Effect Of Fertilization And Spacing On Growth And Grain Yields Of Finger Millet (Eleusine Coracana L.) In Ainamoi, Kericho County, Kenya

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Abstract: Finger Millet is an annual cereal crop widely grown for their seed in various ecological zones in Kenya and was once a staple grain diet of Southern Africa. It is a highly nutritious cereal crop utilized as a good food for infant feeding, special dishes for sick people and for special beverages among some people for example “eraki” beer in Ethiopia. Farmers have a wrong notion that finger millet being a traditional crop does not need any nutrient and usually is grown on marginal lands without applying any fertilizer. This could be an important reason for low productivity in the country. Fertilizer application or nutrient improvement is known to increase yields, yield components of the crop and lead to an improvement in the quality of the produce. A field experiment was conducted in Ainamoi Location in Kericho County to evaluate the effect of spacing and fertilizer levels on growth and yields of Finger Millet (Eleusine coracana) variety P224. Three plant spacing of (i) 40x10 cm, (ii) 30x10 cm and (iii) 20x10 cm was applied with DAP fertilizer rates of 150 kg/ha, 125 kg/ha, 75 kg/ha and 0 kg/ha as basal fertilizer dose at sowing. The experiment was laid out in randomized complete block design with three replications. The results showed that spacing levels that were tested did not have a significant effect on plant height and leaf length but, significantly influenced the number of tillers with the closer spacing of 20 cm x10 cm showing a significantly lower tillering compared to the wider spacing of 30 cm x10 cm and 40 cm x10 cm. This led to a significantly higher grain yield for the closer spacing compared to the wider spacing of 30x10cm and 40x10cm. It is concluded that, though a wider spacing encouraged growth through stem and leaf elongation and tiller formation, this did not adequately compensate for the higher number of heads associated with the closer spacing and thus a closer spacing of 20x10 cm outperformed the wider spacing of 30x10cm and 40x10 cm and gave a significantly higher grain yield. The application of DAP fertilizer (18:46:0) had a significant influence on crop growth as measured by its plant height and leaf length. The higher rates of 125 and 150 kg DAP/ha showed superior growth in height and leaf length compared to no fertilizer and the lower dose of 75 kg DAP/ha. Fertilization had a significant effect on tiller formation; no-fertilizer treatment had a significantly lower number of tillers/plant. The higher dose of fertilizer gave the highest biomass and the highest grain yield. It is concluded that finger millet variety P224 was responsive to DAP application in both growth and yield variables and the higher dose of 150 kg/ha led to higher growth rate and higher performance in grain yield. The interaction between spacing and fertilizer application was ineffective on growth and yield variables for the finger millet variety P224. It is recommended that farmers adopt the closer spacing of 20x10 cm for Finger millet variety P224 in the study area for higher crop yield and farmers to apply a minimum of 125 kg DAP/ha. However, specific soil tests are recommended to establish the appropriate levels at which to apply the N and P fertilizers. Further research is recommended to establish the correct plant population for optimum production as the current three levels was inadequate for a conclusive determination of the exact plant population desirable for the variety P224.

