in weight. Plants are vigorous, productive and begin to bear fruits in 70 days after planting. The immature fruits are used as vegetable (Sujatha and Seshadri, 1989). The number of fruits produced per plant depends to a large extent on number of flowers that are produced and their ability to set fruits (Norman, 1992).

The seeds are black in colour when the fruits mature. The seeds are flat and whitish during the immature stage. Seeds are roasted and eaten.

2.1.1 Light and Soil Requirements.

2.1.2 Light:

Light is of basic importance as the primary source of energy for photosynthetic processes. Plants, which convert radiant energy to chemical energy, constitute the first step in the ecological cycle of every complete ecosystem. The basic structure of green plants with leaves arranged as that of tinda is to intercept large quantities of light to facilitate efficient photosynthesis. The structure of the spongy mesophyll and the stomata apparatus allow rapid gas exchange. In order that a plant can grow, its photosynthates during the day must build up enough organic matter to compensate for the losses by respiration during both night and day (Sujatha and Seshadri, 1989).

2.1.3 Soil Requirements:

Fertile soils are generally considered essential for the production of high yields since plants grow rapidly and require available source of nutrients (Rice *et al.,* 1987). Welldrained sandy and loamy soils are ideal. Slightly acidic soils with a pH of 5.5 to 6.5 are preferred.

2.2 Effect of Mounding on Growth, Yield and Quality of Vegetables.

2.2.1 Introduction to Mounding.

Mounding, one of the tillage practices, is gathering the topsoil into more or less conical heaps at various points in the field using African hoes with wide blade (Onwueme, 1978), which provides conditions favourable for the growth of crops (Culpin, 1982).

According to Onwueme and Sinha (1999) mounds particularly the high ones provide the ultimate in a loose bed for crop root penetration. The process of mound making collects the rich topsoil of the entire field into heaps in which the rich organic matter and most of the plants roots are found. In the normal unmounded soil, only the top few centimeters of the rooting zone would have such fertility.

2.2.2 Effects of Mounding

Mounding improves soil structure which facilitates aeration, water percolation and easy rooting. It also increases growth rate of vegetables due to destruction of insect pests and pathogens present in the soil (Youdoewei *et al*., 1986).

Compacted soil can delay or prevent seedling emergence by impeding physical penetration by the radicle and the plumule. Mounding breaks the clods into fine tilth which otherwise serve as a barrier to promote growth. (Forbes and Watson, 1992).

Mounding loosens the soil to improve infiltration and drainage of water, diffusion of gases, conduction of heat and movement of salt and nutrients which are dependable on the amount of water present in the soils (Biswas and Mukherjee, 1995).

According to Cole and Mathews (1982), mounding among its other effects, brings colder soil to the surface and accelerates warming of the complete soil which facilitates germination of seeds. Mounding eliminates competition from weed growth and improves the physical conditions of the soil.

Onwueme and Sinha (1999) indicated that mounding facilitates harvesting and where the water table is high mounds help to keep most of the roots above the water table.

Vegetable marrow cultivated on mounds yielded 6-8 tonnes per hectare as compared to those cultivated on flat lands which yielded 2-3 tonnes per hectare (Rice *et al*., 1987).

2.2.3 Problems of Mounding.

Work done by Landon (1991) as quoted by Vilane and Mukabwe (1997) indicated that the effects of badly timed tillage operations under such circumstances of perennial crop farming in the form of mounding and ridging are extremely difficult to correct with secondary tillage implements and the results is less than optimum yield.

This then means high cost of production and low profit for the farming business.

2.3 Effect of Staking On Growth, Yield and Quality of Vegetables.

2.3.1 Introduction to Staking

Staking is the provision of an artificial support or a stake to a growing, trailing or climbing plant or plants with vines of straggling habit of growth, to get sunlight, which is essential for photosynthesis (Norman 1992; Mahungu and Otiende, 2004).

2.3.2 Types of Staking.

Onwueme (1978) classified staking into individual, pyramidal and trellising. For individual staking, a stout stake is placed vertically and the plant to be staked is made to twine on it. For individual stake to be effective, the stake must be at least 2m tall.

Shorter stakes result in reduction in yield. In addition the stake must be stout enough to withstand breakage or dislodging especially when the foliage becomes heavy on it. He further indicated that in pyramidal staking, each stand is supplied with a stake but the stakes from three to four adjacent stands are slanted towards one another and tied together at the top to form a rough pyramidal structure. Each plant after twinning the entire length of its stake will then intertwine with the other plants at the point of stake convergence. This type of staking has the advantage of being more stable since the stakes in pyramid tend to support one another.

2.3.3 Effects of Staking.

Staking is done to give plants support during periods of strong winds thus preventing the movement of the roots which break the root hairs, to enable the plant to grow straight as directed and to prevent fruits from touching the ground surface to prevent possible rotting. Staking facilitates spraying for diseases and pests control; weeding, harvesting and other farm operations are easier to do than those in which vines trail on the ground (Onwueme, 1978; Rice *et al*., 1987; Norman, 1992).

Onwueme (1978) and Rice *et al*. (1987) indicated that when plants are staked better leaf display occurs. Mutual shading is reduced so that photosynthetic capacity of the plant becomes greater, thus improving light penetration into the canopy of the crop.
Adelaine (1976) reported that staking improves dry matter production and leaf index.
Amati *et al*.(1995) observed that staking seemed generally to increase fruit size. Staked plants gave significant higher total yields than unstaked plants but there was no significant difference in the total yields of marketable fruits owing to greater losses through cracking among fruits from the staked plants.

Hui *et al*. (2003) reported that staked tomato plants yielded roughly a total of 20% over unstaked plants. In their experiment, they observed that the highest total yield was obtained by the ‘Castelleto’ system in which the plants were staked individually.
When staking was entirely omitted the yield was slightly but not significantly lower.

In South-West Nigeria, Adelaine (1976) reported that staking increases fruit yield by 18 to 25% and Quinn (1973) showed at Samaru, Nigeria that under wet conditions marketable yields were significantly increased by staking the tomato crop. A trial at Nyankpala using 'Maui' tomato showed that staking does not influence total yields (McEwen, 1961). In his review staking experiments in Northern Ghana involving Maui and Anahu cultivars, Nsowah (1969) confirmed the result of McEwen (1961).

An experiment was conducted at ARS, Malepatan, and Pokhara in Malaysia to evaluate the effects of staking methods on the production of fresh green pod of pole bean. It was found that staking was the best in producing the highest fresh pod yield of 6303.8kg/ha than non-staking (81.35kg/ha). Pod production was almost 68% higher in staking as compared to non- staking. Pod length was found to have increased and days to flowering were shortened with staking (Kirchemann, 2000).

Rice *et al*. (1987) concluded that staking in cucumber improves yield and quality of the fruits by keeping the fruits off the ground, thus minimizing disease infection and rotting.

2.3.4 Problems of Staking

According to Norman (1992) problems of staking are attributed to lower total yield per plant, higher susceptibility to blossom end rot, high cracking and sunburn and spread of viral diseases during operations.

Staking is a very laborious aspect of crop production. It is estimated that an average crop farmer spends about 60 man–days per hectare in producing stakes and staking his crops.

In addition conventional stakes are becoming scarcer and more costly as the forest is depleted (Nwosu, 1975).

Shorter stakes result in the reduction in yield. In addition the stake must be stout enough to withstand breakage or dislodging especially when foliage becomes heavy on it. He concluded that staked plants therefore produced higher yield than unstaked ones (Onwueme, 1978).

2.4 Effect of Weeds on Growth, Yield and Quality of Vegetables.

2.4.1 Introduction to Weeds.

Weeds are plants growing at where they are not wanted or a plant which is out of place, example pepper in a tomato field is considered as weed. Weeds encompass all types of undesirable plants, trees, broad leaved plants, grasses, sedges, aquatic plants and parasitic flowering plants such as dodder, mistletoe and witch weed (Gupta, 1998).

Weeds may also be defined as any plant(s) which compete for light, water, air, space and nutrients in the production of crops. Although weeds vary in their growth patterns, they all share a capacity to germinate, establish and grow at a rate much faster than vegetables and complete their life cycle in a matter of weeks (Nonnecke, 1989; Obeifuna, 1991). For instance weeds like *Portulaca oleracae* can be hoed or chopped up before flowering has begun, yet if pieces are left unattended to the fleshy remnants are able to produce flowers and viable seeds before drying up completely.

According to FAO (1986) weeds are herbaceous plants not valued for use or beauty, growing wild and rank, and regarded as a hindrance to the growth of superior vegetation.

A weed infested crop therefore is a complex dynamic system with interference taking place between crop plants, between weed plants and between weed crops (Robert, 1982)

Akobundu (1987) also defined weeds as plants that interfere with human activity or in some way intrude upon human welfare. Without man, there will be no weeds. The type of weeds present and the level of weed infestation depend on the cropping history of the land and the method of land preparation.

2.4.2 Benefits of Weeds

Weeds have some uses such as erosion control by soil binding effects of their roots, some have medicinal value; for example *Henca aspera* is used against snake bites. Weeds, when incorporated into the soil add to the organic content of the soil. They can also be used as mulch to check evaporational losses of water from the soil while some weeds fix atmospheric nitrogen in paddy soils, for example Blue-green algae (*Anabeana spp, Tolypothrix spp),* (Singh, 1988).

2.4.3 Effects of Weeds

According to Lavabre (1991) all crops are affected by weeds to some extent but the seriousness of this depends on the species and the circumstances. Average crop losses due to weeds are estimated at 25% but may be as high as 50% or even 80% with certain food crops. Weeds reduce yield by releasing toxic substances or exudates which inhibit crop growth and act as reservoir for crop pests and diseases which may spread to the crop (Lavabre, 1991).

Weeds are prolific with abundant seed production; for example *Amaranthus spp* etc. Some weeds have very deep roots (sometimes as deep as 8m – 9m). They store food in their rhizome and reappear every year. Examples are *Saccharum spp*, *Cyperus rotundus* etc. Weeds are hardy and resist adverse climatic conditions, disease and soil conditions. Thus they result in severe crop/weed competition or even they overtake the growth of crops (Singh *et al.*, 1982).

The effect of weed competition is reflected in poor crop establishment, reduced leaf numbers and size, yellowing of leaves, reduced leaf longevity, retarded growth and delayed maturity. Weeds may also predispose crops to attack by plant parasitic nematodes and may serve as alternate hosts to these pathogens (Awaar *et al*., 1992).

Patersan *et al*, (1980) indicated that competition from weeds for moisture, nutrients and light directly affect the growth and yield of crop plants. The degree of competition from weeds, however, depends on the crop grown, species of weeds present and the duration of weed competition with the crop.

When weeds compete with the potato crop for light, nutrient and water, yields of tubers can be severely reduced. The size of the reduction depends on the density and competitive ability of the weed species present and availability of light, nutrients and water (Harris, 1992).

According to Lavabre (1991), poor weed control may reduce yields drastically in groundnut production. Thus, in trials carried out in Senegal, delaying the first weeding by 21 days reduced output of pods by 28% and that of fodder by 38%. In Mali, delaying the first weeding by 35 days reduced the output of pods by 33% and that of fodder by 43%.

In critical period of competition between weeds and the bean crop, Vieira (1971) using the bean Var Rico 23 kept fields weeded for 10, 20, 30 or 40 days after emergence and their yields compared to a weed free for 30 days. The critical period was 10 to 30 days and weed competition during this period could decrease yield by 50 to 70%.

According to Ghana Grains Development Project (GGDP, 1996) production guide, for economic consideration to achieve a good yield, one hand weeding within 3–4 weeks after planting is recommended which Akobundu (1980) has indicated that 2 timely weeding within the first 8 weeks after planting are necessary to minimize yield reduction caused by weeds in crops.

Thomas and Allison (1975) and Fordham and Biggs (1985) asserted that with respect to crop-weed competition, a time is often reached during which the weed is found to exert its greatest effect and beyond which the weed shows no significant impact on crop performance. This implies that there is always a peak time for crop-weed competition at which time weed control is critical to minimize crop losses.

Hammaton (1972) found out that control of weeds until 6 weeks after crop emergence gave a yield of soyabean only 85% of that clean-weeded control treatment. Delay weeding until 3 to 6 weeks after emergence gave 89% and 69% respectively of the control.

Lawson (1972) concluded in an experiment on spring cabbage in which competition with weeds from germination onwards affected crop growth and yield with increasing severity. He suggested that timely intervention by removal of weeds in early spring could avoid crop losses.

