



Journal Homepage: -www.journalijar.com
**INTERNATIONAL JOURNAL OF
 ADVANCED RESEARCH (IJAR)**

Article DOI:10.21474/IJAR01/8002
 DOI URL: <http://dx.doi.org/10.21474/IJAR01/8002>



RESEARCH ARTICLE

GROWTH RESPONSE OF FINGER MILLET ON PHOSPHOROUS FERTILIZER AND PLANT DENSITY IN KURIA WEST DISTRICT

Matinde Thomas Waigoge¹ and Benson Maniaji²

1. Maseno University University of Science and Technology.
2. Masinde Muliro University of Science and Technology.

Manuscript Info

Manuscript History

Received: 04 September 2018
 Final Accepted: 06 October 2018
 Published: November 2018

Keywords:-

finger millet, tillers, plant height, head length, lodging.

Abstract

Finger millet (*Eleusine coracana*) is an important nutritional and economic crop that contributes greatly to income and food security of the smallholder farmers in rural areas in sub-Sahara Africa and Asia. The production of this crop has been declining due to reduced area under cultivation and loss in soil fertility. The objective of this study was to establish the growth response of finger millet on different levels of phosphorus fertilizer and plant density. The experiment was setup with Randomized Complete Block Design with treatments being phosphorus levels of Triple Super Phosphate (TSP) (0, 25, 50 and 75 Kg/ha) and spacing in centimeters, S1 (30X10), S2 (30X15) and S3 (30X20). The experimental field was divided into 3x3 meters and replicated twelve times and three blocks. The experiment was conducted in two seasons; the first season seeding was done on 21st November 2014, which is a short season and the second one done on 23rd June 2015, which is a long rain season. Data was collected on growth indicators such as plant height, seed weight, length of the heads and number of fertile tillers. Results indicated that plant density and phosphorus levels had significant effects on finger millet seed weight, number of fertile tillers, plant height and percentage lodging. It was established that spacing and phosphorus levels affected the growth of finger millet in terms of tillering ability, lodging, height, And Head length. The interaction between spacing and fertilizer levels in season one had a significant effect on finger millet height. The contribution of phosphorus to the size of the head length of finger millet appeared to be higher than that of plant density in both seasons

Copy Right, IJAR, 2018., All rights reserved.

Introduction:-

Declining agricultural performance is a major driving force behind growing poverty among African farming populations, and its recovery offers the greatest prospects for rural population to escape poverty. Evidently, food insecurity among the vulnerable poor rural farming populations induces a risk-minimizing conservative attitude towards farming and livelihoods systems. It is in this context that agriculture tends to either be ignored or treated as just another small adjusting sector of the market economy. The importance of traditional crops such as finger millet cannot be over emphasized because of their ability to thrive in soils that have low nutrients and their resistance against most pests and diseases. Traditionally, finger millet was grown on land that has been newly cleared. This

Corresponding Author:-Matinde Thomas Waigoge.

Address:-Maseno University University of Science and Technology.

land had enough nutrients and productivity was guaranteed. With the increase in human population, land has been very scarce and it is very difficult to come across virgin land since all agriculturally available land has been opened up for cultivation.

Since many tropical soils are inherently low in total phosphorus, shifting cultivation never solved phosphorus problems in traditional agricultural systems; in some cases, phosphorus deficiencies were observed immediately after clearing. Finger millet production has for a long time been considered a traditional crop. The use of modern technology like the use of fertilizer has not been seen as an option by farmers. Traditional systems, therefore, relied on growing crop species with low phosphorus requirements and efficient mycorrhiza associations to extract small quantities of phosphorus in the soil. Due to diminishing soil fertility, production has reduced and most farmers have abandoned finger millet. Accordingly, this study attempted to establish how using the correct planting density and fertilizer can increase the growth of finger millet. The rationale for this investigation is the increased demand for finger millet products for both domestic and industrial use, warranting the need to increase its production at the farm level. However, this will only be realized through the use of modern technology such as fertilizers and the right plant population for optimum production to minimize farm costs and increase profits.

Materials and Methods:-

This research focuses on the elements of plant height measured in centimeters (cm), number of fertile tillers, the seed weight of finger millet in grams (g), finger millet percentage lodging and finger millet head length in centimeters (cm) as the dependent variables, against the amount of triple super phosphate (TSP) applied and the spacing used as the independent variables. In all the analysis in this section, an alpha level of 0.05 was used.

Site Description

The following are the descriptions of the site of the experiments.

