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Growth Response of Spider Plant (*Cleome gynandra* L.) on Plant Population and Phosphorous Levels

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Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

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Original Research Article

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ABSTRACT

The study focused on establishing Growth Response of Spider Plant (*Cleome gynandra L.*) on Plant Population and Phosphorous levels due to various recommendations are given on spacing for the same crop by various extension service providers that have made farmers plant the crop using broadcasting, 30 cm x 10 cm, 30 cm x 15 cm and 50 cm x 15 cm, which have not facilitated adequate productivity. The experimental design used was randomised complete block design with three replicates. Three plant spacing of 45x15 cm, 30x15 cm and broadcasting were subjected to five different levels of (0, 20 kg/ha, 30 kg/ha, 40 Kg/ha, 50 Kg/ha). Ten plants per plot were randomly selected and tagged for data collection. The collected data were subjected to analysis of variance (ANOVA) tests using SPSS software. Means were compared using the least significant difference (LSD) test at 5% level of significance. Results indicated that plant height; the number of branches, number of pods and seed yield were significantly affected by spacing and phosphorus levels. The wider spacing and highest level of P had significant effects on the growth of plants and seed yield. The spacing 45× 15 cm had a more positive effect on growth parameters and seeds weight as compared to other spacing(S_1 = broadcasting, S_2 = 30 x 15 cm). The phosphorus levels of F_5 = 50 kgs/ha, F_4 = 40 kgs/ha, F_3 = 30 kgs/ha and F_2 = 20 kg/ha had higher effect on growth and seed yield than the control (F_1) by F_5 registering much effects than the rest. Accordingly, the spacing of 45x 15 cm with phosphorous level 50 kg/ha is recommended for optimal results in spider plant seed production.

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Keywords: *Cleome gynandra; plant height; plant branches; P-levels; plant population; African Leafy Vegetables (ALVs).*

1. INTRODUCTION

Cleome gynandra is a half-yearly ALV, usually alluded to as spider plant/spider weed or spider flower. It is local to Africa, Asia, and the Middle East. In Africa, it is cultivated broadly in lowlands and mid-latitude areas, especially in the dry savannah some of the time, as a sole yield, yet more regularly intercropped with bananas, coffee, and some other ALV like amaranth, cowpea and *corchorus* spp.

Although the growing of spider plant is an old practice, there are no standard recommendations of its appropriate spacing, where the various institution, researchers do recommend differently on spacing. Traditionally, soil fertility in Africa has been maintained through fallow. However, in Kenya, intensive cropping is gradually replacing the traditional shifting cultivation that is associated with long fallow and hence low crop yield. The steady decline in food production due to reduced length of fallow on land has prompt farmers to amend the soil with different materials (organic and inorganic) in order to enhance plant growth and increase yield [1]. For years there has been continuous mining, soil nutrient depletion due to low or poor soil management practices that have led to deficiencies in nitrogen (N), phosphorous (P), potassium (K) and other essential nutrients together with other micro-elements in the soil. Once crops like spider plant are planted in the soil or any other media they keep on extracting nutrients like phosphorous (p) from soil and if there is no proper soil management during the growth period and after this will lead to nutrient deficiencies in the soil [2]. For example, phosphorous (p) deficiency retards plant growth whose deficiency typically appear in the older leaves, in the form of purplish areas and necrosis of leaf margins. The stems of many annual plants suffering from P deficiency are characterized by a reddish colouration originating from an enhanced formation of anthocyanins. Leaves are frequently tinged with a brownish colour and drop off prematurely [3]. It has been suggested that organic manure should be used in place of chemical fertiliser to avoid long-term negative effects of chemical fertiliser on the soil [4]. However, organic manure is usually required in large quantity to sustain crop production and may not be available to the small-scale farmers [5], hence, the need for inorganic fertiliser. The positive effect of the application of inorganic fertilisers on crop yields and yield improvement has been reported [6].

The study was therefore designed to determine the effect of plant population and different levels of phosphorus on the growth of *Cleome gynandra*in Vihiga County.