In his experiment on effects of delayed hand weed control at 30, 45, 60, 90 days intervals and no weeding, on sole crop cassava, Sam-Aggrey (1973) found out that timing and frequency of weeding were important in influencing root number and tuber yield. Delay weed control at 30 days depressed both root number and tuber yield.

Fageiry (1988) observed that in soyabean, full season competition of weeds reduced fruit yield by 78 to 100%. Delay in first hand weeding beyond 30 days after sowing adversely affected soyabean yield and 3-hand weeding at intervals of 15 days were necessary for adequate weed control and high yield.

In examining the frequency of weeding necessary for optimum growth and yield of okra, Iremiren (1988) obtained results which indicated that weed removal within 12 weeks of sowing generally resulted in significantly better growth and yield than in the weedy control plots. Weeding once as early as the first week was beneficial to okra growth and yield as 2 or 3 weedings later in 12 weeks period. Weed removal after 3, 6, 9 and 12 weeks significantly enhanced crop growth and pod yield over all other treatments.

Klingman and Ashton (1975) indicated that 15% of weed stands which were allowed to remain for 5.5 weeks in carrots before removing them resulted in reduced yield by 91%. In onions leaving 15% weed stands for the first 6 weeks before removal reduced onion bulb weight by 86%. A 50% weed stand reduced yield by 91%. The two authors concluded that the first 4 weeks of crop growth are the most critical in affecting crop yields.

Halley (1982) indicated that weeds are injurious or harmful to growing crops and if not controlled, reduced yields from crop will occur while; harvesting and other operations are hindered, produce are contaminated or taints imparted and the products rendered unfit for sale.

According to Klingman and Ashton (1982), vegetable losses due to purple nut sedge in Brazil, estimated as follows; garlic 89%, okra 62%, carrots up to 50% and tomatoes 53%.

Janick (1986) noted that extremely noxious weeds if unchecked may completely dominate crop plants. He observed that crop losses are usually the result of competition for light, water and mineral nutrients. According to him weeds are indirectly responsible for crop losses because they harbour other plant pests. In addition weeds may lower quality and economic value of crops.

Weeds compete with the crop for incident light and nutrients and particularly in the early growth stages can reduce yields drastically (Tivy, 1995).

According to Rajan *et al.* (1996) an increase in temperature has an overall effect of increasing phosphorus absorption by soil solution, which in turn reduces its availability to plants. The frequency of weeding may thus affect the nutrient content of plants. Weeds are capable of absorbing nutrients faster and in relatively larger amount than crop plants and thus profit more from fertilization. In the presence of high weed population density, fertilizer application may stimulate weed growth so greatly that crop plants will be over grown and suppressed.

Bridges *et al*. (1984) indicated that increased production costs have stimulated farmer's efforts to reduce inputs while trying to maintain production level. They emphasized that to maximize profits, weed management programmes must provide effective control or the highest yields are often not the most economic.

2.4.4 Weed Control

Weed control is basically the practice whereby the spread of weeds is curtailed or reduced in a crop production venture. According to Onwueme and Sinha (1999) weeds must be controlled for profit crop production to take place. There are several ways in which weeds can be controlled. These are classified generally as physical, biological, chemical and integrated weed management.

2.4.5 Physical Weed Control

The control of weeds by physical means may be accomplished in a number of ways such as hand pulling; weeding with hand held implements, machine tillage, mowing, and fire, mulching and flooding. Hand pulling is useful where the weed species to be removed occurs in relatively isolated stands. For each weed that has been pulled by hand, destruction is usually nearly complete since both shoot and underground organs may be removed by pulling (Onwueme and Sinha, 1999).

Weeds in the rows of organic row crops cause serious problems for organic growers because hand-weeding may be the only option for sufficient control. Particularly slow germinating vegetable with low initial growth rates such as carrots, direct-sown onion and leek may require many hours of hand-weeding: 100-500 hours per hectare have been reported in Danish and Swedish studies (Melander *et al*., 2004).

Weeds can reduce yields, impede harvest operations and promote the build up of future weed populations (Melander *et al.*, 2004). Like hand pulling, hoeing is most widespread where relatively small areas are cropped. It has the disadvantage of relying on human labour and in the case of the short – handled hoes, excessive stooping is required (Onwueme and Sinha, 1999).

Well-timed tillage operations can effectively counteract the profuse seed – producing capability of many weed species. Tillage should aim at destroying the weed plants before they reach the stage of setting seed. Changes in tillage could have a significant effect on weed control and population. Weed species, soil seed density, seed production and surface residue can influence weed population dynamics under different tillage systems (Onwueme and Sinha, 1999).

According to Quinn (1973), mulching is done primarily to minimize weed growth, conserve moisture and reduce soil erosion during the wet season. He showed that mulching the soil surface with black polythene film or grass in the wet season increased marketable yields and reduced weed growth.

Physical weed control can lighten the burden of hand weeding. Research has shown that flaming combined with subsequent mechanical methods, such as hoeing close to the row or vertical brush weeding, significantly reduced weed numbers (Melander and Rasmussen, 2001).

However, successful weed control requires an accurate timing of individual treatments that may not be possible under difficult weather conditions. It should be expected that physical intra-row (in the row) weed control will be followed by hand weeding to obtain sufficient control particularly in organic fields with high weed numbers (Melander and Rasmussen, 2001).

2.4.6 Biological Weed Control

There are several ways in which biological factors can be manipulated to achieve weed control. The most dramatic instances are those in which natural enemies of the weed species have been identified and are either introduced or encouraged. With this approach, the prickly pear cactus has been controlled in Australia by the Argentine moth borer (*Coctoblastis*) and the Klamath weed has been controlled in the U.S.A by the Klamath weed beetle (Onwueme and Sinha, 1999).

If a crop is grown in one location for several years, the associated weed species are favoured and become increasingly difficult to control as time goes on. Changing the crop species at regular intervals regularly alters the competition dynamics so that no particular group of weeds is given the opportunity to entrench itself (Onwueme and Sinha, 1999).

It has been reported by Wood (1987) that animals, particularly goats, cattle and sheep could be used as an alternative to chemical and mechanical methods of weed control. In his trials he found out that goats were the best to control weeds followed by cattle and sheep.

According to (Onwueme and Sinha 1999), a dense stand of the crop may effectively reduce weed competition to a minimum. An aggressive intercrop planted at high density may be used to suppress weeds. They reported that a dense stand of edibleseed melon is used to minimize weed growth between stands of yam.

2.4.7 Chemical Weed Control

Herbicide performance can be assessed by the percentage killed of target weeds as well as by the minimum damage or check to crop growth. The effectiveness of any herbicide depends on correct choice of chemical for the crop and its weed flora, correct formulation, concentration and spray droplet sizes, compatibility with any other chemicals simultaneously applied, correct stage of crop growth, suitable weather to stop drift, volatilization, poor uptake and crop damage (Lavabre, 1991).

Pankova (1992), observed that bunded application of Stomp at 1kg/ha before weed emergence followed by treatment of the growing weeds and crops with Sonkor plus Nabu (Sethozydim) at 0.3 and 0.2kg/ha respectively reduced weeds significantly and increased yields in sown and transplanted tomatoes. Other injuries have been reported by Villamil and Bernal (1981) who noted that the use of *diphenamid* and *matribuzin* in tomato delayed fruiting and quality of the tomato fruits were also affected.

Herbicides offer the most practical, effective and often the most economical means of reducing crop losses (Parker, 1986). Herbicides for weed control in grain legumes, for example fluorodifen and alachlor were reported by Raj and Wong (1975) to be superior to hand-weeding.

The use of herbicides like glyphosphate (for pre-plant vegetational control) diuron, simasizine or ametryn in mixtures with or followed by parquat or diquat provided effective long term control but it is often not attractive to the small scale farmer due to high cost of the herbicide (Challa, 1990).

According to Fageiry (1988), the most successful herbicide for control of dominant weeds *Echinochloa pyramidalis* and *Rottboellia exaltata* were oxadiazan at a rate of 1.43kg/ha and Oxyfluorfen at 0.48kg/ha.

2.4.8 Integrated Weed Management

Shaw (1982) suggested a formal definition of integrated weed management as a directed agro-ecosystem approach for the management and control of weed population at threshold levels that prevent economic damage in the present and future years.

No one method of weed control can adequately meet the needs of any crop all the time. Changes in environmental factors, land – use systems and shifts in weed and population density, coupled with cost of alternative weed control methods can adequately help to control weeds (Akobundu, 1987).

Integrated weed management (IWM) is neither a method nor a system of weed control but a philosophy whose goal is to use available knowledge in weed science to manage weeds so that they do not cause economic loss to humans. A high priority in IWM is the efficient and economic use of resources while minimizing hazard to the environment. An appropriate IWM is one that economically combines two or more weed management systems with little inputs to obtain a level of weed suppression superior to that ordinarily obtained when one weed management system is used (Akobundu, 1987).

Integrated weed management may involve any of the following weed control systems and combinations; cultural plus chemical, cultural plus biological, cultural plus preventive, biological plus chemical or combinations of three or more of these systems. The choice of the right combination will improve as accuracy in predicting weed-crop interaction increases (Akobundu, 1987). While selective herbicides have been successfully used to control weeds in most cropping situations, some weeds have known to escape control. An IWM strategy involving chemical and cultural control systems has been demonstrated to give better weed control and crop yield than when either cultivation or herbicide was used alone (Akobundu, 1987).

3.0 MATERIALS AND METHODS

3.1 Location and Site of Field Project

The experiment was carried out on the experimental fields of the Department of Horticulture, Faculty of Agriculture, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, (latitude 06^{o} 43'N and longitude 01^{o} 36'W) within the forest zone of Ghana from 1st December 2005 to 25th February 2006.

The area has two distinct rainfall seasons. The major rainy season starts from April to July followed by a dry spell in August. The minor season rains occur between September and November followed by the main dry season from December to March. Mean maximum and minimum temperatures were 30^{o}C and 26^{o}C respectively.

3.2 Soil Type and Cropping History of Site

The type of soil at the experimental area which is Akroso series, is sandy loam in texture and belongs to the forest Ochrosol (Ablor, 1972). It is deep, well-drained with moderately good water holding capacity. The top is about 30cm deep and consists of brown to dark-brown sandy loam soils. The site had been under cultivation to various vegetables in rotation for a considerable number of years. The vegetable cultivated prior to the start of the experiment was ravaya (*Solanum melongena cv*. Baby Aubergine).

3.3 Soil Analysis

Soil samples were collected from the site at depths of 0 – 15cm and 15 – 30cm. The samples from each depth were bulked together. Two samples resulted from the bulking and analysis was determined at the Savanna Agricultural Research Institute, Nyankpala near Tamale.

3.4 Source of Seeds

Tinda seeds were obtained from Dada farms, Pamfokrom near Agona Swedru in the Central region of Ghana.

3.5 Germination Test of Tinda Seeds

Germination test was carried out by sowing ten seeds each on a seedbed, in seed box and in cans filled with loamy soil on 25th November, 2005. The average germination percentage for all the three tests after five days was 97.

3.6 Land Preparation and Field Layout

The experimental area was ploughed on 1st December, 2005 and harrowing was done six days later. The field layout was demarcated immediately after harrowing. The experimental field measured 59m x 14m ($826m^2$) and was divided into three blocks. Each block measured 59m x 4m and each was further divided into 12 plots of 4m x 4m. Adjacent plots were 1m apart and 1m between adjacent blocks. Uniform mounding of a height of about 60cm with a diameter of 60cm was done to the respective plots in each block.

3.7 Experimental Design

The experimental design used was a 2 x 2 x 3 factorial in a Randomized Complete Block Design (RCBD). There were twelve treatments with two land preparation practices; mounding and no mounding, two staking methods; staking and no staking and three frequencies of weeding (once, twice and three times). Whilst the weeding once treatment was done at two weeks after germination, the two and three times weeding treatments were done at fortnightly intervals starting from two weeks after germination.

The treatment combinations were:

$M_0S_0W_1$ No mounding, no staking and weeding once.

$M_0S_0W_2$ No mounding, no staking and weeding twice.

$M_0S_0W_3$ No mounding, no staking and weeding three times.

$M_0S_1W_1$ No mounding, staking and weeding once.

$M_0S_1W_2$ No mounding, staking and weeding twice.

$M_0S_1W_3$ No mounding, staking and weeding three times.