Location

This experiment was performed in Mabera division, Kuria west sub-county, located in Migori County in the south western part of Kenya and covers an area of 581 km². It is located approximately on latitude 1°10' south and longitude 34° 27' east. It has a population of 256, 086 people according to the 2009 census. The main economic activity in Kuria is farming. According to Kenya national bureau of statistics, 79% of people in Kuria live below poverty line. Kuria West District covers 399 km² with an estimated population as at the year 2009 of 148 000 individuals.

Climatology

Kuria is classified among arid and semi-arid areas in Kenya. It receives an average annual precipitation of between 1200-1500 millimeters in a year and has a dry period of three to four months per year. The area is elevated at an altitude of 1400 to 1800 meters above sea level. It has an annual temperature range of 20^oc to 30^oc. Mabera is classified as low midland 2 agro-ecological zones.

Soils

Soil samples in the experiment field was randomly sampled to the depth of 30 cm top soil and taken to Kenya Agricultural and Livestock Research Organization (KALRO); Food Crops Research Institute - Kisii Centre for a soil analysis. See appendix 1. Soils are deep sandy loam with good water holding capacity and are classified as of marginal agricultural potential

Experimental Procedure

In order to reduce experimental error, this experiment was conducted for a period of two seasons, between the growing seasons of 2014 and 2015. The experiment was conducted in two seasons, the first season Seeding was done 21st November 2014, which is a short season and the second season planting was done on 23rd June 2015, which is a long rain season.

Land preparation

Finger millet is a small seeded crop that requires fine tilt. For the research to achieve a fine tilt, numerous land preparation practices were carried out. Land was cleared of bushes to make it workable. Land was cultivated by hand during the primary, secondary and tertiary preparations. The experimental site was ploughed, harrowed and

finally hand leveled to ensure a fine tilth. This was done to maximize soil seed contact and improve uniform germination.

Plot demarcation

Plots were divided into twelve plots of 3x3 meters and one-meter space all-round the plot. Each plot was treated by different levels of treatment and data on finger millet growth was collected regularly. Each plot was labeled with a strong plastic strongly fastened on a stake and clearly marked with the respective treatments. The plastic label was chosen due to its ability to withstand weathering.

Seeding

Kuria district has a two rain season that corresponds to the two planting seasons. Seeding was done 21st November 2014, which is a short season and the second season planting was done on 23rd June 2015, which is a long rain season. Furrows were made in each plot and different levels of Triple super phosphate (0:46:0) fertilizer was used in planting to supply the crops with phosphorus. The furrows were then covered by slight soil before seeding was done. Seeds were dibbled by hand at a depth of 1.5 cm in furrows and each furrow was covered with a thin layer of soil. This was to ensure maximum germination. Triple superphosphate was applied as per the treatments 5 cm away from the seed line and was covered by soil. Two weeks after germination thinning was done to the required spacing as per the specific plot requirement. Top dressing was done after three weeks with Ammonium Sulphate 21:00:00. A flat rate of 50 kilograms of nitrogen per acre (0.045kg per plot) was added to all the plots to ensure that Nitrogen was not a limiting factor and the variations that were to occur in growth would be due to finger millet plant density and phosphorus levels.

Weed control

The common practice of hand weeding was done with maximum care so as not to disturb the roots of finger millet seeding. Though time consuming, hand weeding ensured that there was a careful selection and removal of weeds like rapoko grass (*E. africana*) which is often difficult to distinguish from finger millet in the early growth stages. The crop cannot stand much weed competition in the early stages of growth so it is recommended to keep the crop field free from weeds all the time during the growing period.

During these experiments, weeding was done manually on the third week and the second weeding was done on the fifth week by uprooting the weeds from the plots and a small hoe was used to loosen the soil around the root.

Pest control

Furadan 5G was used to control soil borne pests, other pests like birds were controlled manually while aphids and flies were not witnessed in the experiment area during the growing period.

Harvesting

Harvesting was done 106 days on 27th February 2015 in the first season and 113 days on 15th October 2015 in the second season. This was done manually by cutting picking the heads that had turned brownish. A protected space which is reached by the sun, for sun drying was identified. The harvest was spread and dried. The heads were kept separately per plot and completely dried by airing pinnacles under the sun until the right moisture content was attained which is about 12%. Threshing was done and winnowing carefully done to clean the seeds from debris. The weight of finger millet grains was measured and recorded separately per plot.