2. METHODOLOGY

2.1 Site Description

The test was performed in Gisambai zone, Hamisi District, Vihiga County, on two agriculturists' fields. The examination site lies at an elevation of1685 m above ocean level and within latitude 0°20’N and longitude 35°40'E. The site gets a normal precipitation of 1700 mm yearly, with long rains beginning from March/April and closure in June/July, while short rains fall between September and December. The mean month to month most extreme and least temperature are 23.80°C and 12.40°C individually. The site is under eutricnitisol units as indicated by FAO/UNESCO characterisation. This dirt is profound; much depleted and have a dim rosy dark coloured shading. This zone was picked in view of the notoriety and levels of use of *Cleome gynandra*, by residents.

Soil tests from the site were taken from a significance of 0-20 and 20-40 cm. They have air-dried to experience a 2 mm sifter and analysed for cumulative P by the Mehlich procedure; pH using an extent of 1:2.5 soil water. The soil reaction (pH) was sensibly acidic in the two regions and required dolomitic lime. Levels of soil phosphorus, nitrogen, Potassium, calcium, magnesium, and carbon were to a high degree very deficient in soils from both sites.

2.1.1 Climatology

Hamisi is in the Eastern piece of the County, where rainfall is bimodal and conventional. Long rains happen in March and April, and short rains happen in September and December. April is the wettest month while the driest period is December to January. The mean yearly rainfall is 1700 mm. The County is warm and wet. The normal yearly temperature is 18°C. The temperatures are most astounding in the long stretches of December and January (20°C to 23.8°C in some instances) while least

Temperatures happen around March and April (12.40°C), preceding the long rains.

2.1.2 Soils

Soils in the examination region are reddish brown sandy loam (eutric) with low fertility. The dirt of the test territory was inspected and analysed in June 2014. Samples were taken from the top (0-15 cm), marked then sent to MEA ltd, Nakuru for analysis. The outcomes showed that Nitrogen, phosphorus, and zinc were lacking.

2.2 Land Preparation and Plant Establishment

The seeds of *Cleome* were acquired from an affirmed seed organisation and pre-sprouted to test their feasibility. They were sown directly and thinned a month later. The experiment was set up under rain and was fed bucket irrigation during drought. In the first place, the germination test was done and the outcome was over 90%, leading the acknowledgement of the seeds as being practical. Plot demarcation was done before subjecting the seeds to a particular treatment and afterwards planted physically on seedbeds set up to a fine tilt on a Land that was cleared and crops planted on it a month earlier. Subsequent levelling of the field preceded ridging at a spacing of 45 x 15 cm, 30 x 15 cm and broadcasting according to the plot layout and treatment blends.

2.3 Experimental Design

The research utilised a Randomized Complete Block Design (RCBD) with factorial arrangements. Plot sizes were 2 x 2 m with paths of 1 m between blocks and 0.5 m between the plots with a spacing of broadcasting as a control, 30 x15 cm and 45 x 15 cm subjected to 5 different levels of P_20_5 at a rate of 0, 20 kg/ha, 30 kg/ha, 40 kg/ha and 50 kg/ha. Four ridges were made for subplots where spacing of 45 x 15 cm was being used and six lines or ridges for those of 30 x 15 cm spacing where on broadcasting subplots there were no ridging done 15 treatments and treatment combinations were replicated in three blocks (Table 1 and Fig. 1). The experiment was conducted in Amulavu's and Musimbi's farms which were 3 km apart.

2.4 Treatments and Treatment Combinations

2.4.1 Treatments

Treatments consisted of three spacing at Broadcasting, 30 x15 cm, 45 x 15cm and the application of Triple Super Phosphate during planting at a rate of 50 kg P/ha, 40 kg P/ha, 30 kg P/ha and 20 kg P/ha and zero rates.

Spider plant spacing:

Broadcasting (S_1),
30x 15 cm (S_2),
45 x 15 cm (S_3)

Triple super phosphate (TSP) - 5 levels of P_2O_5:

F_1=0kg/ha
F_2=20 kg/ha
F_3=30 kg/ha
F_4=40 kg/ha
F_5=50 kg/ha

2.5 Treatments and Treatment Combinations

The plot layout used in the experiment was as shown in Fig. 1.