Keywords: Fertilization, Finger millet, Crop Spacing, Grain Yields

1. Introduction

Finger millet is a staple cereal food crop for millions of people in semi-arid and other regions of the world, particularly in Africa and India, and especially those who live by subsistence farming. Ethiopia is the centre of diversity for finger millet. It is grown from sea level to about 2400 meters above sea level and in a wide range of soil types and tolerant notably to high rainfall and a certain degree of alkalinity. It is used in many forms for human food and also as fodder for livestock (Wafula,Siambi & Gwei-Onyango, 2016). Finger millet is widely produced by small scale landholders and consumed locally. Finger-millet is primarily grown today in Eastern and Southern Africa to make beer, as it has been displaced by maize as a staple in many regions (Adunga et al. 2011). It is grown as far west as Central Nigeria, where it is appreciated as a crop that grows in low-fertility soils. It is wide spreading in warm temperature regions from Africa to Japan and Australia but can also grow in colder regions as Northern Ireland during summer**.** Finger millet agronomy plays a great role in increasing and sustaining the crop production and productivity. Soil nutrient application rates, schedule of nitrogen fertilizer application , seed rate and spacing (planting method) are among the major agronomic practices which requires due attention. When the plant density exceeds an optimum level, competition among plants for light above ground and nutrients below ground becomes severe (Bayala, Teklehaimanot, & Ouedraogo, 2002). Consequently plant growth slows down and the grain yield decreases. However, very low plant density may not enable attainment of the yield plateau (Hay & Walker, 1989). It is therefore necessary to determine the optimum density of plant population per unit area under appropriate spacing to obtain maximum yields. It is also quite important to address plant density with respect to soil fertility and millet variety (Frizzel et al.2005). Annual world production of finger millet is at least 4.5 million tons of grain, of which Africa produces perhaps 2 million tons. India is a major producer of ragi in Asia as reported by Verma and Patel (2013), with a production of 2.1 million tonnes and productivity of 1.3 ton/hectare (t/ha). In Eastern Africa, the Major producers are Uganda, Kenya and Ethiopia (Krishnapa, Ramesh, Chandraprakash, Bharathi & Doss, 2009).In Kenya (Kari,2006) reported that production is between 1100-1800 kg per ha. Fetene, Okori, Gudu, Mneney and Tesfaye (2011) have reported that the crop is largely consumed by marginalized inhabitants of semi-arid Asia and Africa and sold to provide subsistence farmers with additional income and is ranked third in cereal production in semi-arid regions of the world after sorghum (Sorghum bicolor) and pearl millet (Pennisetum glaucum). It is highly valued by local farmers for its ability to grow in adverse agro-climatic conditions, where cereal crops such as maize (Zea mays), wheat (Triticum spp.) and rice (Oryzasativa) fail and has been noted to tolerate wide variety of soils. Ecological requirements for the crop shows that it requires annual rainfall ranging from 500-1000mm, which is well distributed throughout the growing season; adapted to a wide range of soil conditions though it prefers fertile, well-drained sandy to loamy soils with pH ranging from 5-7. Finger millet also grows on lateritic or black heavy vertisols and has some tolerance for alkaline and moderately saline soils. In terms of altitude, the crop is found between 1000-2000 m above sea level in eastern and southern Africa and up to 2500-3000 m above sea level in the Himalayas as reported by Quattriccho (2006). Millet is derived from the seed-head, which has the shape of human fingers. In most countries it has local names; the crop is called ragi in India, Koddo (Nepal), dagussa tokuso & barankiya (Ethiopia), wimbi, mugimbi (Kenya); bulo (Uganda); kambale, lupoko, mawale, majolothi, amale & bule (Zambia); rapoko, zviyo, njera, rukweza, mazhovole, uphoko & poho (Zimbabwe); mwimbi & mbege (Tanzania) and kurakkan (Sri Lanka) as reported by Shisanya, Recha and Anyamba (2011). Growth and development of crops depends largely on the development of root system. Phosphorus (P) is one of the three macronutrients that plants must obtain from the soil. It is a major component of compounds whose functions relate to growth, root development, flowering, and ripening (Haruna & Aliyu, 2011). Most of the soils throughout the world are Phosphorus (P) deficient; soils of Kericho are generally acidic in reaction and lateritic in nature. These types of soils usually contain traces of available micronutrients and macronutrients. Moreover, with the introduction of high yielding varieties, increased cropping intensity and heavy applications of N and P fertilizers, the deficiency of some macronutrient have occurred in the country. The beneficial effects on the yield of different crops have been noticed from the soil application of the deficient macronutrient (Rurinda et al., 2014), and the poor performance of fertilizer phosphorus is one of the major causes depressing the productivity of the crops. Hence, the effect of phosphorus on root development is well established (Alinajati & Mirshekari, 2011). Addition of nitrogen and phosphorus fertilizer enhances root development, which improves the supply of other nutrients and water to the growing parts of the plants resulting in an increased photosynthetic area and thereby more grain yields and dry matter accumulation (Sankar et al., 2011). Nutrients in the soil will therefore need to be improved to ensure optimal plant growth. These will include both macro and micro-nutrients. Nitrogen and Phosphorous are such important nutrients; Nitrogen being one of the most important nutrients for growth and head formation and phosphorous being important in photosynthesis hence energy transformation in plants and it improves crop quality. Phosphorus is among the most needed elements for crop production in many tropical soils. It is critical to finger millet because it stimulates growth, initiates flower formation, fertilization and grain formation as well as influence positively the efficiency of the uptake of other nutrients (Haruna & Aliyu 2011). It is required in large quantities in young cells such as shoot and root tips where metabolism is high and cell division is rapid. Potassium is vital for photosynthesis and helps in osmotic pressure balance hence plant turgidity and for fruit (head) formation. Chemical fertilizers or organic manures are used to provide these nutrients however, there is a problem faced by farmers when choosing the correct chemical fertilizer levels to apply because of inadequate knowledge and cost of inputs involved while purchasing them. One of the main problems faced by the farmers is inherent low soil P and degradation due to continued cultivation. Notwithstanding the importance of finger millet, the research attention given to the crop has been limited and the information is scarce on the P management of the crop. Phosphorus is an essential nutrient for the life of plants whereby without adequate supply plants cannot reach their maximum yield. Adoption of proper agronomic management practices to existing varieties can lead to achieving potential yields. Therefore, it is necessary to know the optimum dose of the P fertilizer to be applied for maximum yields without compromising the effects caused to the environment (Wafula, Nicholas, Henry, Siambi & Gweyi-Onyango, 2016). Inorganic fertilizers are readily available with suppliers but more information on application of different and correct levels in finger millet production will help to optimize on both production and yields. Fertilization has been a component of improved cultural practices for most crops since over 90 percent of most arable land of Kericho East sub-County is under frequent cultivation. Constraints and the problem of soil nutrients of low to medium level of available nutrients have caused yields to be below potential levels. It is clear that one of the key nutrients that limits finger millet yield is N, since most of the soils under finger millet growing areas have medium to low soil N availability (75–330 kg N /ha). 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The best way of preventing soil from becoming poor is to put back into it what the plant has taken out and this can only be achieved by the use of inorganic fertilizer and other organic fertilizers or manures (Sankar, Sharma, Dhanapal, Shankar, Mishra, Venkateswarlu & Grace 2011). Based on a long-term field experiment with finger millet, Hemalatha and Chellamuthu (2013) found that continuous application of inorganic N fertilizer alone reduced the soil organic carbon level due to low dry matter production and reduced return of crop residues to the field. In addition to the amount of N supplied, the timing of N application is also important for finger millet. The importance of applying N starts with seed germination, a challenge for small seed crops like finger millet especially under nutrient deficient conditions. The application of inorganic N fertilizer at the time of planting stimulates better crop emergence especially in N deficient soil Rurinda et al. (2014). It has been reported that the major nutrients required by the crop are nitrogen (N), Phosphorus (P) and Potassium (K). Inadequate supply of any of these nutrients during crop growth is known to have negative impact on the reproductive capability, growth and yield of the plant and supplementary amount of nutrients can be added to soil in form of inorganic fertilizer to correct inadequate supply of nutrient to the crop. Nitrogen (N) as an element has been identified to be of critical importance to high yield of finger millet during vegetative development, flowering and seed set. While phosphorus (P) influences fruiting habits, hasten maturity, increases disease resistance, root formation and improves palatability of seeds, increases protein levels and lower fat content as well as balancing other plant nutrients. For potassium (K) its deficiency results in growth restriction and reduction in leaf size. Also, un-even ripening of the seeds can be expected as well as having specific influence on the crop quality (seeds). Similar to inorganic N, this result suggests that application of excess P does not improve yield, but rather that application of balanced fertilizer is crucial. Organic practices have been shown to be important for P nutrition in finger millet. Based on a long-term field study at Tamil Nadu, India (Hemalatha & Chellamuthu 2011) found that continuous application of 100% NPK + FYM increased P availability which agrees with previous findings by Govindappa et al. (2011). Most Kenyan farmers apply mineral fertilizers without considering the optimum level that will minimize production cost, maximize yield, reduce wastage of fertilizer and reduce soil toxicity. For that reason this research was undertaken to find out an optimum level of chemical fertilizer Di-Ammonium Phosphate (DAP) that can maximize growth, production and much more importantly, yields of finger millet under climatic and soil conditions of Kericho East Sub-County.