$M_1S_0W_1$ Mounding, no staking and weeding once.

$M_1S_0W_2$ Mounding, no staking and weeding twice.

$M_1S_0W_3$ Mounding, no staking and weeding three times.

$M_1S_1W_1$ Mounding, staking and weeding once.

$M_1S_1W_2$ Mounding, staking and weeding twice.

$M_1S_1W_3$ Mounding, staking and weeding three times.

The treatment combinations were replicated three times.

3.8 Seed Sowing in Mounds and on Flat Land

Five seeds were sown per hill in either mounds or flat land at a depth of about 2cm on 8th December, 2005. Seeds were then covered with soil. Germination was observed 5 days after sowing.

3.9 Refilling of Vacancies

Some seeds did not germinate especially those on flat land and had to be replaced. Refilling of vacant places was done two weeks after germination by using some of the thinnings from stands with more than one seedling.

3.10 Cultural Practices

3.10.1 Irrigation

Watering during the first week after germination was done using a rubber hose since the experiment was conducted in the dry season. Subsequent watering was done every other day. The frequency of watering increased per week after fruit set.

3.10.2 Fertilizer Application

N.P.K (15:15:15) fertilizer was applied two weeks after germination at the rate of 0.06kg per hectare per plant by ring application method with the fertilizer being placed 5cm away from the plants. The fertilizer was incorporated into the soil by hoeing. Sulphate of Ammonia was also applied at the rate of 0.06kg per hectare per plant in ring placement method when flowering began.

3.10.3 Weed Control

Weed control was done by hoeing at 2, 4 and 6 weeks after germination. All the thirty-six plots were weeded at 2 weeks after germination, whilst the twenty-four plots were weeded twice and twelve plots were weeded three times. Weeds found on the field included *Panicum maximum, Euphorbia heterophylla, Portulaca oleraceae, Ageratum conyzoides, Acanthospermum hispidum, Tridax procumbens, Amaranthus spp, Cyperus rotundus, Sida acuta and Commelina spp.*

3.10.4 Weed Count

The identification and counting of weed species on the experimental plots were done on 27th December 2005, 10th January and 24th January, 2006, corresponding to 2, 4 and 6 weeks after germination. A quadrant of size 50cm x 30cm was randomly placed five times within the two central rows of each plot. The number of weeds per plot in meter squared was then counted and recorded.

3.10.5 Stirring, Mounding and Mulching

The soil was stirred around the root zone and basins created around the seedlings to prevent run offs and to collect enough water around the plants. Remounding was done to shape and maintain the mounds to a height of about 60cm at 2 weeks after germination and at fortnightly intervals till fruiting. Mulching with dry grass was done to those that were replaced and shaded with leafy twigs to avoid scorching by the sun.

3.10.6 Pests and Diseases Control

The first insecticidal spraying was done with Karate 2.5 EC (*Lambda – cyhalothrine)* at a rate of 0.9ml per litre of water when the plants were 3 weeks after germination to control Green shield bug (*Nezara viridula)* which punctured the leaves thereby creating holes in them. Dithane M.45 (*Mancozeb)* was used at a rate of 0.45g/l of water into a knapsack sprayer to control fungal diseases. An insecticidal spray using Actellic 25 EC (*Pirimiphos-methyl)* at the rate 0.45ml/l was done when plants were 5 and 8 weeks old to control grasshoppers (*Zonocerus variegatus*) leaf eating and fruit boring caterpillars (*Heliothis armigera*).

3.10.7 Staking

Treatments that were to be staked were staked when plants were 4 weeks after germination. Individual staking was done using twiggy bamboo stems of about 1.2m in height. Raffia was used to tie the vines to some of the branches of the bamboo.

Stakes were placed 10cm away from the plant in order not to disturb the roots.

3.10.8 Harvesting

Harvesting started 8 weeks after germination. During harvesting immature fruits were cut from the fruit stalk using a knife. This was done in the morning to prevent loss of water from the fruits. About 2cm of the stalk was left attached to the fruits.

Harvesting was done twice in a week for four weeks.

3.11 Termination of experiment

The experiment was terminated on the day of the last harvest as fruit production was observed to have drastically reduced. Plants were also observed to have been dying. The experiment lasted approximately twelve weeks after germination.

3.12 Parameters Studied.

3.12.1 Vegetative Growth Parameters Number of leaves per plant.

Four inner plants were selected from each treatment and number of leaves per plant was recorded by counting the leaves on the main vine and branches when the plant was two weeks after germination and at fortnightly intervals till six weeks after germination.

Number of nodes per plant

Number of nodes was counted at two weeks after germination and at fortnightly intervals till six weeks after germination.

Number of branches per plant

Number of branches was counted at two weeks after germination and at fortnightly intervals till six weeks after germination.

Vine length per plant.

Measurements of the vine length were taken on the main vine just above the soil level to the tip of the vine. This was done with a metre rule when the plants were two weeks after germination and at fortnightly intervals till six weeks after germination.

3.12.2 Reproductive Growth Parameters

Days from germination to flower bud appearance

This was based on visual observation by counting 50% of plants identified on each plot. It was observed on the fourth week after germination.

Days from germination to 50% fruit set.

This was based on visual observation by counting 50% of plants identified on each plot. It was observed on the sixth week after germination.

3.12.3 Yield Parameters

Fruit length/ diameter ratio

Fruit length and diameter were measured from sampled fruits harvested using veneer calipers. The length of the sampled fruits was divided by their respective diameters and this gave the export standard of the crop.

Average number of fruits per plant

Average number of fruits was taken and the total number of fruits was divided by the number of plants from which the fruits were harvested on each plot.

Average weight of fruits per plant

The weight of fruits was taken using sensitive scale balance and the total weights were divided by the number of plants from which the fruits were harvested on each plot.

Total number of fruits per hectare

Total number of fruits was sorted out into marketable and unmarketable fruits. The marketable fruits were again sorted out as non exportable and export market fruits. All were counted from the number of fruits harvested and then projected to yield per hectare.

Total number of marketable fruits per hectare

Total number of export marketable fruits (disease free, uniform in colour, undamaged by pests, not misshapen) was counted from the number of fruits harvested and then projected to yield per hectare.

Total number of non-exportable fruits

Total number of non-exportable fruits (those that were larger in size, hard textured, with slight change in colour) was counted from the number of fruits harvested and then projected to yield per hectare.

Total number of unmarketable fruits per hectare

Total number of unmarketable fruits (those that were diseased, not uniform in colour, damaged by pests, bruised, overgrown and misshapen) were counted from the number of fruits harvested and then projected to yield per hectare.

Total weight of fruits per hectare

A sensitive scale balance was used to weigh all fruits and based on the weight of fruits harvested; they were then projected to kilogram per hectare.

Total weight of marketable fruits per hectare

Total weight of marketable fruits was taken using the sensitive scale balance and from the weight of fruits harvested, they were then projected to kilogram per hectare.

Total weight of non-exportable fruits per hectare

Total weight of non-exportable fruits was taken using the sensitive scale balance and from the weight of fruits harvested, they were projected to kilogram per hectare.

Total weight of unmarketable fruits per hectare

Total weight of unmarketable fruits was taken using the sensitive scale balance and from the weight of fruits harvested, they were then projected to kilogram per hectare.

3.13 Soil Sample Analysis.

Soil samples were analysed at the Savanna Agricultural Research Institute laboratory, Nyankpala near Tamale for nutrient levels (% N, P, K, O, C) and pH.

3.14 Nutrient Analysis

Ten fruits were taken from each treatment harvested and analysed for available nutrients (% moisture, Ash, Carbohydrates, fat, minerals (Fe, K, P, Ca, Na) on treatment basis.

3.15 Cost- Benefit Analysis

Cost-benefit analysis was carried out for all the treatment combinations (weeding, watering, spraying, staking, mounding) and harvesting were costed in order to assess their profitabilities.

3.16 Statistical Analysis

Analysis of variance (ANOVA) was done on all data collected and the least significance difference (LSD) test was used to assess differences between treatment means.

4.0 RESULTS

4.1 Vegetative Growth Parameters

4.1.1 Number of Leaves Per Plant.

Number of leaves per plant at two, four and six weeks after germination showed no significant differences between mounding, staking and frequency of weeding. (Table 1). There were no significant interaction effects on the number of leaves produced at two and four weeks after germination. However, mounding, staking and frequency of weeding three times ($M_1S_1W_3$) interaction significantly produced the highest number of leaves (7.92) per plant at six weeks after germination while no mounding, staking and weeding once ($M_0S_1W_1$) produced the least of (4.68) leaves (Figure 1)

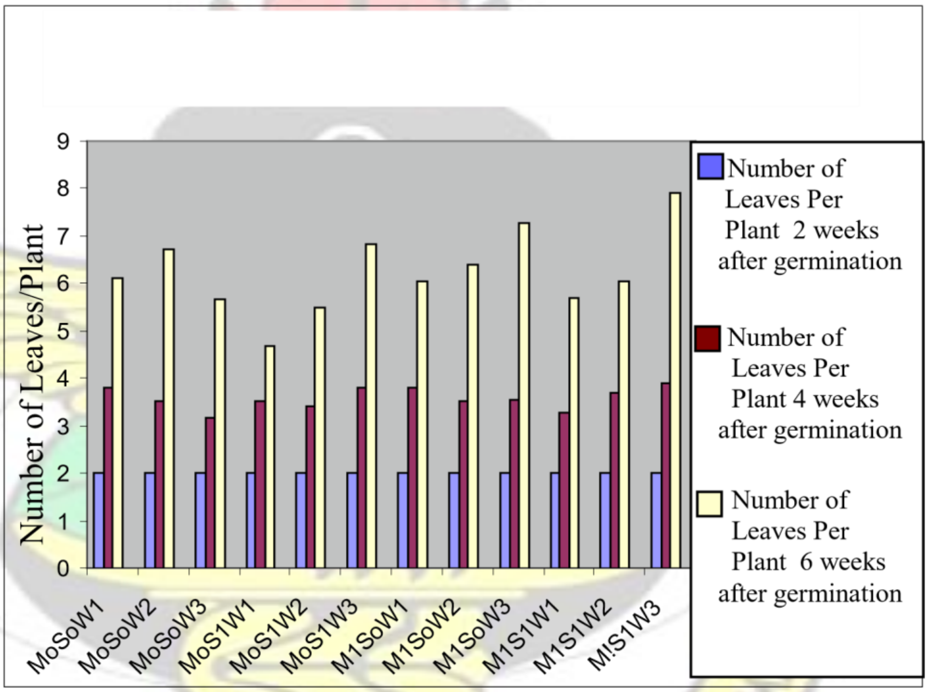
Table 1 Effects of mounding, staking and frequency of weeding on number of leaves produced per plant.

Parameter	Number of Leaves		
	Two Weeks after germination	**Four Weeks after germination**	**Six Weeks after germination**
Treatments			
Mounding			
No Mounding (M_0)	2.21	3.54	5.91
Mounding (M_1)	2.23	3.62	6.56
LSD at 0.05	*NS	NS	NS

Parameter	**Two Weeks after germination**	**Four Weeks after germination**	**Six Weeks after germination**
Treatments Staking			

No Staking (S_0)	2.21	3.54	6.37
Staking (S_1)	2.22	3.61	6.41
LSD at 0.05	NS	NS	NS
Frequency of Weeding			
Once (W_I)	2.22	3.50	5.63
Twice (W_2)	2.22	3.53	6.16
Three times (W_3)	2.23	3.61	6.92
LSD at 0.05	NS	NS	NS

***NS – Not Significant**



LSD at 0.05 at 2 weeks after germination = 0.16

LSD at 0.05 at 4 weeks after germination = 0.94 LSD at 0.05 at 6 weeks after germination = 2.75

Figure 1. Interaction effect of mounding, staking and frequency of weeding on number of leaves produced at two, four and six weeks after sowing.