Table 1. Treatment and treatment combinations

Spacings / Fertilizer levels	S_1 (Broadcasting)	S_2 (30 x 15 cm)	S_3 (45 x 15 cm)
F_1 (0 kg/ha)	F_1S_1	F_1S_2	F_1S_3
F_2 (20 kg/ha)	F_2S_1	F_2S_2	F_2S_3
F_3 (30 kg/ha)	F_3S_1	F_3S_2	F_3S_3
F_4 (40 kg/ha)	F_4S_1	F_4S_2	F_4S_3
F_5 (50 kg/ha)	F_5S_1	F_5S_2	F_5S_3

F_2S_2	F_1S_1	F_4S_3	F_4S_2	F_5S_1	F_3S_1	F_2S_3	F_3S_3	F_5S_2	F_5S_3	F_1S_3	F_2S_1	F_4S_1	F_3S_2	F_1S_2
F_3S_1	F_5S_1	F_1S_1	F_2S_1	F_2S_3	F_1S_3	F_1S2	F_5S_2	F_4S_1	F_4S_2	F_4S_3	F_3S_2	F_3S_3	F_5S_3	F_2S_2
F_5S_3	F_1S_1	F_1S_3	F_4S_1	F_3S_2	F_2S_3	F_4S_3	F_2S_1	F_3S_3	F_3S_1	F_5S_1	F_1S_2	F_4S_2	F_2S_2	F_5S_2

Fig. 1. Plot layout

2.6 Data Collection

Ten (10) plants were haphazardly chosen utilising a table of irregular numbers in each plot and checked suitably. Amid the arbitrary choice of the plants, the outer rows were ignored to acquire exact outcomes. These were utilised to test information from the plots and separate midpoints recorded for later investigation. Information gathering was done week after week, others fortnightly from planting to reaping. The accompanying information is shown below:

i) Date of planting.
ii) Stand count after one week
iii) Plant height(weekly)
iv) Number of branches per plant fortnightly

All the data was recorded and sorted for final analysis as below:

2.7 Data Analysis

Data were collected from the field and summarised in excel and subjected to analysis of Variance ANOVA using SPSS version 20 and the Analysis of Variance (ANOVA) at 5% level of significance. Where there were significant differences, the means were compared using the least significant difference (LSD) and Duncan multiple ranges at $p \leq 0.05$.

3. RESULTS AND DISCUSSION

3.1 Effects of Plant Population and P Levels on Plant Height of Spider Plant

Fig. 1 illustrated information on the impact of plant spacing and P-levels on height for the two sites. Evidently, a spacing of 45 x 15 cm proved to be effective in almost all plots, unlike other intervals. In the same context, P levels influenced plant height significantly with a P level of 50 kg/ha showing significant outcomes compared to P levels of 0 kg/ha, 20 kg/ha, 30 kg/ha, and 40 kg/ha. As such, applying Phosphorous in large amounts enhanced the height of spider plant.

The Anova results in Appendix I revealed a significant variation between the heights of plants with $p \leq 0.05$ for both spacings and P levels Tsubo et al. [6] The blocks did not influence plant heights drawn from varied blocks with p-value =0.463.

The interaction outcomes between spacing and fertiliser were also significant at $p \leq 0.05$, implying a statistically significant variation between the interaction levels, with F5S3 leading to the tallest plant height with (p-value 0.000).

The post hoc experiment investigates the elements behind a significant variation from Tables 1 and 2, indicating a significant variation on the mean of height brought about by different spacing and P levels [7]. As per the experimental outcomes, there was a variation effect of spacing and p-levels on height with lower plant population i.e. 45x 15 cm being taller than densely populated crops (broadcasting) at (P-value=0.000) and higher P-levels i.e. 50 kg/ha registered taller plants than 0 kg/ha P-value ≤0.000. The LSD and Duncan outcomes revealed a significant variation on the impact of spacing and P-levels on plant height respectively; hence, conforming to Ahmed, Fandullah & Hussain's results, having observed that P is basic for the general growth of plants, even its ability to stimulate the growth of roots, enhance stalk and stem stability, while improving flowering, fruit and seed productivity [1].

3.2 Effects of Plant Population and P Levels on Number of Branches

Fig. 2 is an illustration of the effects of spacing and P-levels pose on the number of branches. Apparently, a spacing of 45 x 15 cm increased the number of branches compared to a spacing of 30x 15 cm and broadcasting. Also, phosphorous increased the number of branches and strengthened the stems of the plant.