2. MATERIALS AND METHODS

2.1 Experimental Site description

The experiment was carried out on a farmer's field in Ainamoi ward of Kericho East Sub-County which is located 10km North of Kericho Town. The site falls within an elevation of 1800-2100 m above sea level (asl). The site is covered with undulating slopes and has an agro ecological zone of Upper Midland 1&2 (UM 1&2) suitable for agricultural production. The area receives average annual rainfall ranging from 1500- 1800 mm which is bimodal with short rains starting from the beginning of March and ending in late August while short rains begin from October and goes to December. Rainfall is well distributed throughout the year and is highly reliable since it usually starts from the beginning of March with few exceptions like El-nino or lamina when it comes earlier or later.Temperatures range between 13^0C to 28^0C with low temperatures sometimes experienced below 10^0C especially during the coldest period in the month of July. The land has been under cultivation of food crops with fertilizer use and no lime has ever been applied. Soils are sandy clay loams. Soil analysis report indicated that the soil is acidic, and is deficient in some minerals especially Nitrogen and phosphates. The soil type is with pH ranging from strongly acid (4.78) to slightly alkaline (7.15). Where pH is below the most critical pH (5.0), it should be raised with application of farm yard manures or compost annually and avoidance of application of acidic fertilizers. Finger millet variety P224 was used as the plant material in the study which is commonly referred to as "Wimbi" locally and is becoming one of the orphaned crops in Kericho East Sub County.

2.2 Experimental procedure

There were four fertilizer treatments with three spacial arrangements using a Randomized Complete Block Design (RCBD) with three replications.. Each the three replications had 12 plots measuring 3m by 3m each. There was a distance of 1m between the replicates and 0.5m between the blocks and 0.3m between the plots. Sizes of individual block measured 3 x 39.9m giving a total area of 119.7m^2. The entire experimental plot area was 39.9 x 11m =438.9m^2 (Fig.3.1). Plant population from individual plots depending on spacing was as follows; 40 cm x 10 cm (225 plants), 30 cm x 10 cm (300 plants) and 20 cm x 10 cm (450 plants) .The two factors which were studied in the experiment were the effect of spacing and fertilization on growth and yields of finger millet. The inorganic fertilizer used was di-ammonium phosphate (DAP 18:46:0) at a rate of 150 kg/ha, 125 kg/ha, 75 kg/ha and 0 kg/ha. The finger millet variety used in the experiment was P224. Mechanical weeding was done to control weeds 2 weeks after crop emergence and was repeated as the crop progressed in growth and just before crop matured. The crop was protected against pests and diseases with notable insect pests and fungal diseases with application of fungicides and pesticides. Finger millet seed for the experiment were purchased from Kenya Seed Company Ltd. DAP fertilizer was bought from Parksons Stores a registered Agro dealer in Kericho Town. The soils for the experiment were analyzed at KALRO-Tea Research Institute Laboratories (Kericho).

