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Effects of Intercropping Cowpeas with Maize and Phosphorous Levels on Growth and Yields of Cowpeas in Meru County, Kenya

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Abstract

Cowpea (*Vigna unguiculata* L. Walp) is a legume that is grown for various uses Humans consume it as grain or leaf vegetable and as fodder by livestock. It has high nutritive value and high palatability. It is widely produced in sub-Saharan Africa as a source of income. It is drought tolerant and can suitably be used as an intercrop in an intercropping system. The low yield of cowpea among smallholder farmers due to declining soil fertility has increased the need for site specific fertilizer recommendation. Land fragmentation and reduced arable land makes intercropping of cereals and legumes inevitable. A field experiment was conducted at Kianjai ward in Tigania West Sub County of Meru County during the March –May rain season of 2015 to investigate the effects of intercropping cowpeas with maize and four different levels of phosphorous on growth and yields of cowpeas. The treatments were sole cowpeas, sole maize, sole cowpeas planted with (0 kg/ha, 25 kg/ha, 50 kg/ha and 75 kg/ha SSP) and cowpeas intercropped with maize at (0 kg/ha, 25 kg/ha, 50 kg/ha and 75 kg /ha SSP). The design of the experiment was a Randomized Complete Block Design (RCBD) with four replicates. The results show that with mean plant heights of 41.56 cm, 42.43 cm, 43.00 cm and 45.03 cm respectively for 0, 25, 50 and 75 kg/ha of SSP, plant height at maturity were significantly affected by both fertilizer levels and cropping system ($p<0.05$). The number of pods and cowpeas grain yields were significantly also significantly affected ($p<0.05$). Sole cowpeas recorded the tallest plants, highest number of pods. The mean grain yields for 0, 25, 50 and 75 kg/ha of SSP were 400 kg, 496.88 kg, 593 kg and 699.88 kg respectively with 75 kg/ha. All the Land Equivalent Ratios for intercropping system were greater than one (LER>1) thus showing that intercropping was beneficial. Intercropping cowpeas and maize at 75 kg/ha phosphorous gave the highest Land Equivalent Ratio. It is recommended that in a cowpeas-maize intercropping system application of 75 kg/ha should be adopted. More work should be done to determine effects of intercropping cowpeas with cereal crops other than maize.

Keywords: *Maize, cowpeas, intercropping, Tigania.*

1.0 INTRODUCTION

Cowpea (Vigna unguiculata L. Walp.) plays an important role in the livelihood of millions of people in countries which are developing (El Naim & Jabereldar, 2010).Cowpea has various uses and it is consumed as grain, leaf and forage, with high nutritive value and high palatability (Whitebread & Lawrence, 2006). It is also a cheap protein source for consumers who cannot afford to incorporate animal proteins in their daily diet and provide income to farmers (Nyoki & Ndakidemi, 2014).Reports by FAO indicate that cowpea was grown on an estimated 12.3 million ha in Africa in 2014 and West African countries reporting bulk production from 10.6 million ha. Major producers include Niger, Nigeria, Burkina Faso, Mali and Senegal (Vesterager et al., 2008). Owing to its ability to fix atmospheric nitrogen, it is suitable for enhancing soil fertility (Abayomi et al., 2008). Low cowpea yields in Tropical Africa can be attributed to many factors but poor soil fertility and low application of external inputs are the most important (Haruna et al., 2011). According to Pule-Meulenberg et al. (2010), cowpea is the most commonly grown food legume by farmers in Sub-Saharan Africa (SSA) because of its relatively wide adaptation to drought and low-nutrient environments.

Poor financial status of farmers is a major constraint limiting farmers' utilization of inorganic fertilizer in tropical Africa despite low soil fertility. There is a positive response of cowpea to the application of organic and inorganic fertilizer as reported by several authors from various cowpea grown areas especially phosphorus fertilizers (Nkaa et al., 2014). There is adoption of numreous cropping systems to increase productivity and ensure sustainability and one such system is intercropping which is defined as the growing of more than one crop on the same piece of land within the same year to promote their interaction and thus increase productivity by avoiding dependence on only one crop (Sullivan, 2003). According to Ijoyah and Fanen (2012), selecting the crops to be grown together is an important consideration for any successful intercropping. Further reports indicate that factors which are likely to cause incompatibility such as planting density, competition for nutrients and root density need to be considered (Ijoyah & Jimba, 2012). Farmers practice intercropping with a wide array of crops consisting ordinarily of a major crop and other less significant crops, however it is pertinent that the selection of compatible crops be given priority as this depends on their growth habit, land, light, water and fertilizer utilization (Thayamini & Brintha, 2010). Intercropping plays a vital role in subsistence food production in both advanced and emerging countries (Adeoye et al., 2005).