4.1.2 Number of Nodes Per Plant

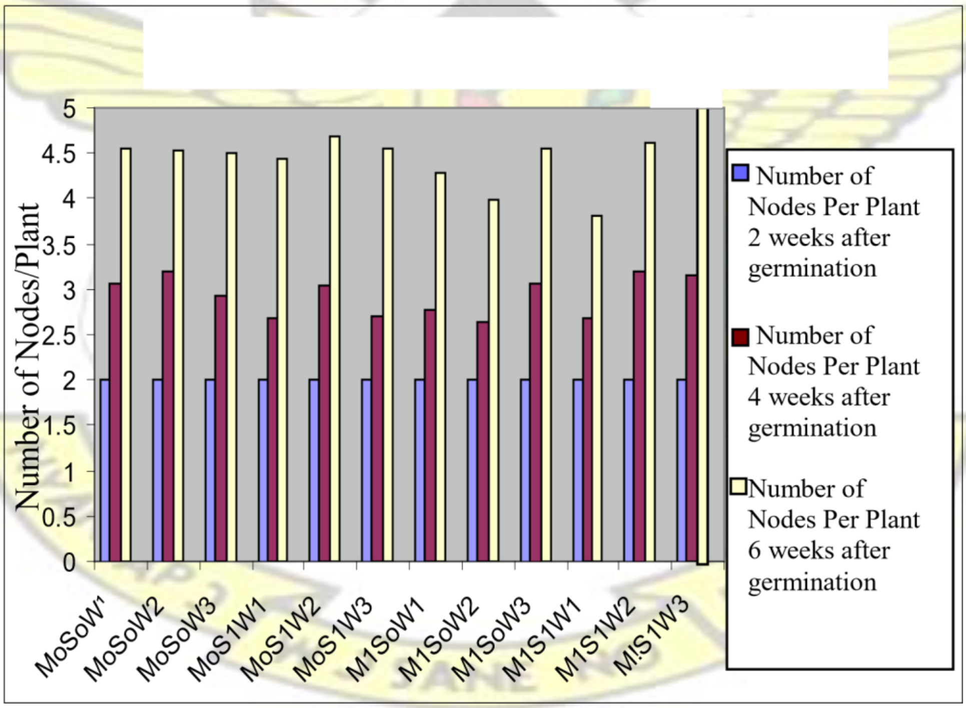
Number of nodes per plant at two, four and six weeks after germination showed no significant differences between mounding, staking and frequency of weeding. (Table 2). No Significant interaction effects existed between the treatments on number of nodes at two and four weeks after germination. At six weeks after germination the highest number of nodes was significantly produced by mounding, staking and frequency of weeding three times ($M_1S_1W_3$) interaction while mounding, staking and weeding once ($M_1S_1W_1$) interaction produced the least (figure 2).

TABLE 2 Effect of Mounding, Staking and Frequency of Weeding on Number of Nodes Per Plant

Parameter / TREATMENTS	Number of Nodes		
	Two Weeks after germination	Four Weeks after germination	Six Weeks after germination
Mounding			
No Mounding (M_0)	2.00	2.93	4.54
Mounding (M_1)	2.00	2.92	4.27
LSD at 0.05	*NS	NS	NS
Staking			
No Staking (S_0)	2.00	2.94	4.40
Staking (S_1)	2.00	2.91	4.41
LSD at 0.05	*NS	NS	NS

Parameter TREATMENTS	Two Weeks after germination	Four Weeks after germination	Six Weeks after germination
Frequency of Weeding			
Once (W_1)	2.00	2.80	4.27
Twice (W_2)	2.00	3.02	4.45
Three times (W_3)	2.00	2.96	4.50
LSD at 0.05	*NS	NS	NS

***NS – Not Significant**



LSD at 0.05 at 2 weeks after germination = 0.00

LSD at 0.05 at 4 weeks after germination = 0.82

LSD at 0.05 at 6 weeks after germination = 0.85

Figure 2. Interaction effect of mounding, staking and frequency of weeding on number of nodes per plant at two, four and six weeks after sowing

4.1.3 Number of Branches Produced Per Plant.

Number of branches produced per plant at two, four and six weeks after germination showed no significant differences between mounding, staking and frequency of weeding (Table 3). Significant interaction effect existed between the treatment at four and six weeks after germination. The highest number of branches produced at four and Six weeks after germination was mounding, staking and frequency of weeding three times interaction ($M_1S_1W_3$) while no mounding, staking and weeding three times interaction ($M_0S_1W_3$) produced the least (Table 3).

TABLE 3 Effect of Mounding, Staking and Frequency of Weeding on Number of Branches Per Plant

Parameter	Number of Branches		
Treatments	Two Weeks after germination	Four Weeks after germination	Six Weeks after germination
Mounding			
No Mounding (M_0)	0.00	0.58	1.08
Mounding (M_1)	0.00	0.78	1.46
LSD at 0.05	*NS	NS	NS
Staking			
LSD at 0.05			NS

No Staking (S_0)	0.00	0.71	1.30
Staking (S_1)	0.00	0.66	1.24
	NS	NS	

Treatments	**Two Weeks after germination**	**Four Weeks after germination**	**Six Weeks after germination**
Frequency of Weeding			
Once (W_I)	0.00	0.57	1.26
Twice (W_2)	0.00	0.76	1.44
Three times (W_3)	0.00	0.71	1.11
LSD at 0.05	NS	NS	NS
Interactions			
$M_0S_0W_1$	0.00	0.91	1.38
$M_0S_0W_2$	0.00	0.81	1.52
$M_0S_0W_3$	0.00	0.33	0.81
$M_0S_1W_1$	0.00	0.47	1.05
$M_0S_1W_2$	0.00	0.47	1.28
$M_0S_1W_3$	0.00	0.47	0.47
$M_1S_0W_1$	0.00	0.58	1.24
$M_1S_0W_2$	0.00	0.81	1.38
$M_1S_0W_3$	0.00	0.81	1.49
LSD at 0.05			NS

Parameter			
$M_1S_1W_1$	0.00	0.33	1.38
$M_1S_1W_2$	0.00	0.94	1.58
$M_1S_1W_3$	0.00	1.24	1.66
LSD at 0.05	NS	0.82	0.70

***NS – Not Significant**

4.1.4 Vine Length Per Plant.

Vine length per plant at two, four and six weeks after germination showed no significant differences between mounding, staking and frequency of weeding (Table 4). There were significant differences between the mean vine length per plant at four and six weeks after sowing for mounding, staking and frequency of weeding interaction. However, mounding, staking and weeding three times interaction ($M_1S_1W_3$) produced the longest vine per plant while the shortest was produced by no mounding, staking and weeding three times interaction ($M_0S_1W_3$) at four and six weeks after sowing (Figure 3)

TABLE 4 Effect of Mounding, Staking and Frequency of Weeding on Vine Length Per Plant

	Vine length per plant Parameter		
	Two Weeks after germination	Four Weeks after germination	Six Weeks after germination
Treatments			
Mounding			

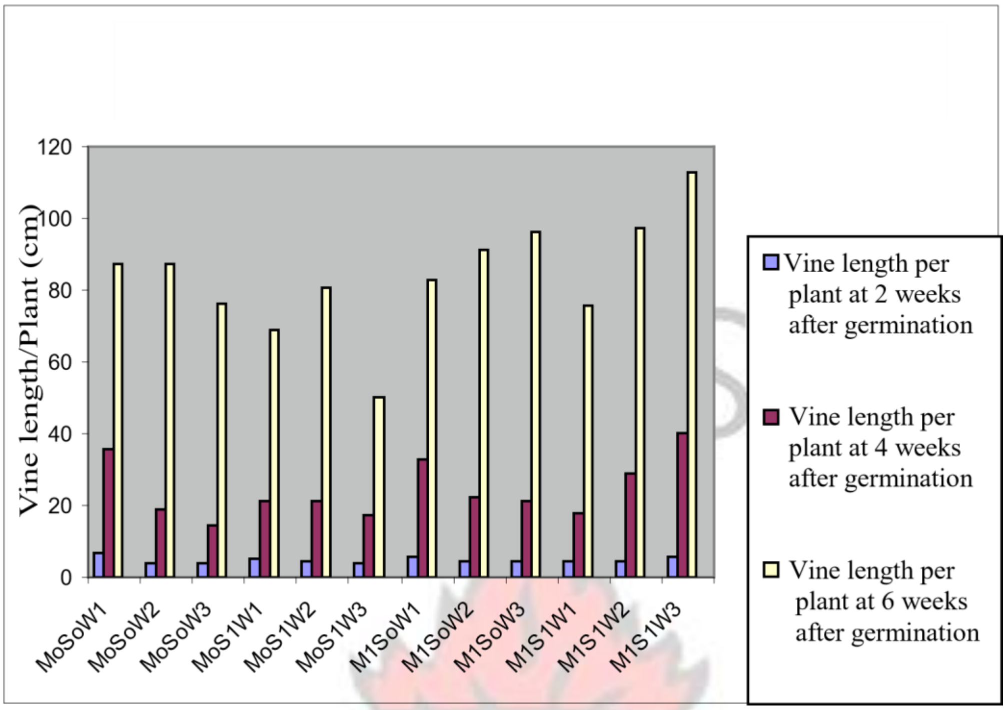
No Mounding (M_0)	4.67	21.2	75.0
Mounding (M_1)	4.83	27.2	92.7
LSD at 0.05	*NS	NS	NS
Staking			
No Staking (S_0)	4.89	24.1	80.50
Staking (S_1)	4.61	24.1	86.90
	NS	NS	

	Two Weeks after germination	**Four Weeks after germination**	**Six Weeks after germination**
Treatments			
Weeding Frequency			
Once (W_1)	5.33	26.7	78.60
Twice (W_2)	4.42	22.7	89.00
Three times (W_3)	4.50	23.2	83.90
LSD at 0.05	NS	NS	NS

***NS – Not Significant**

LSD at 0.05			NS

Parameter



LSD at 0.05 at 2 weeks after germination = 1.44

LSD at 0.05 at 4 weeks after germination = 21.55

LSD at 0.05 at 6 weeks after germination = 54.11

Figure 3. Interaction effect of mounding, staking and frequency of weeding on vine length per plant at two, four and six weeks after sowing.

4.2 Reproductive Growth Parameters

4.2.1 Number of Days from Germination to Flower Bud Appearance and 50% Fruit Set.

Reproductive parameters on number of days from germination to flower bud appearance and 50% fruit set showed no significant differences between mounding, staking and frequency of weeding (Table 5). The treatments however showed significant interactive effects in their number of days from germination to flower bud appearance but not from days to fruit set. $M_1S_1W_3$ interaction was the earliest to expose flower buds (18 days) while $M_0S_0W_2$ took the longest time (24 days) to expose flower buds. Number of days from germination to 50% fruit set was not significantly affected by the treatment interactions (Table 5).

TABLE 5 Effect of Mounding, Staking and Frequency of Weeding on Number of Days from Germination to Flower Bud Appearance and 50% Fruit Set

Parameter	Days from germination to flower bud appearance.	Days from germination to 50% fruit set Treatments
Mounding		
No Mounding (M_0)	21	43
Mounding (M_1)	20	42
LSD at 0.05	*NS	NS
Staking		
No Staking (S_0)	20	43
Staking (S_1)	21	42
	NS	
	Days from germination to flower bud appearance.	**Days from germination to 50% fruit set**
Treatments		
Weeding Frequency		
Once (W_1)	21	42
LSD at 0.05		NS

Parameter		
Twice (W_2)	21	43
Three times (W_3)	20	42
LSD at 0.05	NS	NS
Interaction		
$M_0S_0W_1$	23	44
$M_0S_0W_2$	24	46
$M_0S_0W_3$	23	46
$M_0S_1W_1$	21	45
$M_0S_1W_2$	20	44
$M_0S_1W_3$	23	45
$M_1S_0W_1$	20	44
$M_1S_0W_2$	22	44
$M_1S_0W_3$	20	44
$M_1S_1W_1$	21	44
$M_1S_1W_2$	20	43
$M_1S_1W_3$	18	43
LSD at 0.05	5.0	NS

***NS – Not Significant**

4.3 Yield Parameters

4.3.1 Fruit Length/Diameter Ratio

Fruit/length diameter ratio showed no significant differences between mounding, staking and frequency of weeding (Table 6). Fruit length diameter ratio was significantly affected by mounding, staking and frequency of weeding interactions. No mounding, no staking and weeding twice interaction ($M_0S_0W_2$) and no mounding, no staking and weeding three times interaction ($M_0S_0W_3$) produced the largest ratio while the least was produced by mounding, no staking and weeding twice interaction ($M_1S_0W_2$) (Table 6).