Treatment and Treatment Combination

In this experiment, 50 Kilogram Nitrogen per hectare was top dressed to each plots. This was to limit the variation of nitrogen in the plot so that all variations in the variables measured could be attributed to phosphorus levels. The following was how treatment and treatment combination was done;

Treatment

In this study, Treatments constituted of a 3 x 3 factorial arrangement in a Completely Randomized Block Design. Each treatment was replicated three times. Treatments were spacing and fertilization. Spacing: according to the Kenya Agricultural Research Institute (KARI), the recommended spacing for finger millet is 30 cm inter rows and 15 cm intra rows. S1= 30 cm by 10 cm; S2= 30 cm by 15 cm (recommended) and S3=30 cm by 20 cm

P₂O₅ Levels: In order to supply Phosphorus fertilizer, Triple Super phosphate (0:46:0 N: P: K) was applied at four different rates as a treatment; F1= 0 kilogram per hector (control); F2=25 kilograms per hector; F3 = 50 kilograms per hector and F4= 75 kilograms per hector. According to Schulte and Kelling, 1992, the availability of phosphorus in Triple superphosphate has a solubility rate of 87%.

Treatment combination

Table 3.1:-Treatment Combinations of Spacing and Phosphorus Used in the Experiment in the Two Seasons.

Fertilizer levels				
Spacing	F1	F2	F3	F4
S1	S1F1	S1F2	S1F3	S1F4
S2	S2F1	S2F2	S2F3	S2F4
S3	S3F1	S3F2	S3F3	S3F4

KEY	
Spacing in cm	Phosphorus fertilizer in Kg/ha
S1 – 30X10	F1 – 0
S2 – 30X15	F2 – 25
S3 – 30X20	F3 – 50
	F4 – 75

Plot Layout

Experiments were laid out in a Randomized Complete Block Design with three replicates. This layout was used for two seasons, but in pieces of land.

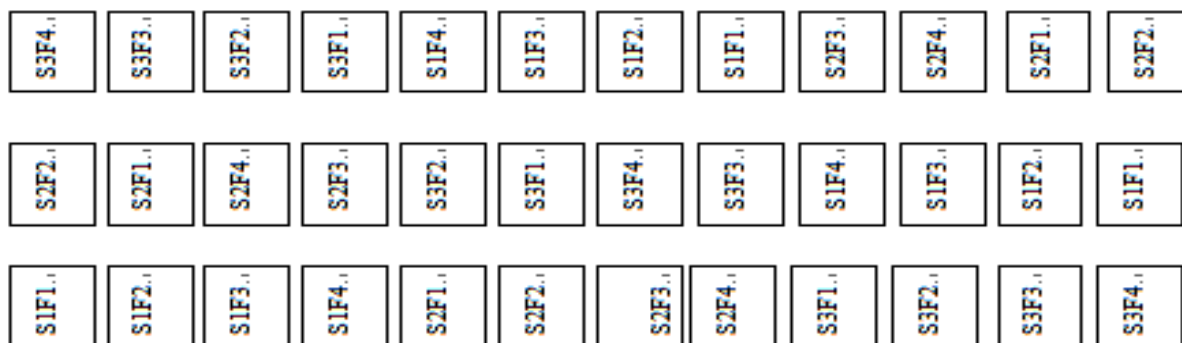


Figure 3.1:-Plots Layout in Three Replicates Used in the Two Seasons

Data Collection

Data regarding the following parameters was observed and recorded and were presumed to be the measure of finger millet growth; Plant height in centimeters was measured weekly, Number of fertile tillers was counted once after flowering, percentage lodging was measured once two weeks before harvesting, and the average head length of the finger millet estimated in centimeters per plot once after browning of the heads.

Data Analysis

Data collected was recorded and summarized in excel and analyzed using SPSS version 20. Research hypotheses were tested using two-way Analysis of Variance (ANOVA). A post hoc test was conducted by L.S.D. to compare the means of finger millet growth parameters in the two seasons of the experiment

Results and Discussion:-

Plant Height

Plant height was measured fortnightly for the two seasons. The data is presented in figure 4.1 below. It can be seen from the data that finger millet height increased with the increase in spacing and the amount of phosphorus levels applied. Blocks with 0 kg/ha produced the minimum plant height and those with 75kg/ha showed a higher plant height. It is evident that spacing also affected plant height since the lesser the spacing the higher the plant height was recorded.

When ANOVA was done (see Appendix II), it showed that there was a significant difference between seasons, P-levels and spacing ($p < 0.05$). It was also found that the interaction effect between spacing and P is significant. However, there was no significant difference between blocks ($p = 0.308$).

A post-hoc analysis was done for both spacing and P-levels and the results are given in table 4.1 and table 4.2. The results showed a significant mean difference across all the treatments. From the table 4.1 below, it shows that while all spacing had a significant mean finger millet height, the highest difference was between 30 x 10 and 30 x 20, while the least was 30 x 15 and 30 x 20.