Table 3.3: *Treatment combinations*

FERTILIZER / SPACING	FT0	FT1	FT2	FT3
S1	S1FT0	S1FT1	S1FT2	S1FT3
S2	S2FT0	S2FT1	S2FT2	S2FT3
S3	S3FT0	S3FT1	S3FT2	S3FT3

2.3 Data Collection

The following data was collected;

i) Plant Height
Plant height was measured from 5 randomly selected plants in the inner rows from two weeks after germination and repeated at intervals of two weeks till plant maturity i.e. when there was no more increase in leaf elongation

ii) leaf Length
The longest leaf length per plant was taken from leaf attachment to the stem to the tip of the sampled plants at intervals of two weeks after germination i.e. 21 days after sowing up to plant maturity when there was no more increase in leaf size.

iii) Number of tillers formed
The number of tillers per plant was counted after an initial thinning to the required plant population. The number of tillers was counted at intervals of two weeks until when there was no more increase in tillers formed

iv) Number of heads formed
Number of heads formed was counted after the plant flowered at 60 days until all the plants had completely flowered nearing time of maturity.

v) Dry matter yield
The entire plant parts from the sampled plants were dried to constant weight, then weighed and their weights recorded according to treatments.

vi) Grain yield
Grain yields was arrived at the end of the study period where all heads were harvested from the 5 randomly selected plants from each plot when over 60% of the heads were physiologically mature after turning colour from green to yellowish-brown to avoid damage by pest infestation especially birds. Harvested heads then sun-dried to attain a constant weighed and measured using an electronic weighing scale. The grains were threshed and weighed. Lastly, moisture content (MC) of the grains was taken using a moisture meter at 13% before the grains were finally weighed. Yields per plot were later converted to tones per hectare.

3. RESULTS AND DISCUSSION

The experiment investigated the effects of fertilizer application and Spacing on growth and yields of Finger millet in Ainamoi ward, Kericho County.

4.1 Effect on Finger Millet Plant Height

Data on plant height was taken from the five randomly selected plants in the plots and measured using a meter ruler from 14 days after germination followed by subsequent two weeks intervals until the plants matured at 105 days. The measurement was taken from ground level up to the tip of the plant. The data was then summarized in excel and analyzed using SPSS program to generate the graphs (Fig.4.1 and Table 4.1).

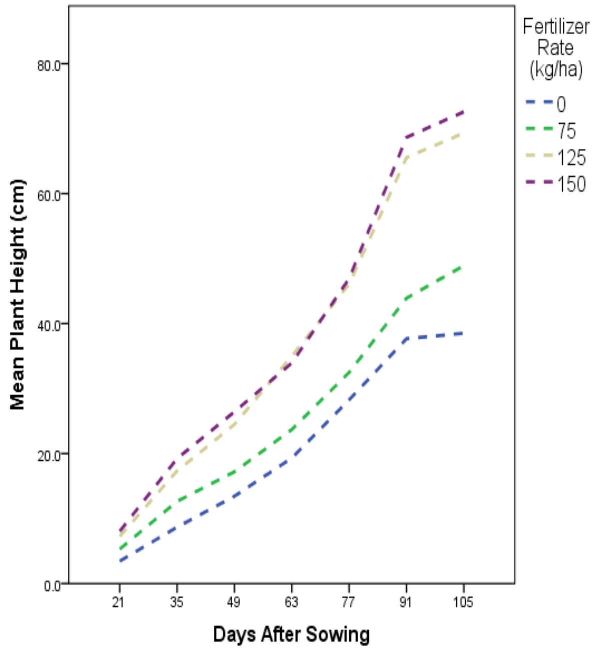

Figure 4.1: *Changes in plant height*

Table 4.1: *Effect of fertilizer rates on plant height*

Fertilizer levels(kg/ha)	0	75	125	150
0	X	-3.423	-14.975*	-16.520*
75	X	X	-11.552*	-13.097*
125	X	X	x	-1.545
150	X	X	x	X

The mean difference is significant at the .05 level

Analysis for variation in plant height due to treatments indicated that there was a significant influence ($P<0.05$) on plant height arising from the application of DAP fertilizer at different levels, there was no significant ($P>0.05$) variation in plant height due to the differences in spacing. From the results, it shows that application of fertilizers had a positive significant effect ($P< 0.05$) on the plant height (Fig. 4.1 and Table 4.1). There was no significant difference in mean plant height between 0 and 75 kg DAP/ha fertilizer application. There was a mean difference in plant height of about 15.9 cm between no fertilizer application and 125 kg DAP/ha and with the difference of 5% alpha level. The difference in mean plant height between no fertilizer and 150 kg DAP/ha was significantly different with a mean difference of about 16.5 cm. A comparison between 75 kg DAP/ha and 125 kg DAP/ha gave a mean difference of about 11.5 cm and the difference was significant at 5% alpha level. 75 kg DAP/ha and 150 kg DAP/ha similarly gave a significantly different mean plant height of about 13.1 cm. There was however no significant difference between 125 kg DAP/ha and 150 kg DAP/ha (Table 4.1). Plant height seemed to increase with an increase in fertilizer level but, no fertilizer gave a lower mean plant height compared to 125 and 150 kg DAP/ha respectively. Also 125 kg DAP/ha gave a higher mean plant height compared to 75 kg DAP/ha while 125 and 150 kg DAP/ha did not show significant difference (Table 4.2). These results suggests that fertilizer rates influenced plant height with varied results with fertilizer levels but beyond 125 kg DAP/ha application no influence is noticeable in changes in plant height. The same results have been reported by (Pradhan et al.2011 & Rathore et al.2004) in an experiment conducted in India (Department of Agronomy, College of Agriculture) where the authors observed that growth factors like plant height differed significantly with direct influence of fertilizer application levels which they attributed to the difference to the major roles played by N & P in plant growth. Current observations shows that N& P in DAP fertilizer applied may have been responsible for the differences in plant growth may have been due to the role of Nitrogen in the synthesis of proteins and other growth factors and Phosphorus in root development which encourages nutrient uptake as reported by (Wafula, Siambi & Gweyi-Onyango, 2016) in an experiment conducted in two sites in western Kenya(Alupe & Kakamega) where the authors reported that increased levels of Phosphorus increased the grain yields over non fertilizer application during the long and short season in both sites.