TABLE 6 Effect of Mounding, Staking and Frequency of Weeding on Fruit Length/ Diameter Ratio Parameter Fruit Length/Diameter Ratio Treatments Mounding

No Mounding (M_0)	0.868
Mounding (M_1)	0.831
LSD at 0.05	*NS
Staking	
No Staking (S_0)	0.844
Staking (S_1)	0.855 LSD
at 0.05	NS

LSD at 0.05

Parameter	
Weeding Frequency	
Once (W_1)	0.863
Twice (W_2)	0.844 Three
times (W_3)	0.842
	NS
	Fruit Length/Diameter Ratio
Treatments	
Interactions	
$M_0S_0W_1$	0.843
$M_0S_0W_2$	0.883
$M_0S_0W_3$	0.883
$M_0S_1W_1$	0.873
$M_0S_1W_2$	0.870
$M_0S_1W_3$	0.857
$M_1S_0W_1$	0.873
$M_1S_0W_2$	0.747
$M_1S_0W_3$	0.837
$M_1S_1W_1$	0.863
$M_1S_1W_2$	0.877
$M_1S_1W_3$	0.790
LSD at 0.05	0.10

***NS – Not Significant**

4.3.2 Average Number and Average Weight of Fruits Per Plant

Average number and average weight of fruits per plant showed no significant differences between mounding, staking and frequency of weeding (Table 7). Average number and average weight of fruits per plant were not significantly affected by mounding, staking and frequency of weeding interactions.

TABLE 7 Effect of Mounding, Staking and Frequency of Weeding on Average Number and Average Weight of Fruits Per Plant.

Parameters	Average Number of Fruits Per Plant	Average Weight of Fruits Per Plant
Treatments		
Mounding		
No Mounding (M_0)	1.16	2.14
Mounding (M_1)	1.57	2.82
LSD at 0.05	*NS	NS
Staking		
No Staking (S_0)	1.24	2.42

Parameter		
Staking (S_1)	1.45	2.54
LSD at 0.05	NS	NS
Weeding Frequency		
Once (W_1)	1.26	2.28
Twice (W_2)	1.58	2.87
Three times (W_3)	1.27	2.29
LSD at 0.05	*NS	NS

Parameters	Average Number of Fruits Per Plant	Average Weight of Fruits Per Plant
Treatments		
Interactions		
$M_0S_0W_1$	1.35	3.68
$M_0S_0W_2$	1.17	1.18
$M_0S_0W_3$	1.07	1.22
$M_0S_1W_1$	1.18	1.19
$M_0S_1W_2$	1.68	3.03
$M_0S_1W_3$	0.88	0.97
$M_1S_0W_1$	1.32	2.82
$M_1S_0W_2$	1.47	1.53
$M_1S_0W_3$	1.43	2.38
$M_1S_1W_1$	1.18	2.22
$M_1S_1W_2$	1.99	3.38
$M_1S_1W_3$	2.06	4.58
LSD at 0.05	NS	NS

***NS – Not Significant**

4.3.3 Total Number and Total Weight of Fruits Per Hectare

Total number and total weight of fruits per hectare showed no significant differences between mounding, staking and frequency of weeding (Table 8). Total number of fruits per hectare showed significant interactive differences between $M_1S_1W_3$ and $M_0S_1W_3$. The highest total number and total weight of fruits per hectare of 9,775 and 3,593.75kg was produced by $M_1S_1W_3$ interaction while the least of 5,219 and 2,343.75kg was also produced by $M_0S_1W_3$. There were no significant interaction effects between the treatments on total weight of fruits per hectare (Table 8).

TABLE 8 Effect of Mounding, Staking and Frequency of Weeding on Total Number and Weight of Fruits Per Hectare

Parameter	**Total Number of Fruits Per Hectare**	**Total weight of Fruits Per hectare. (kg)**
Treatments		
Mounding		
No Mounding (M_0)	6,638	2,793.75
Mounding (M_1)	7,663	3,035.50
LSD at 0.05	*NS	NS
Staking		
No Staking (S_0)	6,938	2,837.50
Staking (S_1)	7,988	2,993.75
LSD at 0.05	NS	NS

Parameter	Total Number of Fruits Per Hectare	Total weight of Fruits Per hectare. (kg)
Treatments Weeding Frequency		
Once (W_1)	7,481	2,881.25
Twice (W_2)	6,856	2,493.75
Three times (W_3)	7,494	2,962.50
LSD at 0.05	NS	NS
Interaction		
$M_0S_0W_1$	8,475	3,556.25
$M_0S_0W_2$	5,825	2,550.00
$M_0S_0W_3$	5,900	2,462.50
$M_0S_1W_1$	5825	2,743.75
$M_0S_1W_2$	7,769	3,156.25
$M_0S_1W_3$	5,219	2,343.75
$M_1S_0W_1$	7,325	2,768.75
$M_1S_0W_2$	5,631	2,643.75
$M_1S_0W_2$	7,650	3062.50
$M_1S_1W_1$	7,519	2,881.25
$M_1S_1W_2$	7,669	3,218.75
$M_1S_1W_3$	9,775	3,593.75
LSD at 0.05	4,550	NS

***NS - Not Significant**

4.3.4 Total Number and Weight of Marketable Fruits Per Hectare

Total number and weight of marketable fruits per hectare showed no significant differences between mounding, staking and frequency of weeding (Table 9). Total number of marketable fruits per hectare showed significant interactive differences between $M_1S_1W_3$ and $M_0S_1W_3$ with $M_1S_1W_3$ producing the highest and $M_0S_1W_3$ producing the least number of marketable fruits. Total weight of marketable fruits was not significantly affected by the treatment interaction (Table 9).

TABLE 9 Effect of Mounding, Staking and Frequency of Weeding on Total Number and Weight of Marketable Fruits Per Hectare

Parameters	Total Number of Marketable Fruits Per Hectare	Total Weight of Marketable Fruits Per Hectare (kg)
Treatments		
Mounding		
No Mounding (M_0)	2,825	1,212.50
Mounding (M_1)	3,338	1,325.00
LSD at 0.05	*NS	NS
Staking		
No Staking (S_0)	2,944	1,212.50
Staking (S_1)	3,219	1,337.50
LSD at 0.05	NS	NS

Parameters	Total Number of Marketable Fruits Per Hectare	Total Weight of Marketable Fruits Per Hectare (kg)
Treatments		
Weeding Frequency		
Once (W_1)	3100	1,225.00
Twice (W_2)	2,988	1,275.00
Three times (W_3)	3,156	1,300.00
LSD at 0.05	NS	NS
Interactions		
$M_0S_0W_1$	3,856	1,243.75
M_0S0W_2	2,475	1,143.75
$M_0S_0W_3$	2,494	1,168.75
$M_0S_1W_1$	2,469	1,143.75
$M_0S_1W_2$	3,381	1,362.50
$M_0S_1W_3$	2,281	1,206.25
$M_1S_0W_1$	3,088	1,131.25
M_1SoW_2	2,438	1,150.00
M_1SoW_3	3,313	1,338.00

$M_1S_1W_1$	3,219	1,387.50
$M_1S_1W_2$	3,656	1,450.00
$M_1S_1W_3$	4,319	1,487.50
LSD at 0.05	2,000	NS

***NS – Not Significant**

4.3.5 Total Number and Weight of Unmarketable Fruits Per Hectare

Total number and weight of unmarketable fruits per hectare showed no significant differences between mounding, staking and frequency of weeding (Table 10). Mean total number and mean total weight of unmarketable fruits per hectare were not significantly affected by mounding, staking and frequency of weeding interaction (Table 10).

TABLE 10 Effect of Mounding, Staking and Frequency of Weeding on Total Number and Weight of Unmarketable Fruits Per Hectare.

Parameters Treatments	Total Number of Unmarketable Fruits (ha)	Total Weight of Unmarketable Fruits (kg/ha)
Mounding		
No Mounding (M_0)	2,819	1156
Mounding (M_1)	2288	1056

LSD at 0.05	*NS	NS
Staking		
No Staking (S_0)	2,800	1,181
Staking (S_1)	2,306	1,025
LSD at 0.05	NS	NS

Parameters Treatments	Total Number of Unmarketable Fruits (ha)	Total Weight of Unmarketable Fruits (kg/ha)
Weeding Frequency		
Once (W_1)	2725	1,219
Twice (W_2)	2,481	1,088
Three times (W_3)	2,456	1,006
LSD at 0.05	NS	NS
Interactions		
$M_0S_0W_1$	3,231	1,500.00
$M_0S_0W_2$	2,013	1,093.75
$M_0S_0W_3$	2,156	1,025.00
$M_0S_1W_1$	2,038	1,031.25
$M_0S_1W_2$	2,850	1,043.75
$M_0S_1W_3$	2,075	1,000
$M_1S_0W_1$	2,350	1,243.75
$M_1S_0W_2$	1,881	1,075.00
$M_1S_0W_3$	2,838	1,150.00
$M_1S_1W_1$	2,838	1,093.75
$M_1S_1W_2$	2,644	1,143.75
$M_1S_1W_3$	2,606	1,212.50
LSD at 0.05	NS	NS

***NS – Not Significant**

4.3.6 Total Number and Weight of non-exportable Fruits Per Hectare

Total number and weight of non-exportable fruits showed no significant differences between mounding, staking s and frequency of weeding (Table 11). There were significant differences between the mean total number of non-exportable fruits per hectare for mounding, staking and frequency of weeding interaction. There were no significant differences between the mean total weight of non-exportable fruits per hectare for mounding staking and frequency of weeding interaction. $M_1S_1W_3$ produced the highest total number of non-exportable fruits while $M_0S_1W_3$ produced the least total number of non-exportable fruits.

TABLE 11 Effect of Mounding, Staking and Frequency of Weeding on Total Number and Weight of non-exportable Fruits Per Hectare

Parameters Treatments	Total Number of non-exportable Fruits Per Hectare	Total Weight of non-exportable Fruits Per Hectare (kg)
Mounding		
No Mounding (M_0)	1,525	525.00
Mounding (M_1)	1,506	556.25
LSD at 0.05	*NS	NS

Parameters exportable Fruits Per Fruits Per Hectare Treatments	Total Number of non- of non-exportable	Total Weight Hectare (kg)
Staking		
No Staking (S_0)	1688	631.25
Staking (S_1)	1344	456.25
LSD at 0.05	NS	NS
Frequency of Weeding		
Once (W_1)	1881	518.75
Twice (W_2)	1388	531.25
Three times (W_3)	1281	575
LSD at 0.05	NS	NS

Interactions		
$M_0S_0W_1$	1513	706.25
$M_0S_0W_2$	1338	312.50
$M_0S_0W_3$	1250	268.75
$M_0S_1W_1$	1319	568.75
$M_0S_1W_2$	1538	775.00
$M_0S_1W_3$	863	512.50
$M_1S_0W_1$	1880	393.75
$M_1S_0W_2$	1313	418.75
$M_1S_0W_3$	1500	625.00
Parameters exportable Fruits Per Fruits Per Hectare	**Total Number of non- of non-exportable**	**Total Weight Hectare (kg)**
Treatments		
$M_1S_1W_1$	1463	400.00
$M_1S_1W_2$	1369	625.00
$M_1S_1W_3$	2850	893.75
LSD at 0.05	1,000	NS

***NS – Not Significant**

4.4 Analysis of Nutrient Contents of the Fruit Samples

4.4.1 Nutrient Content of Fruits as affected by Mounding

Table 12a shows that mean moisture, ash, protein, iron, potassium and phosphorus content of the fruit samples were significantly affected by mounding. The higher moisture, ash, protein, iron, potassium and phosphorus content of the fruits samples were produced by no mounding (M_0). Mounding significantly ($P<0.05$) increased fat and carbohydrate content of the fruit samples than no mounding. Mounding also did not significantly affect mean calcium and sodium content of the fruit samples.

4.4.2 Nutrient Content of Fruits as affected by Staking

Mean moisture, ash, protein, iron, calcium and potassium content of the fruit samples were significantly affected by staking methods. Plants which were not staked had fruits which had higher ash, protein, iron, calcium and potassium content of the fruit samples from plants which were staked (Table 12a). Staking significantly increased fat, carbohydrates and phosphorous content of the fruit samples than no staking. Sodium content of the fruit samples showed no significant differences between no staking and staking (Table 12a).

4.4.3 Nutrient Content of Fruits as affected by Frequency of Weeding. Table 12a shows nutrient content of fruits as affected by frequency of weeding. Mean moisture content of fruit samples was significantly affected by weeding frequencies. Weeding twice had the highest moisture followed by weeding once and weeding three times. Mean ash content of fruits samples was significantly affected by frequency of weeding. Weeding once had the highest ash content of the fruit samples followed by weeding twice and weeding three times. Weeding three times significantly increased the protein content of the fruit samples followed by weeding twice and weeding once. Fat content of the fruit samples showed significant differences between weeding three times, weeding once and weeding twice. Weeding three times produced the highest fat content followed by weeding once and weeding twice.