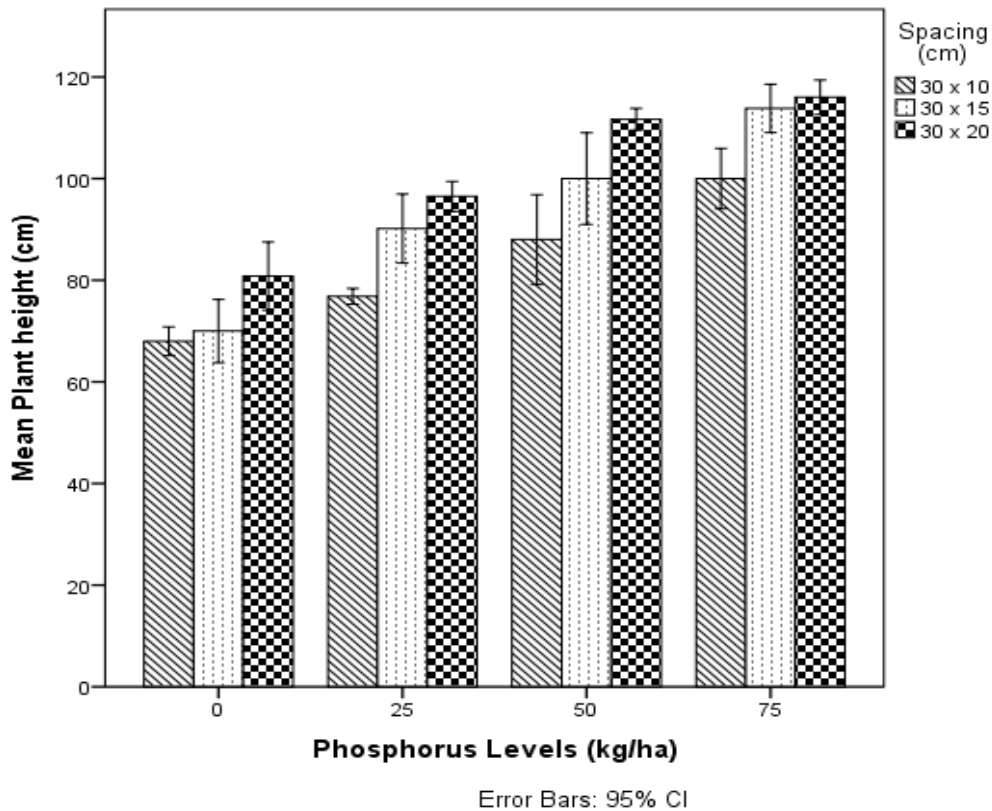


Figure 4.1:-The effect of spacing and phosphorus levels on the Mean plant height.

An analysis of variance showed that there was a significant difference P-levels and spacing. This can be explained by the fact that, phosphorus helps in root development in serials, more space meant more room for roots; hence, proper utilization of nutrients, which in turn led to an increase in height of finger millet. This is supported by Ashiono et al. (2005), who observed that Phosphorus helps in the formation of root nodules that increase the rate of Nitrogen fixation. Ojo et al. (2015) noted that Phosphorus helps in root formation and increases the growth rate of plants. It also helps in water use efficiency (Mukherjee, 2012).

Higher plant density finger millet leads to competition for growth factors and there reaches a point where even root development is hindered. This is supported by Dessibourg (2010), who stated that spacing in finger millet influences the growth rate of the crop. Table 4.2 shows the marginal mean difference in plant height as a result of P – levels, the highest was between 0 kg/ha and 75 Kg/ha and the smallest difference was exhibited by 50 Kg/ha and 75 Kg/ha. This can be explained by the fact that Phosphorus helps in stem elongation and the soils initially had limited Phosphorus. Groote et al. (2005) noted that adding phosphorus to soil low in nutrients helps available phosphorus to promote root growth and stem hardening in serials.

Table 4.1:-Post-hoc analysis of the effect of spacing on plant height

Spacing in cm	30 x 10	30 x 15	30 x 20
30 x 10		-10.29*	-18.04*
30 x 15			-7.75*
30 x 20			

The mean difference is significant at the 0.05 level.

Table 4.2:-Post-hoc analysis of the effect of P-levels on plant height

P -levels Kg/ha	0	25	50	75
0		-14.89*	-26.94*	-37.00*
25			-12.06*	-22.11*
50				-10.06*
75				

The mean difference is significant at the 0.05 level.

Percentage Lodging

Percentage lodging was measured once at the maturity of finger millet for all seasons. The data is presented in Figure 4.2 below. It can be seen from the data that finger millet percentage lodging declined with the increase in the amount of phosphorus applied. Smaller spacing recorded lower percentage lodging than wider spacing.