4.2 Effect on Finger Millet Leaf Length

The length of the longest leaf from the randomly five selected plants in each plot was measured from the point of attachment to the stem up to the tip of the leaf using a meter rule. The measurements were taken two weeks after germination and on two weeks intervals thereafter until when the crop attained physiological maturity i.e. when the leaves stagnated in growth at 105 days after sowing.

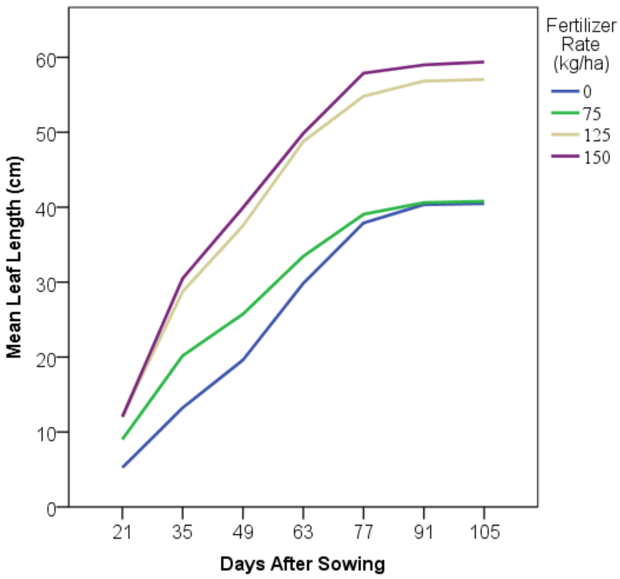

Figure 4.2: *Leaf Length Response to Different Fertilizer Rates*

Table 4.2: *Effect of Fertilizer rates on Leaf length*

Fertilizer levels(kg/ha)	0	75	125	150
0	X	-3.169	-15.589*	-17.417*
75	X	X	-12.420*	-14.248*
125	X	X	x	-1.828
150	X	X	x	X

Mean Separation by LSD (* significant at 5% level of significance)

When the data on leaf lengths were subjected to analysis of variance, it indicated a significant difference (P< 0.05) due to the application of fertilizer; however, the differences due to spacing were not significant at the 5% level of significance. The observations made indicates that at doses above 75 kg/ha, the fertilizer enhanced vegetative growth, but there was no added growth change when the dose exceeded 125 kg/ha as there was no significant difference in plant height between the 125 kg/ha plots and the 150 kg/ha plots. There was no significant difference in mean leaf length between 0 fertilizer application and 75 kg DAP/ha. There was a mean difference in leaf length of about 15.6 cm between no fertilizer application and 125 kg DAP/ha and the difference was significant at 5% alpha level. Similarly the difference in mean leaf length between no fertilizer and 150 kg DAP/ha was significantly different with a mean difference in leaf length of about 17.4 cm. A comparison between 75 kg DAP/ha and 125 kg DAP/ha gave a mean difference of about 12.42 cm and the difference was significant at 5% alpha level. 75 kg DAP/ha and 150 kg DAP/ha also gave a significantly different mean leaf length of about 14.2 cm. However, there was no significant difference between 125 kg DAP/ha and 125 kg DAP/ha (Table 4.2). The leaf length appeared to increase with increase with increasing levels of fertilizer; with no fertilizer giving a lower mean leaf length compared to 125 kg DAP/ha and compared to 150 kg DAP/ha. Similarly 125 kg DAP/ha gave higher mean leaf length compared to 75 kg DAP/ha while 125 kg DAP/ha and 150 kg DAP/ha did not differ significantly (Table 4.2) This results seem to suggest is influenced by fertilizer levels as indicated by o fertilizer level giving lower leaf length compared with 75 or 125 kg DAP/ha. Similar results have been reported by (Pradhan, Thakur, Patel & mishra. 2011) from an experiment conducted in India Department of Agronomy, College of Agriculture, where the authors observed that leaf length varied significantly as influenced by different fertilizer levels. The authors attributed the differences to critical role played by Nitrogen and Phosphorus in the process of photosynthesis and assimilation of photosynthates. The current observations suggest that N & P in the DAP fertilizer applied may have been responsible for the differences in leaf elongation probably due to the role of Nitrogen in the synthesis of proteins and other organic substances in the plant and the role of phosphorus in root development which enhances nutrient uptake. These two synergistic nutrients apparently may have been responsible for the differences in leaf growth. The uptake of nutrients and water is mostly a function of root development as asserted by Pradhan et al., 2011.

4.3 Effect onNumber of Tillers per plant

Data on the number of tillers was taken from the randomly selected five plants per plot was counted manually and recorded. Means were worked out and subjected to analysis of variance. The analysis of Variance indicated significant differences (P<0.05) due to the differences in spacing (plant population). There were also significant differences (P < 0.05) due to the application of fertilizer.