Mean carbohydrate content of the fruit samples were significantly affected by frequency of weeding. Weeding once had the highest carbohydrate content of the fruit samples followed by weeding twice and weeding three times. Iron content of the fruit samples showed significant differences between weeding three times, weeding once and weeding twice. The highest iron content of the fruit samples was produced by weeding three times followed by weeding once and weeding twice. Mean calcium content of the fruit samples were significantly not affected by frequency of weeding. However, weeding once had the highest calcium content of the fruit samples followed by weeding three times and weeding twice. Mean potassium content of the fruit samples were significantly affected by frequency of weeding. The highest potassium content of the fruit samples was produced by weeding three times followed by weeding twice and weeding once. There were no significant differences between sodium content of the fruit samples for weeding once and weeding three times. There were significant differences between sodium content of the fruits samples for weeding once, weeding three times and weeding twice. Weeding once produced the highest sodium content of the fruit samples whiles weeding twice produced the least. Mean phosphorus content of the fruit samples were significantly affected by frequency of weeding. Weeding once and weeding three times produced the highest phosphorus content of the fruit samples followed by weeding twice.

TABLE 12a ANALYSIS OF NUTRIENT CONTENT OF THE FRUITS AS AFFECTED BY MOUNDING, STAKING AND FREQUENCY OF WEEDING

Parameters	Moisture %	Ash %	Protein %	Fat %	Carbohy-drate (mg/100g)	Iron (mg/100g)	Calcium (mg/100g)	Potassium (mg/100g)	Sodium (mg/100g)	Phosphorus (mg/100g)
TREATMENTS										
No Mounding	94.94	7.42	23.46	0.31	3.51	8.45	280.9	588.39	56.9 63.0	4239 3425
Mounding	94.21	6.68	19.40	0.62	4.50	6.39	270.2	554.68	NS	115.2
LSD at 0.05	0.11	0.03	0.02	0.04	0.04	0.006	NS	0.65		
No staking	94.96	7.89	21.67	0.43	3.76	7.88	315.7	583.17	63.1	3719 3945
Staking	94.18	6.20	21.18	0.50	4.24	6.96	235.3	559.17	56.8	115.2
LSD at 0.05	0.11	0.03	0.02	0.04	0.04	0.006	35.59	0.65	7.09	
Weeding Once	94.48 94.96	8.26	18.21	0.41	4.15 4.07	6.98 6.94	295.8	563.03	66.0 52.2	3934
Weeding twice	94.28	6.47	18.88	0.40	3.78	8.34	257.9	562.37	61.7	3653
Weeding three times	0.14	6.42	27.20	0.56	0.05	0.007	272.9	589.21	8.68	3909
LSD at 0.05		0.04	0.03	0.05			NS	0.80		141.1

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4.4.4 Nutrient Content of Fruits as Affected by Mounding, Staking and Frequency of Weeding Interaction

All the parameters studied were significantly affected by mounding, staking and frequency of weeding interaction (Table 12b). $M_1S_0W_2$ produced the highest moisture content of fruit samples while $M_0S_0W_2$ produced the least. $M_1S_0W_1$ produced the highest ash content of fruit samples while $M_1S_1W_3$ produced the least. The highest protein content of fruit samples was produced by $M_0S_0W_3$ while the least was produced by $M_1S_1W_1$. $M_1S_0W_1$, $M_1S_0W_3$ and $M_1S_1W_1$ produced the highest fat content of fruit samples while $M_0S_0W_2$ produced the least. The highest carbohydrate content of fruit samples was produced by $M_1S_1W_1$ while $M_0S_0W_3$ produced the least. $M_0S_0W_1$ had the highest iron content of the fruit samples while $M_1S_1W_1$ produced the least. The highest calcium content of the fruit samples was produced by $M_1S_0W_1$ while the least was produced by $M_1S_1W_2$. $M_0S_0W_3$ produced the highest potassium content of the fruit samples while $M_1S_1W_1$ produced the least. $M_0S_0W_1$ produced the highest sodium content of the fruit samples while $M_0S_0W_2$ produced the least. The highest phosphorus content of the fruit samples was produced by $M_0S_1W_3$ while the least was produced by $M_1S_1W_3$ (Table 12b)

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TABLE 12b ANALYSIS OF NUTRIENT CONTENT OF THE FRUIT SAMPLES AS AFFECTED BY MOUNDING, STAKING AND FREQUENCY OF WEEDING INTERACTION.

Parameters	Moisture %	Ash %	Protein %	Fat %	Carbohy-drate (mg/100g)	Iron (Mg/100g)	Calcium (Mg/100g)	Potassium (Mg/100g)	Sodium (Mg/100g)	Phospho-rus (mg/100g)
Treatment										
INTERACTION										
$M_0S_0W_1$	94.40	7.23	20.35	0.16	4.40	10.60	313.20	594.00	77.70	3621
$M_0S_0W_2$	92.10	7.10	16.85	0.14	2.95	7.68	287.60	541.10	37.80	3270
$M_0S_0W_3$	94.93	9.90	36.34	0.15	2.50	10.42	309.00	639.50	63.60	3491
$M_0S_1W_1$	96.00	8.22	18.60	0.25	2.92	6.36	272.90	582.00	56.50	4080
$M_0S_1W_2$	93.20	6.83	16.65	0.55	5.15	7.23	293.50	583.50	52.50	5020
$M_0S_1W_3$	95.00	5.24	31.96	0.60	3.12	8.40	209.10	583.50	53.50	5954
$M_1S_0W_1$	94.90	10.33	20.36	0.80	3.42	6.02	352.60	607.50	61.00	4790
$M_1S_0W_2$	96.23	6.74	21.45	0.50	3.93	6.48	291.70	569.00	63.50	3292
$M_1S_0W_3$	93.23	6.06	14.66	0.80	5.36	6.10	340.40	548.00	75.00	3851
$M_1S_1W_1$	93.20	7.26	13.51	0.80	5.87	4.95	244.40	468.60	68.70	3244
$M_1S_1W_2$	92.60	5.20	20.58	0.50	4.23	6.37	159.00	556.00	53.00	3032
$M_1S_1W_3$	94.30	4.47	25.83	0.70	4.16	8.42	233.10	579.00	54.70	2339
LSD at 0.05	0.28	0.07	0.06	0.10	0.09	0.01	87.19	1.59	17.36	282.20

4.5 Cost Benefit Analysis

4.5.1 Treatment/Total Expenditure (In Hectares) Analysis

The treatments had different expenditure at each treatment level. From Table 13, it could be observed that, when there was no mounding, no staking but frequency of weeding once ($M_0S_0W_1$), the total expenditure in hectares was GH¢ 312.5. The cost components included weeding, spraying, watering, fertilizer application and harvesting. The amount was arrived at as result of converting the land size value under total expenditure which is quoted in metres to hectares.

The $M_0S_0W_2$ gave an increase in cost of GH¢ 390.63. This is an indication that weeding alone accounted for about 25% of the total cost with the other components accounting for the remaining 75%.

It could be realized from Table 13 that, in the $M_0S_0W_1$, $M_0S_0W_2$, $M_0S_0W_3$ where there was only weeding, expenditure totaled GH¢ 1197.92 that is (312.5 +390.63 +494.79). There was a change when staking was introduced. The total expenditure for this amounted to GH¢1822.42 that is (520.33 + 598.96 + 703.13). This figure GH¢ 1197.92 indicates that staking alone accounted for GH¢624.5 that is (1822.42– 1197.92). In the situation where mounding and weeding were combined, total expenditure was GH¢1614.46 that is (451.39 + 529.39 + 633.68). The difference between this and the situation where there was only weeding indicated that GH¢416.54 was spent on mounding, that is (1614.46 – 1147.92). It will be appropriate for the farmer to make efforts to control cost especially weeding so that a higher relative profit could be realized.

4.5.2 Treatment/Sales Analysis

It could be seen from Table 13 that, total sales is given by the summation of nonexportable and marketable fruits. The total sales figures assumed undulating nature according to the various treatments applied. Looking at the first treatment, the first weeding alone realized a total sale of GH¢962.94. This figure declined to GH¢765.18 when the second weeding was done. It can be seen that both the second and third weeding did not have any positive effect on sales but a negative return to sales because total sales reduced though very marginal from the second to the third weeding. Total sales for weeding amounted to GH¢2491.96.

When staking was done with the first weeding, total sales was GH¢856.7. This figure increased to GH¢1055.36 which was very encouraging and it is an indication that this treatment produced a positive results and should be given a careful look. However, the figure dropped. It can be said that the third weeding coupled with the staking contributed relatively negative returns to sales. In spite of all these, staking and weeding showed an improvement in sales rather than when only weeding was done. This is shown in the total sales which amounted to GH¢2784.38 as against the former GH¢2491.96.

The contribution of mounding was not better than staking but it showed a consistent improvement increasing all the time. Mounding with the first weeding ($M_1S_0W_1$) showed total sales of GH¢787.06. This later increased to GH¢806.69 and then further increased to GH¢988.08. It could be seen that total sales was increasing at an increasing rate when the mounding treatment was applied. Summing up total sales under mounding, GH¢2581.83 was realized which fell below what was realized under the previous treatments (staking). It could be said that, mounding, staking and weeding have positive returns on sales. Initially, total sales was GH¢935.72, and then increased to GH¢1052.08 and then finally to GH¢1168.06 (Figure 5). The highest figures for sales was recorded under this treatment because total sales under the three situations that is mounding, staking and weeding yielded GH¢3155.86. However, it will be very misleading for one to think that this is the best situation until the profit patterns have been studied. Though sales figures may be high, expenditure may be equally high to absorb a greater percentage of sales.

4.5.3 Treatment/Profitability Analysis

Table 13 shows that the highest net profit was realized at the first treatment when there had been no mounding, no staking but weeding once, that is ($M_0S_0W_1$). This might possibly be due to the low total expenditure associated with the treatments. The second weeding reduced profit margin to about half. Profits started from GH¢650.44, reduced to GH¢374.55 and then to GH¢269.05. A total of GH¢1294.04 was accrued as profit when only weeding was done.

When the next treatment of staking started, profits started from GH¢336.36, then increased to an appreciable level of GH¢456.4 and then reduced drastically to GH¢169.2. This is due to the increase in expenditure and reduction in total sales. A total of GH¢961.96 was realized as profits under this treatment where staking and weeding were done.

With the treatment in which mounding and weeding were done some interesting scenarios profit margins started from GH¢335.66, and then fell to GH¢277.31 and rose again to GH¢354.41. This summed up to GH¢967.38. A careful study of the total sales figures indicated that staking and weeding contributed more to sales than mounding and weeding. This could be as a result of the expenditure level rising so high to annual increases in revenue.

The profitability at the treatment where mounding, staking and weeding were carried out is not as encouraging. Net revenue values started from GH¢275.99 and then rose to GH¢314.24 and then finally to GH¢326.04. Though the highest figures were not recorded under this circumstance, profit figures were increasing all the time. A total of GH¢916.27 was the profit realized under the three treatments. The profitability table showed that the first treatment of $M_0S_0W_1$ contributed more in terms of profit margins than the other treatments or their combinations.