From the ANOVA results (see Appendix III), there was a significant difference between seasons. P-levels had a significant effect on the lodging percentage of finger millet. But there was no significant difference of spacing to the percentage lodging of finger millet ($p= 0.803$). It was also found that the interaction effect between spacing and P-levels was not significant ($p=0.521$). However, there was no significant difference between blocks ($p=0.104$).

A post-hoc analysis was done for spacing and the results are given in table 4.2. The results showed a significant mean difference across the spacing. As such, Salasya et al. (2007)'s findings that Phosphorous help in strengthening the stem of plants are justified. An increase in phosphorus levels led to a general drop in the percentage lodging. Berry et al. (2004) observed that phosphorus helps in the filling of the seeds, in photosynthesis and the strengthening of stem. A well-developed rooting system in finger millet and a good stem may have had an impact on reducing percentage lodging (Knowler & Bradshaw, 2007).

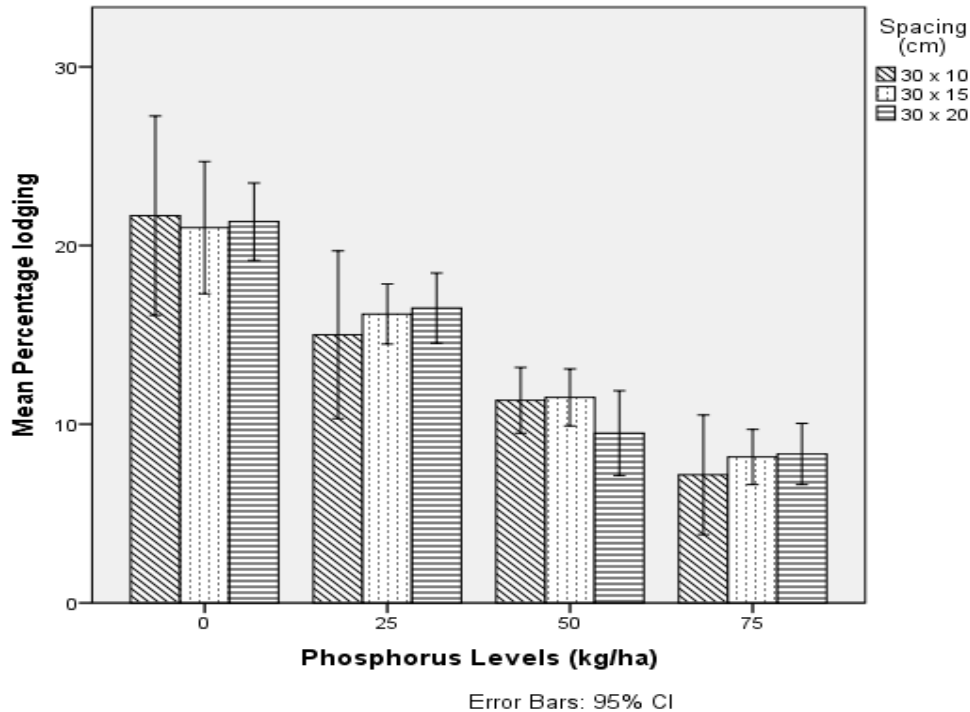


Figure 4.2:-The effect of spacing and phosphorus levels on the Mean percentage lodging of finger millet.

Table 4.3:-Post-hoc analysis of the effect of p levels on percentage lodging

P-levels	0	25	50	75
0		5.44*	10.56*	13.44*
25			5.11*	8.00*
50				-2.89*
75				

The mean difference is significant at the 0.05 level.

Number of Fertile Tillers

The number of fertile tillers was counted per plot after they had flowered in all seasons. The data is presented in figure 4.3 below. It can be seen from the data that finger millet produced fertile tillers as the amount of phosphorus applied increased. Smaller spacing recorded lower numbers of fertile tillers than wider spacing.

ANOVA results (see Appendix IV) showed that there was no significant difference between seasons ($p=0.139$), but both P-levels and spacing had a significant difference. It was also found that the interaction effect between spacing and P-levels was not significant ($p=0.931$). Also, there was no significant difference between blocks ($p=0.663$).

Post-hoc analysis was done for both spacing and P-levels and the results are given in table 4.4 and table 4.5. The results showed a significant mean difference across all the treatments. 30 x 20 had the highest difference which was significant.