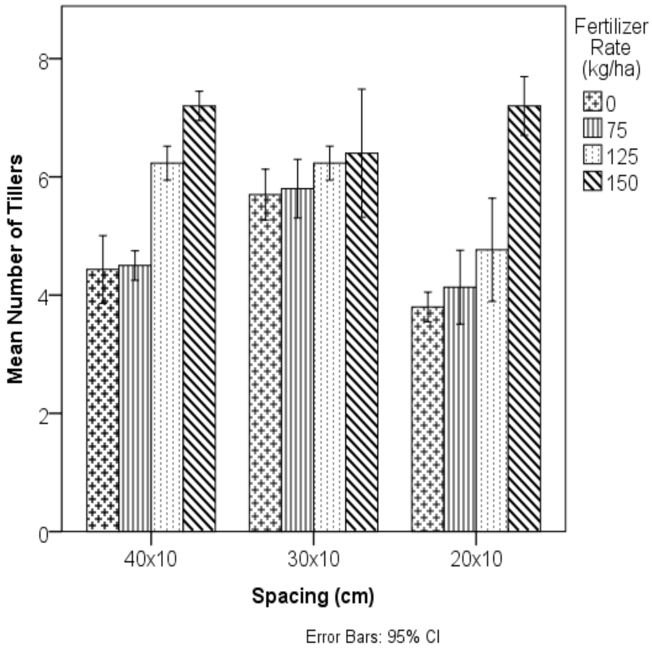

Figure 4.3: *Effect of treatments on number of tillers per plant*

Table 4.3: *Spacing effects on Number of tillers*

Spacing(cm)	20x10	30x10	40x10
20x10	x	-0.56*	-0.37*
30x10	x	X	0.19
40x10	x	X	x

Means separated by LSD at 0.05, * Significant at .05 level

Tiller formation was significantly influenced by the application of DAP (Table 4.3) and there were significant differences among all the fertilizer levels, the control (no fertilizer) had a significantly lower number of tillers than all the levels of fertilizers (figure 4.3). This indicates that fertilization encouraged tiller formation in the crop. The two wider spatial arrangements of 30x10cm and 40x10cm appeared to encourage tiller formation. From the results it shows that there was significant difference in the mean number of tillers between spacing of 20x10 cm and 30x10 cm of about 0.5. Also there was a significant difference in mean number of tillers between 20x10 cm and 40x10 cm of about 0.3 but, there was no significant difference in the mean number of tillers between 30x10 cm and 40x10 cm (Table 4.3) indicating that tiller formation is encouraged by a wider spacing. This agrees with the results reported by (Maobe et al. 2014) in an experiment conducted under high potential conditions of Kisii highlands,southwest Kenya (KARI) which reported that spacing in finger millet is a factor in tiller formation which influences grain yields.

4.4 Effect 0n Number of Heads per plant

The data on the number of heads per plant from the five randomly sampled plants from each plot was taken and recorded at 105 days after sowing. The number of heads per plant was taken by physically counting then the data recorded was analyzed using SPSS programme to generate the graphs.

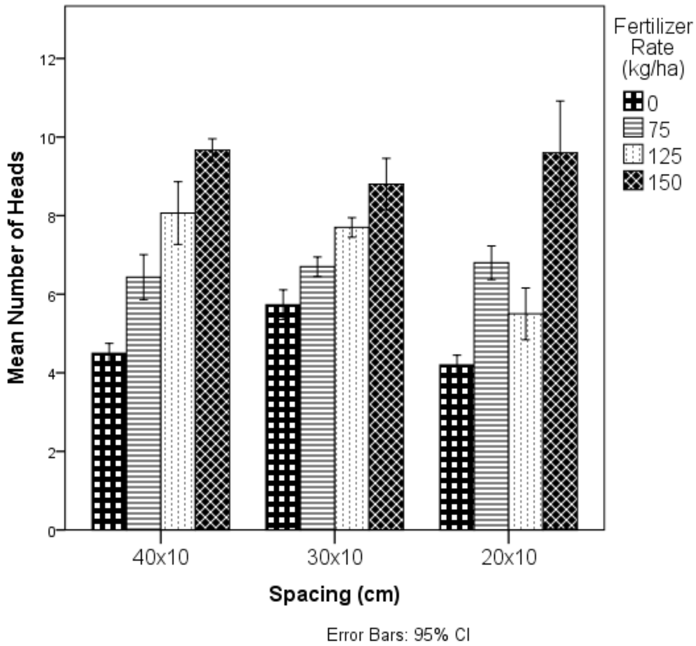

Figure 4.4: *Effects of spacing and fertilizer level on number of heads*

Table 4.4: *Effects of Spacing on Number of Heads*

Spacing(cm)	20x10	30x10	40x10
20x10	x	-0.71*	-0.64*
30x10	x	X	0.07
40x10	x	X	x

Means separated by LSD at 0.05 α level

The number of heads counted from the sampled plants at physiological maturity for each treatment was subjected to analysis and results indicated a significant influence of fertilizer application on the number of heads per plant. Plots also differed significantly ($P<0.05$) on the number of heads per plant due to variation in spacing (figure 4.4).The results shows that there was no significant difference between the spatial arrangement of 30x10 cm and 40x10 cm in the mean number of heads formed at maturity of the plants. The difference in mean number of heads was shown between 20x10cm and 30x10 cm with a mean number of heads of about 0.7 whereas there was also a significant difference I mean number of heads formed between the spacing of 20x10 cm and 40x10 cm with a difference of about 0.6. This is in conformity with what was reported by Maobe et al., 2014 in an experiment conducted in KARI, KISII reported that optimum yields of finger millet is obtained with a spacing of 30x10 cm with a plant population of 333,333 plants produced more grains per ha compared to a wider spacing of 40x10 cm or a narrow spacing of 20x10 cm which was in conformity with the results reported in an experiment conducted in Kakamega in western Kenya (Ojulong 2013).