Table 13 Cost-Benefit Analysis

Treatments	Mounding GH¢	Staking GH¢	Weeding Once GH¢	Weeding Twice GH¢	Weeding Three times GH¢	Watering GH¢	Spraying GH¢	Fertilization GH¢	Harvesting GH¢	Total expenditure GH¢	Total expenditure per/ha GH¢
$M_0S_0W_1$			0.333			0.333	0.333	0.17	0.333	1.49	312.50
$M_0S_0W_2$			0.333	0.38		0.333	0.333	0.17	0.333	1.87	390.63
$M_0S_0W_3$			0.333	0.38	0.50	0.333	0.333	0.17	0.333	2.37	494.79
$M_0S_1W_1$		1.0	0.333			0.333	0.333	0.17	0.333	2.49	520.33
$M_0S_1W_2$		1.0	0.333	0.38		0.333	0.333	0.17	0.333	2.87	598.96
$M_0S_1W_3$		1.0	0.333	0.38	0.50	0.333	0.333	0.17	0.333	3.37	703.13
$M_1S_0W_1$	0.667	1.0	0.333			0.333	0.333	0.17	0.333	2.16	451.39
$M_1S_0W_2$	0.667		0.333	0.38		0.333	0.333	0.17	0.333	2.54	529.39
$M_1S_0W_3$	0.667		0.333	0.38	0.50	0.333	0.333	0.17	0.333	3.04	633.68
$M_1S_1W_1$	0.667	1.0	0.333			0.333	0.333	0.17	0.333	3.16	659.72
$M_1S_1W_2$	0.667	1.0	0.333	0.38		0.333	0.333	0.17	0.333	3.54	738.85
$M_1S_1W_3$	0.667	1.0	0.333	0.38	0.50	0.333	0.333	0.17	0.333	4.04	842.01

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Treatments	Sales of marketable fruits (GH¢)	Sales of Local Market fruits (GH¢)	Total sales per/ha GH¢	Profit per/ha GH¢
$M_0S_0W_1$	710.71	252.23	962.94	650.44
$M_0S_0W_2$	653.57	111.61	765.18	374.55
$M_0S_0W_3$	667.86	95.98	763.84	269.05
$M_0S_1W_1$	653.57	230.13	856.70	336.36
$M_0S_1W_2$	778.57	276.79	1055.36	456.40
$M_0S_1W_3$	689.28	183.04	872.32	169.20
$M_1S_0W_1$	646.43	140.63	787.06	335.66
$M_1S_0W_2$	657.14	149.55	806.06	277.31
$M_1S_0W_3$	764.57	223.51	988.08	354.41
$M_1S_1W_1$	792.86	142.86	935.72	275.99
$M_1S_1W_2$	828.57	223.51	1052.08	314.24
$M_1S_1W_3$	848.86	319.2	1168.06	326.04

5.0 DISCUSSION

5.1 Observations

It was observed that *Cyperus rotundus* dominated all the plots. In plots that were not mounded, not staked and weeded once, the weeds served as alternate host for insect pests like fruit borers to destroy most of the fruits. This observation is in tune with what Youdeowei *et al*. (1994) reported that weeds act as alternate host to pests and harbour many fungal, viral and bacteria diseases.

Harvesting of fruits were found to be easier as fruits hung on the vines on those plots that were mounded, staked and weeded three times ($M_1S_1W_3$) than those plots that were not mounded, not staked and weeded once ($M_0S_0W_1$) in which fruits were hidden in the weeds. This observation is similar to Melander *et al*. (2004) and Bridges *et al*. (1984) who reported that weeds reduce yields, impede harvest operation and promotes the build up of future weed population thereby increasing production cost.

5.2 Vegetative Growth Parameters

5.2.1 Effect of Mounding, Staking and Frequency of Weeding on Number of Leaves Per Plant

There were significant interaction effect existed between number of leaves per plant for $M_1S_1W_3$ and $M_0S_1W_1$. This might probably be due to mounding and frequency of weeding. Plants in the treatment $M_1S_1W_3$ virtually had no weeds to compete with for light, nutrients, space and moisture because weeding was done three times, while plants found on $M_0S_1W_1$ interaction had only one weeding. The plants had to compete with weeds for available nutrients, space, moisture and light. This might have retarded the growth of the plants hence reducing the number of leaves in treatment $M_0S_1W_1$. This observation is similar to what Awaar *et al.* (1992) reported that the effect of weeds competition is reflected in poor crop establishment, reduced leaf numbers and size. Plants in treatment $M_1S_1W_3$ were mounded so they had good aeration, water and nutrient absorption than plants in the $M_0S_1W_1$ interaction. Because the plants in the $M_0S_1W_1$ interaction were not mounded, the soil was very compact which made root penetration into the soil to absorb nutrients difficult. This might have led to low absorption of nutrients which might have resulted in reduced photosynthetic activity, hence the few number of leaves found in treatment $M_0S_1W_1$. This observation is similar to what Youdoewei *et al.* (1986) reported that mounding improves aeration, water percolation and easy rooting of crops thereby increasing growth of the crop.

5.2.2 Effect of Mounding, Staking and Frequency of Weeding on Number of Nodes Per Plant

There were significant ($P<0.05$) interactive differences between number of nodes per plant for $M_1S_1W_3$ and $M_1S_1W_1$. This might probably be due to frequency of weeding, because weeds in the $M_1S_1W_1$ were controlled once leading to weeds competing with the plants for moisture, nutrients, light and space. This might have reduced the number of nodes in the plants found in $M_1S_1W_1$. Again, plants in the $M_1S_1W_3$ had increased number of nodes because the plants were free from weeds and therefore improved root activity. This is similar to what Partesan *et al.* (1980) reported that competition with weeds for moisture, nutrients and light directly affects the growth of crop plants.

5.2.3 Effect of Mounding, Staking and Frequency of Weeding on Number of Branches Per Plant

Number of branches influences the growth and yield of plants. Branches increase the photosynthetic surface area by exposing leaves to sunlight. There were significant interactive differences between mean number of branches per plant at six weeks after sowing for $M_1S_1W_3$ and $M_0S_1W_3$. This might probably be due to mounding practices. Since the $M_1S_1W_3$ were mounded, nutrients were conserved in the soil and therefore improved root activity of the plants to absorb dissolved nutrients to the various parts for the plant to increase growth. This might have increased the number of branches per plant in the $M_1S_1W_3$ than plants that were not mounded, staked and weeded three times ($M_0S_1W_3$). This is similar to what Rice *et al.* (1987) reported that fertile soil is generally considered essential for the production of high yield of crops.

5.2.4 Effect of Mounding, Staking and Frequency of Weeding on Vine Length Per Plant

The mean vine length per plant at four weeks after germination was significantly affected by mounding, staking and frequency of weeding interaction. This might probably be due to mounding practices which might have improved aeration. Also since the land was mounded, staked and weeded three times nutrients were at their optimum levels for the roots of plants to absorb to increase the vine length per plant than plants in the $M_1S_1W_1$, $M_0S_0W_3$ and $M_0S_1W_3$. This is similar to the findings of Rice *et al.* (1987) that fertile soil is generally considered essential for the production of high yield of crops. Vine length per plant at six weeks after germination showed significant ($P<0.05$)

differences between $M_1S_1W_3$ and $M_0S_1W_3$. This might probably be due to mounding. Mounds making breaks clumps in the soil to fine tilth and allows easy percolation of air and water into the soil. The moisture in the soil might have dissolved the nutrients for plant roots in the $M_1S_1W_3$ to absorb and transport to the various parts of the plants. This might have increased the vine length of plants in the $M_1S_1W_3$ more than plants in the $M_0S_1W_3$. This is similar to what Biwas and Mukherjee (1995) reported that loose soil plays a vital role by influencing infiltration and drainage of water, movement of salts and nutrients in the soil.

5.3 Reproductive Growth Parameters

5.3.1 Effect of Mounding, Staking and Frequency of Weeding on Number of Days From Germination to Flower Bud Appearance and 50% Fruit Set.

The number of days from germination to flower bud appearance showed significant ($P<0.05$) differences between $M_1S_1W_3$ and $M_0S_0W_2$. This might probably be due to mounding. Mounding loosened the soil which influenced infiltration of water for dissolving nutrients for easy absorption by roots of the crops in the $M_1S_1W_3$. Since the experiment was conducted in the dry season, the soil was compacted so roots of crop in the $M_0S_0W_2$ could not penetrate into the soil to absorb enough nutrients to promote early exposure of flower buds. This is similar to Forbes and Watson (1992) that compact soils delayed or prevented seedlings emergence by impeding physical penetration by the radicle. Also, since the plants in the $M_1S_1W_3$ were mounded, staked and weeded three times the leaves might have intercepted maximum sunlight for photosynthesis, and the plants were free from weeds to compete for moisture, space, light and nutrients.

This might have increased growth, early flower bud appearance and 50% fruit set in the $M_1S_1W_3$ plants. This is similar to Onwueme and Sinha (1999) who reported that mounds making particularly the high ones provide the ultimate in a loose bed for crop root penetration. Norman (1992) also indicated that when trailing plants and plants with weak stems are not staked, they are susceptible to blossom end rot, high cracking, sunburn and spread of viral diseases which reduce crop yield.

5.4 Yield Parameters

5.4.1 Effect of Mounding, Staking and Frequency of Weeding on Fruit Length/Diameter Ratio.

Fruit length/diameter ratio showed significant interactive differences between their values for $M_0S_0W_2$ and $M_0S_0W_3$ from $M_1S_0W_2$. This might probably be due to adequate nutrient supply in both $M_0S_0W_2$ and $M_0S_0W_3$ which were higher than plants in the $M_1S_0W_2$. Though plants found in the $M_1S_0W_2$ were mounded, moisture might have been evaporated from the soil for the fibrous roots to absorb little nutrients to the various parts of the plants in the $M_1S_0W_2$ hence less fruit length/diameter ratio. Though $M_0S_0W_2$ had the largest fruit length/diameter ratio, $M_1S_1W_3$ had the best fruit length/diameter ratio as the three factor interactions best affected the yield of the plants. As reported by Sujatha and Seshadri (1989) export standards prefer fruits with weight of 60g and fruit length/diameter ratio of 0.790cm-0.990.

5.4.2 Effect of Mounding, Staking and Frequency of Weeding on Total Number and Weight of Fruits Per Hectare

Mean total number of fruits per hectare was significantly affected by mounding, staking and frequency of weeding interaction. $M_1S_1W_3$ was mounded so the soil was loosened to allow moisture to dissolve the nutrients to distribute to the various parts of the plants to increase yield. In the second week of harvesting, plants in $M_0S_1W_3$ were affected by *Fusarium oxyporium* disease which might probably be a factor of reducing the yield of plants in $M_0S_1W_3$ because the land was not mounded to expose pest and diseases pathogens in the soil. This is similar to what Youdeowei *et al.* (1994) reported that mounding exposes insects pests and pathogens to the soil surface to be destroyed and thereby help improve the growth rate of vegetables due to the destruction of insect pests and pathogens.

5.4.3 Effect of Mounding, Staking and Frequency of Weeding on Total Number and Weight of Marketable Fruits Per Hectare.

Total marketable fruits per hectare showed significant ($P<0.05$) interactive differences between $M_1S_1W_3$ and $M_0S_1W_3$. This may be attributed to mounding practices. Because the soil was loosened during mounding plant roots might have penetrated into the soil to absorb nutrients to increase plant yield in the $M_1S_1W_3$ than $M_0S_1W_3$. This is similar to what Sinnadurai (1992) reported that under favourable climatic conditions and adequate nutrients supply there could be an increased in the number of flowers produced, number of fruits set and the number of fruits per plant.

5.4.4 Effect of Mounding, Staking and Frequency of Weeding on Total Number and weight of non-exportable Fruits Per Hectare

Total number of non-exportable fruits per hectare was significantly affected by mounding, staking and frequency of weeding interaction. Though both $M_1S_1W_3$ and $M_0S_1W_3$ were staked and weeded three times, plants found on the mounded plots produced more fruits than plants found on the plots not mounded. This may be attributed to the loosened nature of the mounded soil which might have allowed good aeration and drainage in the soil. The nutrients in the soil were dissolved for roots of the crops to absorb and were transported to the various parts of the plant to increase fruit yield. This is similar to what Youdoewei *et al.* (1986) reported that mounding improved soil structure which facilitates aeration, water percolation and easy rooting of crops.

5.5 Nutrient Analysis of Fruits

5.5.1 Nutrient Content of Fruits as Affected by Mounding

Moisture, ash, protein, iron, calcium and phosphorus content of the fruit samples showed significant differences between no mounding and mounding. Although, mounding breaks clods into fine tilth and helps to improve drainage and aeration in the soil, it might probably predispose plants to drought because of the large surface area exposed. This might have caused moisture and volatile nutrients in the soil to be evaporated and this might have probably resulted in less absorption of nutrients by the roots. It is therefore possible that not much moisture and nutrients might have been absorbed and transported to the various parts of plants and fruits in treatment M_1. Because there was no disturbance in the soil of the M_0 plants, nutrients might have been conserved in the soil to be absorbed and transported by the roots of the plants to treatment M_0. This might have increased moisture, ash, protein, iron, calcium and phosphorus content of the fruit samples in treatment M_0.