The analysis of variance shows that there was a significant effect of P – levels on the production of fertile tillers. This can be attributed to the strong rooting network that Phosphorus has on cereals. With enough roots and nutrients, tillers had the opportunity to grow to maturity and become fertile i.e. produce heads. Wide spacing provided room for growth and less competition for minerals, sunlight and water. The post hoc results showed that overcrowding effect reduces the ability of finger millet to produce fertile tillers. P level of 75 kg/ha had the highest difference showing that tillering is a function of spacing and phosphorus level. Since wider spacing (lower plant density) reduces competition, it makes cereal crops to develop strong basal tillers, which are fertile. In this regard, Phosphorus helps in the rooting system of cereals (Barrett, 2008).

Mignouna et al. (2011) reported that the number of tillers and panicles per square meter in finger millet and other cereal population are largely a function of planting density or seed rate. Conducting his experiment in wheat, Godfray et al. (2010) observed that Tillering increases dramatically with lower plant population levels.

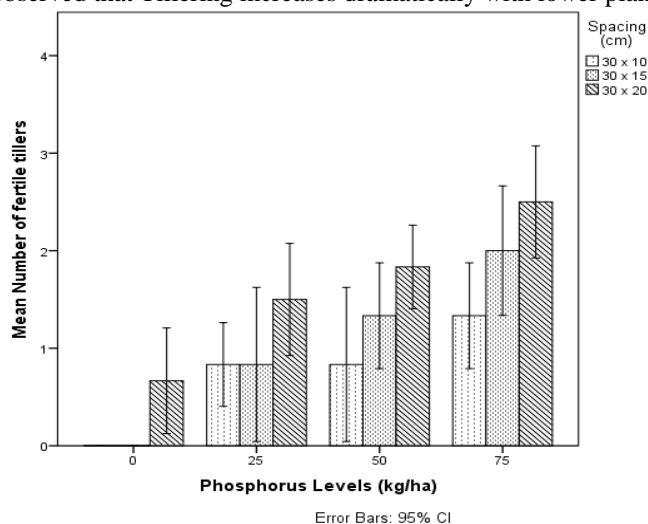


Figure 4.3:-Effect of spacing and phosphorus levels on the Mean fertile tillers of finger millet.

Table 4.4:-Post-hoc analysis of the effect of spacing on number of fertile tillers

	30 x 10	30 x 15	30 x 20
30 x 10		-.50*	-1.00*
30 x 15			-.50*
30 x 20			

The mean difference is significant at the 0.05 level.

Table 4.5:-Post-hoc analysis of the effect of P-levels on the number of fertile tillers

	0	25	50	75
0		-0.56*	-1.00*	-1.61*
25			-0.44*	-1.06*
50				-0.61*
75				

The mean difference is significant at the 0.05 level.

Finger Millet Head Length

The average size of finger millet head was measured at the maturity point of finger millet per plot in centimeters. Data is summarized in figure 4.4 below. The head length of finger millet increased with the increase in spacing (reduced plant population per unit area) and also it shows that as the level of fertilizer increases, the head length also increases.

From the ANOVA analysis (See Appendix V), there was no significant difference between seasons ($p=0.069$), but both P-levels and spacing had a significant effect. It was also found that the interaction effect between spacing and P-levels was significant ($p=0.009$). Also there was no significant difference between blocks ($p=0.616$).

The analysis of variance results indicated a significance difference effect of p – levels on the head length. This can be attributed to the fact that Phosphorus plays a role in seed fertilization and due to that more P-level led to higher head length. According to the findings of Shinggu et al. (2009), Proper phosphorus dose plays an important role in the growth of finger millet.