4.5 Biomass

The entire plant parts from the sampled plants were dried to constant weight, then weighed and their weights recorded according to treatments.

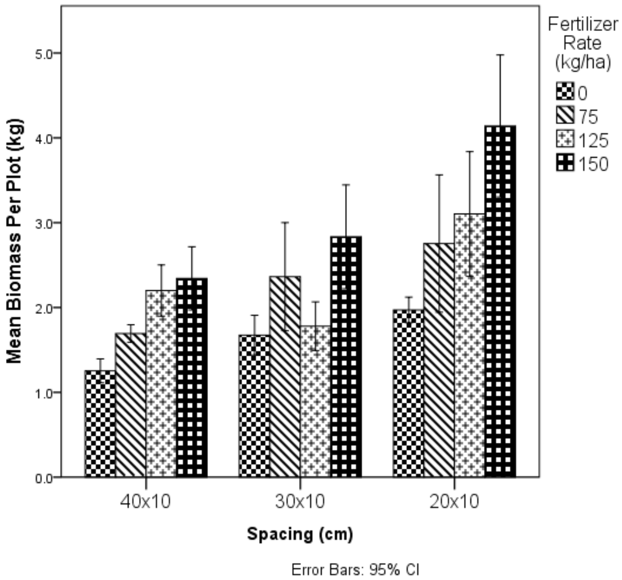

Figure 4.5: *Mean Biomass per plot for each spacing and fertilizer level*

Table 4.5:*Fertilizer effects on plant Biomass*

Kg DAP/ha	**0**	**75**	**125**	**150**
0	**x**	**-0.638***	**-0.729***	**-1.473***
75	**x**	**X**	**-0.091**	**-0.836***
125	**x**	**X**	**x**	**-0.744***
150	**x**	**X**	**x**	**X**

Means separated by LSD at 0.05 α level, * Significant at 0.05 level

The data subjected to analysis indicated a significant difference in the quantity of biomass generated per plot as a result of differences in fertilizer levels and spacing (figure 4.5). A closer spacing of 20x10 cm gave significantly higher biomass compared to a wider spacing of 30x10cm and 40x10 cm. The higher plant population gave rise to more plant material. The control plot; without added fertilizer gave significantly lower biomass compared to the plots with fertilizer (table 4.5). From the results a comparison of no fertilizer application and 75 kg DAP/ha had significant difference in biomass of about 0.6. No fertilizer application and 125 kg DAP/ha showed a significant difference of about 0.7, whereas no fertilizer and 150 kg DAP/ha had a significant difference of approximately 1.4. Fertilizer application of 75 kg DAP/ha compared with 125 kg DAP/ha had no significant difference while a comparison between 75 and 150 kg DAP/ha had a significant difference of about 0.8. A comparison of 125 and 150 kg DAP/ha had a significant difference of 0.7. The Nitrogen and Phosphorous nutrients in the DAP (18:46:0) fertilizer may have encouraged plant growth through its supply of Nitrogen for vegetative growth and phosphorous for root development and subsequent improved uptake of other nutrients from the soil as reported by (Wafula, Siambi & Gweyi-Onyango, 2016)

4.6 Effect on Grain Yield of Finger Millet

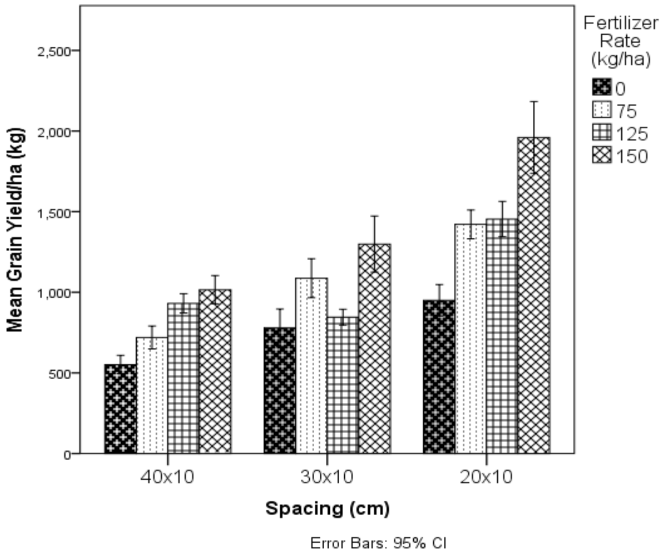

Figure 4.6: *Mean grain yield for each spacing and fertilizer level*

There were significant differences (P<0.05) between the plots on grain yield due to the differences in fertilizer levels and differences in plant population (spacing) as illustrated in (figure 4.6). Grain yield from the control (no fertilizer) were significantly lower, the highest application of 150 kg DAP/ha gave the highest mean grain yield an indication that the finger millet was quite responsive to fertilizer application (figure 4.6).