Table 1. DMRT on effects of P-levels on plant height

P-levels	Plant height
0kg/ha	97.66[a]
20kg/ha	114.14[b]
30kg/ha	115.52[c]
40kg/ha	117.83[d]
50kg/ha	120.55[e]

The ANOVA was done on the effects of plant population and P levels on the number of branches for the two sites. The results proved that there was a significant difference between the number of branches with p≤0.05, for both spacing and P levels. The blocks too revealed to have no significant difference on the number of branches from different blocks with p-value = 0.312.

The interaction effect between spacing and fertiliser was also found to be significant (0.000). It indicates that there was a significant difference between the interaction levels with F5S3 (P level of 50 kg/ha and a spacing of 45x 15 cm) showing the highest number of branches with p-value = 0.000 [8].

The post hoc test was done to investigate the factor that caused a significant difference. In table 4.3 and 4.4, showed that there was a significant difference on the means of the number of branches caused by different spacing and P levels [9]. The test whether the difference was caused by either plant population or P levels shows that there was significant difference between plant population and between P levels on number of branches with a spacing of 45x 15 cm having many branches than 30x 15 cm and broadcasting at p≤0.05 and higher P levels of 50 kg/ha registering highest number of branches than other P levels [10].

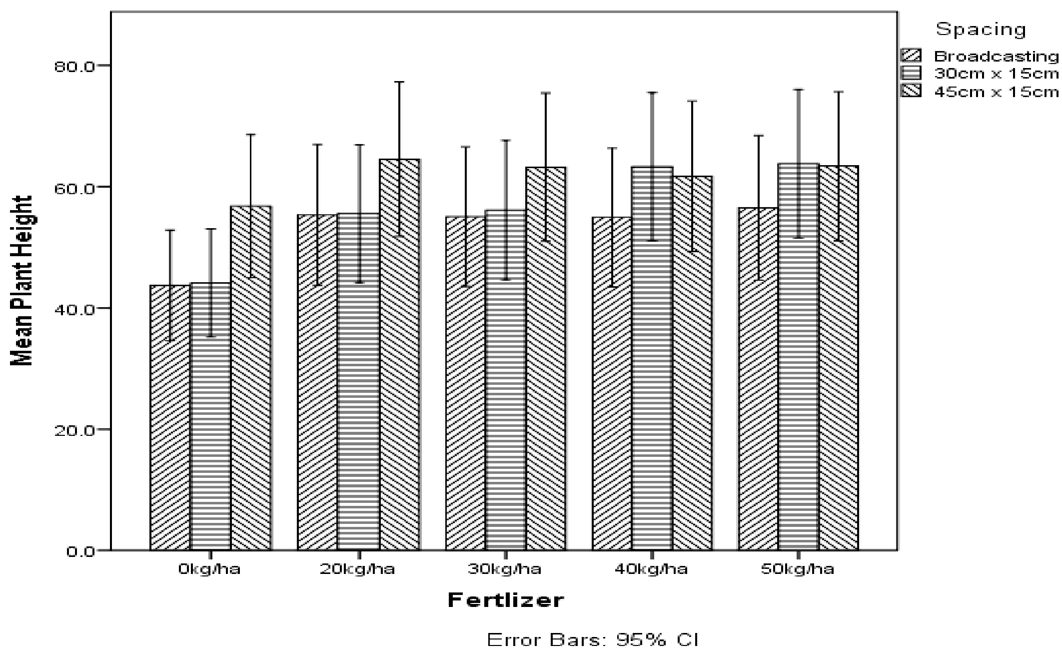

Fig. 2. Effect of plant population and p-levels on plant height

Table 2. LSD test on plant population effects on the number of branches

	Broadcasting	30 x 15 cm	45 x 15 cm
Broadcasting		-4.33*	-5.60*
30 x 15 cm			-1.27*
45 x 15 cm			