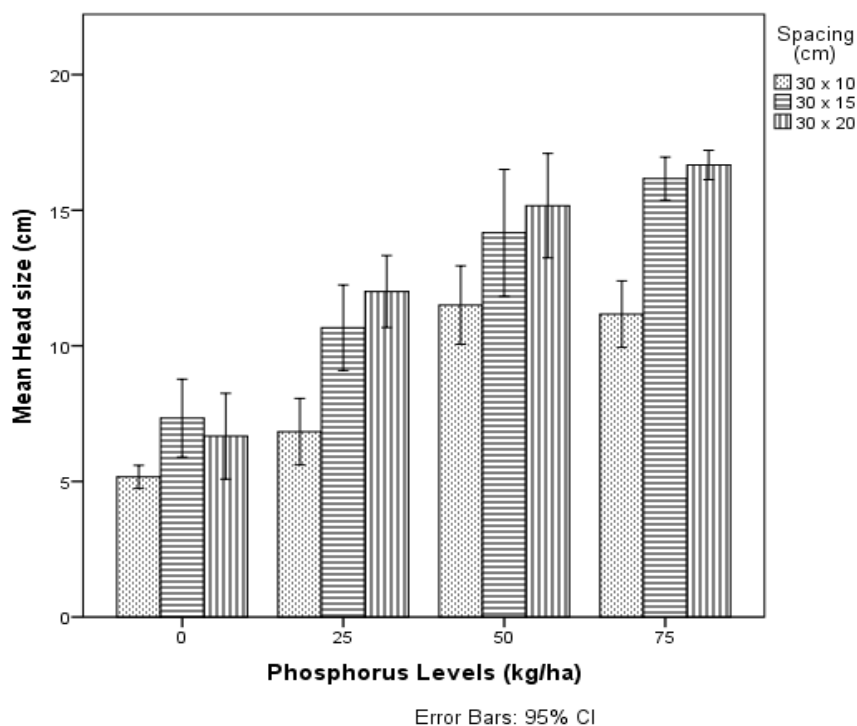


Figure 4.4:-The effect of spacing and phosphorus levels on the Mean length of finger millet head.

Post-hoc analysis was done for both spacing and P-levels and the results are given in table 4.6 and table 4.7. The results showed a significant mean difference across all fertilizer levels. This shows that low plant density had an effect on the bigger size of finger millet length. From the P levels, it is clear that 75 kg/ha had the highest effect and 50 kg/ha had a slightly lower effect.

Table 4.6:-Post-hoc analysis of the effect of spacing on finger millet head length

Spacing in cm	30 x 10	30 x 15	30 x 20
30 x 10		-3.42*	-3.96*
30 x 15			-0.54
30 x 20			

The mean difference is significant at the 0.05 level.

Table 4.7:-Post-hoc analysis of the effect of P-levels on finger millet head length

P levels	0	25	50	75
0		-3.44*	-7.22*	-8.28*
25			-3.78*	-4.83*
50				-1.06*
75				

The mean difference is significant at the 0.05 level.

Conclusions:-

In this experiment, the objective was to determine the growth response of finger millet to plant density and P-levels. Growth was measured by estimating plant height, percentage lodging, number of fertile tillers, and finger millet head length. From the results, plant density plays a fundamental role in finger millet growth. Results showed that the effect of spacing was significant in plant height, Number of fertile tillers, and finger millet head length, although there was no significant difference in finger millet lodging percent. Apparently, there was an increase in growth in

most of the parameters evaluated as the P-levels increased. The P-levels had a significant effect on plant height, percentage lodging, number of fertile tillers, and finger millet head length. The interaction effect between spacing and P-levels was significant on plant height, and finger millet head length. However, it was not significant on percentage lodging and number of fertile tillers. From the results, it was found that there was a significant increase in finger millet growth as phosphorus levels increased from 0 to 75 kg/ha.

Recommendations

Further research needs to be done to evaluate the economic level of phosphorus use and the effect of phosphorus on finger millet in different cropping systems.

References:-

1. Ashiono, G.B., Gatuiku, S., Mwangi, P. and Akuja, T.E. (2005). Effect of Nitrogen and Phosphorus Application on Growth and Yield of Dual-purpose Sorghum (*Sorghum bicolor* (L) Moench), E1291, in the Dry Highlands of Kenya. *Asian Journal of Plant Sciences*, 4: 379-382.
2. Barrett, C. B. (2008). Smallholder Market Participation. Concepts and Evidence from Eastern and Southern Africa. *Food Policy* 33(4), pp. 299–317.
3. Berry, P. M., Sterling, M., Spink, J. H., Baker, C. J., Sylvester-Bradley, R., Mooney S. J., Tams, A. R., Ennos, A. R. (2004). Understanding and reducing lodging in cereals. *Advances in Agronomy* 84, 217-271
4. Dessibourg, O. (2010). Arsenic-based bacteria point to new life forms. *New Scientist* 18(4),
5. Godfray, C., Beddington, J., Crute, I., Haddad, L., Lawrence, D., Muir, J., Pretty, J., Robinson, S., Thomas, S. M. and Toulmin, C. (2010). Food security: the challenge of feeding 9 billion people. *In science* 327 (5967), pp. 812–818.
6. Groote, H., Owuor, G., Doss, C., Ouma, J., Muhammad, L. and Danda, K. (2005). The maize green revolution in Kenya revisited. *Journal of Agricultural and Development Economics* 2 (1), pp. 32–49.
7. Knowler, D., Bradshaw, B. (2007). Farmers' adoption of conservation agriculture: A review and synthesis of recent research. *Food Policy* 32 (1), pp. 25–48.
8. Mignouna, D. B., Manyong, V. M., Rusike, J., Mutabazi, K. D. S. and Senkondo, E. M. (2011). Determinants of adopting Imazapyr-resistant maize technologies and its impact on household income in western Kenya. *AgBioForum* 14 (3), pp. 158-163.
9. Mukherjee, K. (2012). Toolkit: Promotion of SRI-Millet with small and marginal farmers in Chhattisgarh: A practitioner's manual. *NewsReach* 12(11): 28-35. [PRADAN's livelihood and development bimonthly magazine]
10. Ojo, A. O., Adetunji, M. T., Okeleye, K. A., and Adejuyigbe, C. O. (2015). Soil Fertility, Phosphorus Fractions, and Maize Yield as Affected by Poultry Manure and Single Superphosphate. *Institute of Agricultural Research and Training: Obafemi Awolowo*
11. Salasya, B., Oduori, C., Ambitsi, N., Onyango, E., Oucho, P. and Lumuli, J. (2007). A study on the status of finger millet production in western Kenya. *Nairobi: University Press*
12. Shinggu, C.P., Dadari, S.A., Shebayan, J. A. Y., Aekpe, D. I., Mahadi, M. A., Murkthar, A. and Asala, S. W. (2009). Influence of spacing and seed rate on weed suppression in finger millet (*Eleusine corocana* L. Gaertn). *Middle East Journal of Scientific Research* 4 (4): 267-270.