Table 4.6*Fertilizer effects on Grain yield*

Kg DAP/ha	0	75	125	150
0	x	-315.78*	-316.89*	-664.78*
75	x	X	-1.1	-349.00*
125	x	X	x	-347.89*
150	x	X	x	X

Means separated by LSD at 0.05 α level, * Significant at 0.05 level

Table 4.7: *Effects of spacing on mean grain yield (kg/ha)*

Spacing(cm)	**20x10**	**30x10**	**40x10**
20x10	**x**	**443.50***	**641.83***
30x10	**x**	**X**	**198.33***
40x10	**x**	**X**	**X**

Means separated by LSD at 0.05 α level, * Significant at 0.05 level.

There was significant increase in grain yield as the fertilizer levels increased; 75 kg/ha of fertilizer gave a significantly higher mean yield compared to the control with a mean yield difference of about 315 kg/ha, similarly the 125 kg/ha fertilizer gave a significant mean yield increase of about 316 kg/ha from the control as indicated in table 4.6. The higher fertilizer dose of 150 kg/ha gave the highest grain yields; a mean difference of about 664, 349 and 347 kg with the control, 75 kg and 125 kg respectively (Table 4.6). This finding suggests that Finger millet grain yield was responsive to fertilizer application. Bekele, Getahun and Bereje (2016) reported similar findings for N levels (23, 46, 69 & 92 kg of N/Ha) in grain yields in experiments conducted in Gumuz region of Ethiopia. Bekele et al.

(2016) found that increasing the levels of P led to increased grain yield and increasing N levels from 0 to 92 kg/ha gave a significantly higher grain yield of Finger millet raising the yield from 1142 to 1769 kg/ha. The presence of Nitrogen and Phosphorous in the test fertilizer may have supplied N and P nutrients required for increased photosynthetic activity and accumulation of organic matter in the crop resulting in higher grain yields. Alinajata and Mirshekari (2011) have argued that P and N enhances root development which ultimately leads to better absorption of other nutrients & water for growth and yields in crops. Haruna and Aliyu (2011) have also pointed out the importance of phosphorous in grain formation in cereals and a similar argument has been advanced by Sankar et al. (2011).The closer spacing of 20x10 cm gave a significantly higher grain yield compared to the wider spacing of 30x10 cm and 40x10 cm (Table 4.7). This may have been attributed to the higher plant population that resulted in higher number of heads and more grains from the closer spacing compared to the wider spacing. The adverse effect of competition between plants associated with closer spacing may not have been significant as to affect yields at a spacing of 20x10cm. Shinggu, Dadari, Shebayan, Adekpe, Mahadi, Mukhtar and Asala (2009) reported similar results in which a narrow spacing had a strong positive effect on crop biomass and yield. According to Shinggu et al. (2009) narrow spacing suppresses weeds and eventually leads to increased yields. Similar results were also reported by Shinggu and Gani (2012) in a study conducted in savanna ecology of Nigeria where a closer inter-row spacing produced a higher number of panicles and higher grain yield at 15 cm inter-row space compared to over 20 cm; this was attributed to higher panicle numbers according to the researchers.

4. Conclusions

The spacing levels that were tested did not have a significant effect on plant height and leaf length. Spacing significantly influenced the number of tillers with the closer spacing of 20 cm x10 cm showing a significantly lower tillering compared to the wider spacing of 30 cm x10 cm and 40 cm x10 cm. It is concluded that a closer spacing of 20 cm x10 cm discourages tillering and wider spacing is favorable for tiller-formation. This may be attributed to interplant competition for nutrients and competition for photo-synthetically active radiation. However due to the higher plant population at the closer spacing of 20x10 cm the number of heads per plant was higher compared to wider spacing of 30x10cm and 40x10cm. This led to a significantly higher grain yield for the closer spacing compared to the wider spacing of 30x10cm and 40x10cm. It is concluded that, though a wider spacing encouraged growth through stem and leaf elongation and tiller formation, this did not adequately compensate for the higher number of heads associated with the closer spacing and thus a closer spacing of 20x10 cm outperformed the wider spacing of 30x10cm and 40x10 cm and gave a significantly higher grain yield. The application of DAP fertilizer (18:46:0) had a significant influence on crop growth as measured by its plant height and leaf length. The higher rates of 125 and 150 kg DAP/ha showed superior growth in height and leaf length compared to no fertilizer and the lower dose of 75 kg DAP/ha. Fertilization had a significant effect on tiller formation; no-fertilizer treatment had a significantly lower number of tillers/plant. The higher dose of fertilizer gave the highest biomass and the highest grain yield. It is concluded that finger millet variety P224 was responsive to DAP application in both growth and yield variables and the higher dose of 150 kg/ha led to higher growth rate and higher performance in grain yield. The interaction between spacing and fertilizer application was ineffective on growth and yield variables for the finger millet variety P224.

5. Recommendation

The closer spacing of 20 cm x 10 cm for Finger millet variety P224 resulted in a higher number of heads per unit area and a higher overall grain yield. It is recommended that farmers adopt the closeq `r spacing for Finger millet variety P224 in the study area for higher crop yield. The application of DAP fertilizer at rates of above 125 kg DAP/ha improved the growth and yield characters of the crop. It is recommended that farmers apply a minimum of 125 kg DAP/ha. However, specific soil tests are recommended to establish the appropriate levels at which to apply the N and P fertilizers. Further research is recommended to establish the correct plant population for optimum production as the current three levels was inadequate for a conclusive determination of the exact plant population desirable for the variety P224.

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