**. The mean difference is significant at the 0.05 level*

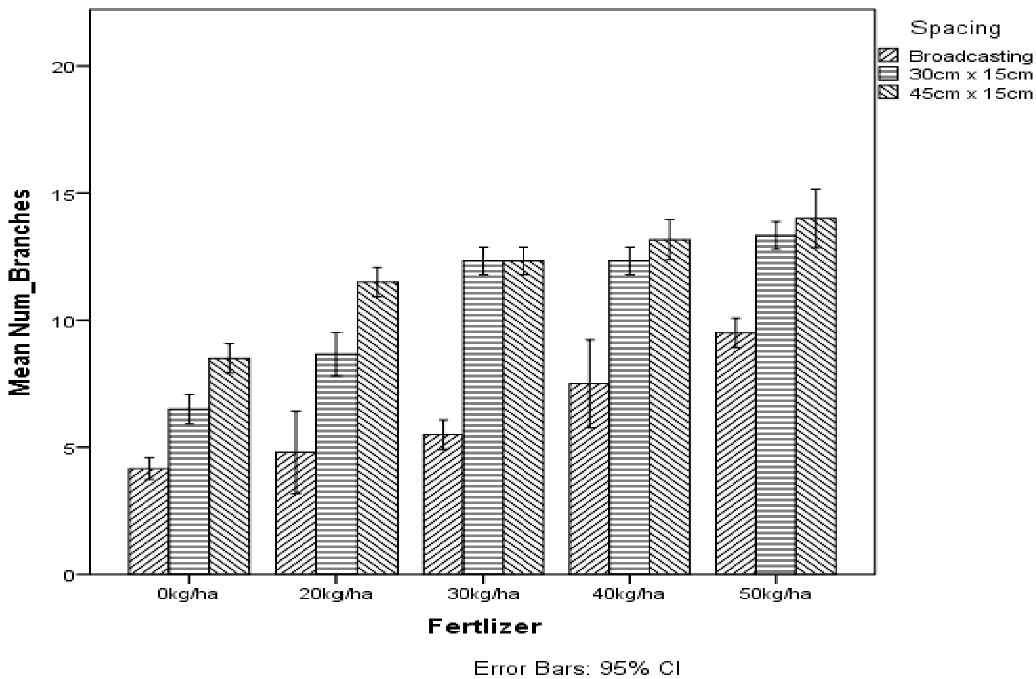

Fig. 3. Effects of spacing and p-levels on number of branches

Table 4. DMRT on effects of P-levels on number of branches

P- levels	Number of branches
0 kg/ha	6.39[a]
20 kg/ha	8.33[b]
30 kg/ha	10.06[c]
40 kg/ha	11[d]
50 kg/ha	12.28[e]

4. CONCLUSION

The focus of this study was to establish growth response of spider plant to P-levels and population in terms of the spacing intervals. As per the findings, height and number of branches were influenced by both plant population and p-levels, with the broad spacing of 45 x 15 cm and a significant rate of 50 kg/ha resulting into tallest plants, and many branches; hence, safe to say, spacing and p-levels enhance the plant's height and increases the number of branches.

5. RECOMMENDATIONS

In this study the recommendations are:

i. The use of Triple Super Phosphate at the rate of 50 kg P/ha is viable to enhance the growth of the crop.
ii. The spacing interval of 45x 15 cm is appropriate for improved growth.
iii. Regular soil testing is needed to ensure that the application of Trip Super Phosphate conforms to the area's soil analytical outcomes.
iv. Further studies with varied space intervals and plant species at different P-levels are necessary to establish the most accurate spacing, species, and P-levels for improved growth.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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APPENDICES

Appendix I: Soil Analysis Report – Musimbi's Farm (Site One)

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MEA/SAR/2012

Soil Analysis Report

Customer Name:	Benson Maniaji	Crop:	Maize, beans,kales	Date Received:	11/06/2014
Farm Name:	Musimbi's farm	Crop Stage:		Date Analysed:	15/06/2014
Address:		Comments:		Report Date:	23/06/2014
Contact Person:	Margaret-MEA LTD	Condition:	Wet	Sample ID:	

Lab. No.	S3411(B)	Depth of Sample	Top	Sample Colour	Brown	Analyst	Stella, Kariri, Gitau