Appendices**Appendix I:-Soil analysis report**

kenyaagricultural&livestockresearchorganizationfoodcropsresearchinstitutekisii centre

P.O. Box 523-40200,
Tel 0202122762 (Wireless)
Email:kari.kisii@kari.or
Website:
G

Soil Test Report

Location of farm, town or village, county: MABERA, MIGORI COUNTY Crop(s) to be grown

Date sample received 16/11/2014

Date sample reported 19/11/2014

Reporting officer (through Director KALRO KISII) Jacob Ademba

Soil Analytical Data		
Field or plot	Thomas Matinde	
Lab. No/2014	302/14	
Soil depth /cm	Top soil	
Fertility results	Value	class
Soil pH	5.5	moderately acidic
Elect. Cond. $\mu\text{s}/\text{cm}$	0.1	moderate
Org. Carbon %	2.0	adequate
Phosphorus ppm	19	deficient
Nitrogen (%)	0.10	low
Manganese me %	1.4	adequate

Interpretation and fertilizer recommendation

The soil reaction (pH) is moderately acidic. The P and N content is low. Organic matter content is adequate but should be maintained by the application of Farmyard Manure. NOTE: Test results are based on customer sampled sample(s).

Appendix II:-ANOVA results for plant height

Tests of Between-Subjects Effects						
Dependent Variable: Plant height (cm)						
Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	
Block	39.361	2	19.681	1.204	.308	
Season	767.014	1	767.014	46.920	.000	
Spacing	3931.861	2	1965.931	120.261	.000	
P levels	13734.153	3	4578.051	280.051	.000	
spacing * p levels	434.139	6	72.356	4.426	.001	
Error	931.792	57	16.347			
Total	19838.319	71				
a. R Squared = .953 (Adjusted R Squared = .941)						

Appendix III:-ANOVA results for finger millet percentage lodging

Tests of Between-Subjects Effects					
Dependent Variable: Percentage lodging					
Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Block	23.528	2	11.764	2.356	.104
Season	174.222	1	174.222	34.895	.000
Spacing	2.194	2	1.097	.220	.803
p_levels	1891.278	3	630.426	126.270	.000
spacing * p_levels	26.139	6	4.356	.873	.521
Error	284.583	57	4.993		
Total	2401.944	71			

a. R Squared = .882 (Adjusted R Squared = .852)

Appendix IV:-ANOVA results of the number of fertile tillers

Tests of Between-Subjects Effects					
Dependent Variable: Number of fertile tillers					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Block	.250	2	.125	.413	.663
Season	.681	1	.681	2.251	.139
Spacing	12.000	2	6.000	19.842	.000
p_levels	25.153	3	8.384	27.727	.000
spacing * p_levels	.556	6	.093	.306	.931
Error	17.236	57	.302		
Total	55.875	71			

a. R Squared = .692 (Adjusted R Squared = .616)

Appendix V:-ANOVA results for finger millet head length.

Tests of Between-Subjects Effects					
Dependent Variable: Head size (cm)					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Block	1.750	2	.875	.489	.616
Season	6.125	1	6.125	3.424	.069
Spacing	221.083	2	110.542	61.799	.000
p_levels	770.819	3	256.940	143.643	.000
spacing * p_levels	34.139	6	5.690	3.181	.009
Error	101.958	57	1.789		
Total	1135.875	71			

a. R Squared = .910 (Adjusted R Squared = .888)