5.5.2 Nutrients Content of Fruits as Affected by Staking

There were significant differences between moisture, ash, protein, iron, calcium and potassium content of the fruit samples for no staking and staking. Although, staking ensures good ventilation and sufficient sunshine to get to most parts of the plants to increase fruit yield through enhanced photosynthesis, those plants in treatment S_1 might have probably lost moisture and volatile nutrients in the soil through evaporation. This might have resulted in less nutrient absorption by the roots of the plants to be transported to the various parts of the fruits in treatment S_1 while these minerals were retained in the soil to be absorbed and transported to the various parts of the plants and the fruits in treatment S_0. There were significant differences between fats and carbohydrates content of fruit samples in treatment S_1 and S_0. Those plants that were staked were able to trap enough sunlight to manufacture carbohydrates through photosynthesis. This might probably have increased the fat and carbohydrates content of the fruits of plants in treatment S_1 than treatment S_0.

5.5.3 Nutrient Content of Fruits as Affected by Frequency of Weeding.

Ash and carbohydrate content in the fruit samples showed significant differences between their values for W_1 and W_2. This might probably be due to early weeding. This was so because nutrients in the soil might have been at its optimum to be absorbed by the roots of crop in W_1 to all parts of the plant to increase carbohydrate content in the fruit samples. This is similar to what Sam-Aggrey (1973) reported that delayed hand weed control after thirty days on sole crop cassava depressed both root number and tuber yield. Moisture content of the fruit samples showed significant differences between W_2 and W_1. The explanation is that weeds were cleared at fortnightly intervals, so there were no weeds competing with the plants for the available moisture in the soil and this became an advantage to the roots of plants in treatment W_2 hence, more moisture content in the fruit samples from W_2 plants. Calcium, sodium and phosphorus content of the fruit samples from plants in treatment W_3 might probably be due to frequent elimination of weeds at fortnightly intervals. So available nutrients were easily absorbed by the roots of plants to increase the above nutrients in the fruits sampled in treatment W_3. This is similar to what Janick (1986) reported that extremely noxious weeds if unchecked may completely dominate crop plant. He observed that plant losses are usually the result of competition with weeds for light, water and mineral nutrients.

5.5.4 Nutrient Content of Fruits as Affected by Mounding, Staking and Frequency of Weeding Interaction

High levels of moisture content of the fruit samples of plants in $M_1S_0W_2$ and protein and potassium content of fruit samples in $M_1S_0W_3$ as well as ash, fats and calcium content of fruit samples of plants in $M_1S_0W_1$ might be a result of frequency of weeding and mounding practices. Mounds making turned the soil upside-down which made the soil structure porous for water and air to percolate easily. This enabled the plant roots to absorb enough moisture and nutrients from the soil to the various parts of the fruits. Again, weeding eliminated weeds from the field so the moisture and nutrients which might have been absorbed by the weeds were directed to the plants in the $M_1S_0W_2$,

$M_1S_0W_3$ and $M_1S_0W_1$. This probably increased the moisture in treatment $M_1S_0W_2$ protein and potassium content of the fruits of plants in the $M_1S_0W_3$, ash, fat and calcium content of the fruits of plants in the $M_1S_0W_1$. Carbohydrate content of the fruit samples of plants in the $M_1S_1W_1$ might be attributed to mounding and staking practices. Since the plants were staked, the leaves might have been more exposed to trap more sunlight for the preparation of carbohydrates through photosynthesis. This might have increased carbohydrate content of the fruits in $M_1S_1W_1$. Again, mounding improved the soil structure which allowed drainage and aeration into the soil. This made it easier for the nutrients to be absorbed by the roots of the plants and then transported to the various parts of the plant. This might have increased the carbohydrate content of the fruit samples of plants in the $M_1S_1W_1$. This is similar to what Amati *et al.* (1995) reported that staking seemed generally to increase fruit size. The high phosphorus content of the fruit samples of plants in the $M_0S_1W_3$ might be as a result of its readily availability in the soil and consecutive clearing of weeds at fortnightly intervals, gave way to the roots of plants absorbing more nutrients to increase phosphorus content of the fruit samples of plants in the

$M_0S_1W_3$.

5.6 Cost Benefit Analysis

The differences in the results of cost benefit analysis might probably be due to mounding, staking and frequency of weeding because weeding three consecutive times coupled with staking and mounding contributed negative returns to sales from treatment $M_1S_1W_3$ rather than when only one weeding was applied to plants that were not mounded, nor staked and weeded once ($M_0S_0W_1$). The situation where all the three cultural practices (mounding, staking and frequency of weeding) were applied as in $M_1S_1W_3$ showed very encouraging but the highest total expenditure incurred in this treatment led to least profit margin in the $M_1S_1W_3$ as compared to $M_0S_0W_1$ which had less expenditure with the highest profit margin. This is similar to what Bridges *et al.* (1984) reported that to maximize profit weed management programmes provides effective control within the first three weeks after sowing.

6.0 SUMMARY AND CONCLUSION

A field experiment to investigate the effect of mounding, staking and frequency of weeding on growth, yield and quality of tinda (*Paecitrullus fistulosus)* was carried out at the Department of Horticulture, Kwame Nkrumah University of Science and Technology, Kumasi from 1st December, 2005 to 25th February, 2006.

The experimental area measuring 59m x 14m ($826m^2$) was divided into three (3) blocks. Each block measured 59m x 4m and contained twelve plots each measuring 4m x 4m. Adjacent plots were 1m apart and 1m between adjacent blocks. Inter and intra row spacing was uniform. Uniform mounding of a height of about 60cm and 60cm diameter was done to some of the plots that were assigned to the blocks.

The experimental design used was a 2x2x3 factorial in a Randomised Complete Block Design (RCBD). There were twelve treatment combinations comprising two land preparation practices (mounding and no mounding), two staking methods (staking and no staking) and three frequencies of weeding (once, twice and three times). The twelve treatments were replicated three times bringing the total number of plots to thirty-six.

The twelve treatment combinations were allocated to the experimental plots at random by picking pieces of paper containing the treatments. Five seeds were sown per hill in mounds and on flat land at a depth of about 2cm and covered with soil on 1st December, 2005. Routine watering, fertilization, pests and disease control, mounding, staking, weed control and harvesting were the cultural practices carried out.

Parameters used for assessment were; vegetative growth (number of leaves, nodes, branches and vine length per plant), reproductive growth (number of days from germination to flower bud appearance and 50% fruit set, yield (fruit length/diameter ratio, average number and average weight of fruits per plant, total number and total weight of fruits, total number and weight of marketable fruits, total number and weight of non-exportable fruits and total number and weight of unmarketable fruits per hectare), analysis of fruit nutrients and cost-benefit analysis.

Vegetative growth parameters on number of leaves, nodes, branches and vine length per plant were significantly affected by mounding, staking and frequency of weeding interactions. Mounding, staking and frequency of weeding three times interaction produced the highest number of leaves, nodes, branches and longest vine length per plant.

Reproductive growth parameters on number of days to flower bud appearance were significantly affected by mounding, staking and frequency of weeding interaction. Number of days to 50% fruit set was not significantly affected by mounding, staking and frequency of weeding and their interactions.

Fruit length/diameter ratio was significantly affected by mounding, staking and frequency of weeding interaction.

Average weight of fruits per hectare was not significantly affected by mounding, staking and frequency of weeding and their interactions.

Total number of fruits, total export marketable fruits and total non-exportable fruits per hectare were significantly affected by mounding, staking and frequency of weeding interaction.

All the fruit nutrients analysed for were significantly affected by mounding, staking and frequency of weeding and their interactions. Nutritive qualities analysed for were moisture, ash, protein, carbohydrates and minerals (sodium, calcium, potassium, iron and phosphorus).

Cost-benefit analyses showed that plants that were mounded, staked and weeded three times had the highest income and highest expenditure. Plants that were not mounded, not staked and weeded once had the least expenditure with the highest profit margin. Plants that were not mounded, staked and weeded three times recorded the lowest profit margin.

CONCLUSION

Mounding, staking and weeding three times increased growth, yield and quality of tinda but to reduce cost of its agronomic practices, it would be economical for farmers not to mound nor stake but to weed once during the dry season to maximize profit in the growing of tinda.

RECOMMENDATION

Experiments should be done in future to find out a suitable weeding regime in the rainy season in combination with other cultural practices.

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8.0 APPENDICES

Appendix 1: Analysis of soil samples before the experiment.

Depth of Soil (cm)	pH	% Organic Carbon	% N	P (mg/kg)	K (mg/kg)	Ca Cmol/kg	Mg Cmol/kg	% Sand	% Silt	% Clay
0 - 15	6.40	1.20	0.039	215.30	114.70	5.6	0.8	78.08	15.59	6.34
15-30	5.99	0.97	0.036	186.05	120.01	5.0	1.2	78.09	13.50	8.32

Appendix 2

Pictures Showing Growth Stages of Tinda

PLATE 1: Vegetative Growth of Tinda

PLATE 2: Reproductive Growth of Tinda (Fruiting Stage)

Appendix 2 Continuation

PLATE 3: Reproductive Growth of Tinda (Flowering Stage)

Appendix 3 Cost-Benefit Analysis Showing Expenditure and Income of Tinda Fruits per hectare

Treatment	Mounding Gh¢	Staking Gh¢	Weeding Once Gh¢	Weeding Twice Gh¢	Weeding Three times Gh¢	Watering Gh¢	Spraying Gh¢	Fertilization Gh¢	Harvesting Gh¢	Total expenditure Gh¢	Total expenditure per/ha Gh¢
$M_0S_0W_1$			0.333			0.333	0.333	0.17	0.333	1.49	312.50
$M_0S_0W_2$			0.333	0.38		0.333	0.333	0.17	0.333	1.87	390.63
$M_0S_0W_3$			0.333	0.38	0.50	0.333	0.333	0.17	0.333	2.37	494.79
$M_0S_1W_1$		1.0	0.333			0.333	0.333	0.17	0.333	2.49	520.33
$M_0S_1W_2$		1.0	0.333	0.38		0.333	0.333	0.17	0.333	2.87	598.96
$M_0S_1W_3$		1.0	0.333	0.38	0.50	0.333	0.333	0.17	0.333	3.37	703.13
$M_1S_0W_1$	0.667	1.0	0.333			0.333	0.333	0.17	0.333	2.16	451.39
$M_1S_0W_2$	0.667		0.333	0.38		0.333	0.333	0.17	0.333	2.54	529.39
$M_1S_0W_3$	0.667		0.333	0.38	0.50	0.333	0.333	0.17	0.333	3.04	633.68
$M_1S_1W_1$	0.667	1.0	0.333			0.333	0.333	0.17	0.333	3.16	659.72
$M_1S_1W_2$	0.667	1.0	0.333	0.38		0.333	0.333	0.17	0.333	3.54	738.85
$M_1S_1W_3$	0.667	1.0	0.333	0.38	0.50	0.333	0.333	0.17	0.333	4.04	842.01

93 **Appendix 3: Continuation of Cost Benefit Analysis Showing Expenditure and Income of Tinda Fruits per hectare**

Treatment	Total Expenditure (Gh¢)	Mean Total (Gh¢)	Per Hectare (Gh¢)	Marketable Fruits (KG)	Sales of marketable fruits (GH¢)	Sales of Local Market fruits (GH¢)	Total sales per/ha	Profit per/ha
$M_0S_0W_1$	1.49	0.298	312.5	1243.75	710.71	252.23	962.94	650.44
$M_0S_0W_2$	1.87	0.311667	390.63	1143.75	653.57	111.61	765.18	374.55
$M_0S_0W_3$	2.37	0.338571	494.79	1168.75	667.86	95.98	763.84	269.05
$M_0S_1W_1$	2.49	0.415	520.33	1143.75	653.57	230.13	856.70	336.36
$M_0S_1W_2$	2.87	0.41	598.96	1362.5	778.57	276.79	1055.36	456.40
$M_0S_1W_3$	3.37	0.42125	703.13	1206.25	689.28	183.04	872.32	169.20
$M_1S_0W_1$	2.16	0.36	451.39	1131.25	646.43	140.63	787.06	335.66
$M_1S_0W_2$	2.54	0.362857	529.39	1150	657.14	149.55	806.06	277.31
$M_1S_0W_3$	3.04	0.38	633.68	1338	764.57	223.51	988.08	354.41
$M_1S_1W_1$	3.16	0.451429	659.72	1887.5	792.86	142.86	935.72	275.99
$M_1S_1W_2$	3.54	0.4425	738.85	1450	828.57	223.51	1052.08	314.24
$M_1S_1W_3$	4.04	0.448889	842.01	1485.5	848.86	319.2	1168.06	326.04