Parameter	Symbol	SI Units	Results	Range Low	Range High	Pictorial Deficient	Pictorial Optimal	Pictorial Toxic	Method Used
*pH	pH	-	5.32	5.50	7.00	■			MEA/SFAM/S001
Hp	Hp	m.e%	0.5	0.50	1.00	■			MEA/SFAM/S002
*Phosphorus	P	ppm	15.00	20.00	100.00	■			MEA/SFAM/S005
*Potassium	K	m.e%	0.04	0.20	1.50	■			MEA/SFAM/S006
*Calcium	Ca	m.e%	0.34	2.00	10.00	■			MEA/SFAM/S007
*Magnesium	Mg	m.e%	0.24	1.00	3.00	■			MEA/SFAM/S009
Manganese	Mn	m.e%	0.62	0.10	1.00		■		MEA/SFAM/S010
Sodium	Na	m.e%	0.51	0.10	2.00		■		MEA/SFAM/S008
Sulphur	S	m.e/l	-	-	-				MEA/SFAM/S011
Iron	Fe	ppm	112.65	5.00	10.00			■	MEA/SFAM/S013
Copper	Cu	ppm	1.67	1.00	2.00		■		MEA/SFAM/S014
Zinc	Zn	ppm	6.68	5.00	10.00		■		MEA/SFAM/S015

Percentage and Ratios

*Nitrogen %	%	%N	0.16	0.20	0.80	■			MEA/SFAM/S004
*Carbon %	%	%C	1.90	2.00	5.00	■			MEA/SFAM/S003
Ca:Mg Ratio	-	Ca:Mg	13.25	4.00	7.00			■	CALCULATION

#Remarks

Soil reaction (pH) is moderately acidic and requires dolomotic lime. Levels of soil phosphorus, potassium, nitrogen, Calcium, Magnesium and carbon (organic matter contents) are very deficient. Well decomposed organic manure should be added to improve soil microbial activity. Generally the soil is of poor fertility.

#Recommendation

			Sprays/Coating/Inoculant
Maize	MEA Mazao 10, 10:26:10 + TE @ 200 kg/ha	CAN 27 % N @ 275 kg/ha	
Beans	MEA NPK @ 0:23:15+TE @100kg/ha	+ Biofix @ 150g/25kg of seeds	
Kales	MEA Mazao 10, 10:26:10 + TE @ 15g/plant	CAN 27 % N @ 15g/plant 4 wks later	
Manure	5 tons/ha of well decomposed organic manure		

Authorization:

Sign: ______________

MEA LIMITED LABORATORY

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EC 17025 accreditation

Appendix II: Soil Analysis Report – Amulavu's Farm (Site Two)

KENYA ACCREDITATION SERVICE
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MEA FERTILIZERS ®
MEA/SAR/2012

Soil Analysis Report

Customer Name:	Benson Maniaji	Crop:	Maize, beans,kales	Date Received:	11/06/2014
Farm Name:	Amulavu's farm	Crop Stage:		Date Analysed:	15/06/2014
Address:		Comments:		Report Date:	23/06/2014
Contact Person:	Margaret-MEA LTD	Condition:	Wet	Sample ID:	

Lab. No.	S3411(A)	Depth of Sample	Top	Sample Colour	Brown	Analyst	Stella, Kariri, Gitau

Parameter	Symbol	SI Units	Results	Range		Pictorial			Method Used
				Low	High	Deficient	Optimal	Toxic	
*pH	pH	-	5.29	5.50	7.00				MEA/SFAM/S001
Hp	Hp	m.e%	0.4	0.50	1.00				MEA/SFAM/S002
*Phosphorus	P	ppm	10.00	20.00	100.00				MEA/SFAM/S005
*Potassium	K	m.e%	0.04	0.20	1.50				MEA/SFAM/S006
*Calcium	Ca	m.e%	0.34	2.00	10.00				MEA/SFAM/S007
*Magnesium	Mg	m.e%	0.19	1.00	3.00				MEA/SFAM/S009
Manganese	Mn	m.e%	0.62	0.10	1.00				MEA/SFAM/S010
Sodium	Na	m.e%	0.48	0.10	2.00				MEA/SFAM/S008
Sulphur	S	m.e/l	-	-	-				MEA/SFAM/S011
Iron	Fe	ppm	106.87	5.00	10.00				MEA/SFAM/S013
Copper	Cu	ppm	1.74	1.00	2.00				MEA/SFAM/S014
Zinc	Zn	ppm	6.79	5.00	10.00				MEA/SFAM/S015

Percentage and Ratios

*Nitrogen %	%	%N	0.19	0.20	0.80				MEA/SFAM/S004
*Carbon %	%	%C	1.94	2.00	5.00				MEA/SFAM/S003
Ca:Mg Ratio	-	Ca:Mg	13.25	4.00	7.00				CALCULATION

#Remarks

Soil reaction (pH) is moderately acidic and requires dolomotic lime. Levels of soil phosphorus, potassium, nitrogen, Calcium, Magnesium and carbon (organic matter contents) are very deficient. Well decomposed organic manure should be added to improve soil microbial activity. Generally the soil is of poor fertility.

#Recommendation

Maize	MEA Mazao 10, 10:26:10 + TE @ 200 kg/ha	CAN 27 % N @ 275 kg/ha	
Beans	MEA NPK @ 0:23:15+TE @100kg/ha	+ Biofix @ 150g/25kg of seeds	
Kales	MEA Mazao 10, 10:26:10 + TE @ 15g/plant	CAN 27 % N @ 15g/plant 4 wks later	
Manure	5 tons/ha of well decomposed organic manure		

Authorization:

Sign:

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Appendix III: Anova on effects of plant population and P levels on plant height Tests between subjects effects

Source	Type III sum of squares	Df	Mean square	F	Sig.
Site	1703.025	1	1703.025	257.860	.000
Block	10.270	2	5.135	.777	.463
Spacing	2782.561	2	1391.280	210.658	.000
Fertilizer	5819.834	4	1454.959	220.300	.000
Spacing * Fertilizer	1792.704	8	224.088	33.930	.000
Error	475.520	72	6.604[a]		
Totals	12584.344	89			

Appendix IV: Table of random numbers between 1 and 140

Line 1	46	79	32	51	58	60	83	116	97	34	89
Line 2	29	7	42	76	25	15	62	95	85	11	58
Line 3	21	38	35	94	108	68	93	5	87	57	15
Line 4	117	47	45	37	13	93	128	47	31	91	7
Line 5	88	132	106	120	20	53	110	63	4	37	55
Line 6	91	130	80	69	45	115	53	21	138	86	25
Line 7	82	87	52	128	21	18	66	35	123	17	46
Line 8	126	95	94	93	12	13	27	88	8	38	39
Line 9	23	97	68	70	62	25	23	132	138	64	136
Line 10	115	88	133	86	117	62	128	44	61	10	14
Line 11	66	55	57	83	136	138	45	107	125	109	19
Line 12	110	139	47	46	101	78	21	76	34	31	7
Line 13	30	72	6	128	64	126	131	69	106	26	103
Line 14	21	44	51	40	10	99	115	15	118	64	103
Line 15	113	102	17	83	124	97	72	34	72	89	7
Line 16	105	45	23	70	67	73	70	20	96	61	83
Line 17	76	72	100	72	34	108	119	20	132	66	19
Line 18	46	23	138	32	140	116	6	71	74	94	118
Line 19	88	66	61	8	106	117	104	108	18	40	31
Line 20	121	11	119	92	59	92	122	114	136	57	63
Line 21	97	97	91	43	120	100	133	38	14	135	40
Line 22	90	82	104	130	98	91	124	43	116	112	14
Line 23	72	92	46	62	55	19	83	54	89	108	35
Line 24	120	132	51	77	106	45	55	37	132	91	10
Line 25	86	7	69	134	102	101	120	81	106	119	78
Line 26	126	57	85	96	110	62	50	86	4	59	102
Line 27	108	69	56	70	77	117	68	124	54	1	10
Line 28	50	132	130	107	130	6	94	125	21	49	133
Line 29	23	33	80	73	123	113	101	26	133	11	67
Line 30	105	111	115	28	99	11	15	73	137	20	22

Appendix V: Anova on effects of plant population and P-levels on number of branches

Tests of between-subjects effects					
Dependent variable: Number of branches					
Source	**Type III sum of squares**	**Df**	**Mean square**	**F**	**Sig.**
Site	24.544	1	24.544	84.420	.000
Block	.689	2	.344	1.185	.312
Fertilizer	382.556	4	95.639	328.949	.000
Spacing	517.422	2	258.711	889.834	.000
Fertilizer * Spacing	43.244	8	5.406	18.592	.000
Error	20.933	72	.291		
Total	989.389	89			

R Squared = .979 (Adjusted R Squared = .974)

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history/26113