The problem of soil fertility is not only an agronomic challenge; it is also strongly attributed to social and economic factors. However, the constraint of soil fertility in poor farmlands can be ameliorated through intercropping. Findings by Adeleke and Haruna (2012) show that usual practice of intercropping pulses with cereals enhances land productivity rather than addressing the challenges related to soil fertility. Reports have also indicated that maize and cowpea intercropping was beneficial on nitrogen poor soil. Dahmardeh et al. (2010) found that intercropping cowpeas and maize increases the amount of nitrogen, phosphorus, and potassium contents associated to monocrop of maize. Amos et al. (2012) noted that soil fertility maintenance and improvement cannot be exclusively through the use of inorganic fertilizers. Intercropping systems have some challenges in relation to planting, fertilizer application and management, weeds and pest management, and harvesting. This is because these farm operations are done manually by farmers engaged in small-scale production (Sullivan, 2003).

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Cowpea productivity in sub-Saharan African countries is very low due to low input agriculture common amongst farmers. In Kenya, report by the Ministry of agriculture (2012) indicates that area under cowpea production increased from 85,510 ha in 2006 to 115,800 ha in 2011 but the average production stands at between 0.2 - 0.5 t/ha. Continuous cropping without the use of either organic or inorganic fertilizers has been cited as one of the causes of declining soil fertility (Odhiambo & Mag, 2008). Low soil P is caused by continuous cultivation and nutrient depletion (Magani & Kuchinda, 2009).

Land fragmentation and reduced arable land makes intercropping of cereals and legumes inevitable. This coupled with declining soil fertility have led to cowpeas yields persistently remaining low thus compromising food security and therefore exposing millions to risk of hunger. . One of the options for reducing low yields as a result of low soil P content is to determine the best level of P application so as to increase yield and returns from cowpea.

Cowpeas do not normally respond to nitrogen or phosphorus fertilizers. However, where soils are highly eroded an application of 5 tons/ha of dry compost or manure is beneficial (Ministry of Agriculture, Field technical handbook, 2002). This information conflicts with what KALRO recommends that cowpeas be planted using SSP or TSP as basal fertilizer at the rate of 20-25 kg per hectare in a mono cropping system. This general recommendation may however not be suitable in an intercropping system. In Tigania West sub-county, farmers have been intercropping cowpeas with maize without adequate information on the effects it has on growth and yields and whether inorganic phosphorous is necessary. This study is geared towards determining the effects of intercropping cowpea (variety M 66) with maize (variety H 513) and phosphorous levels in Tigania West Sub County.

2.0 MATERIALS AND METHODS

2.1 Site Description

The experiment was located at a farm in Kianjai Location of Tigania West sub-county. The site is located at an altitude of 1433 Meters above sea level in UM2 Agro Ecological Zone (AEZ). The area receives a bimodal rainfall with the short rains falling between March and May and the long rains in October to December. The area receives rainfall of between 1360 mm to 1576 mm and annual mean temperatures of 18.2 – 20.6°C (Jaetzold et al., 2006).

2.2 Experimental Procedure

Land was cleared of bush and stumps and soil sampled for analysis. The land was then manually tilled using a hoe. It was then leveled by grading all the raised areas. The land was then subdivided into 4 blocks and each block was separated from the other by a 1.0 m path and 0.5 m paths separated the 4 × 3 m plots.

Simultaneous planting of cowpeas and maize was done on 20th March 2014. The cowpeas were planted at a spacing of 60 × 20 cm under pure stand and 75 × 20 cm in intercrop with three cowpeas seeds sown per hill. Maize was planted at a spacing of 75 × 60 cm with two maize seeds per hill. Single Super Phosphate was applied as per the design of the experiment and no top-dressing fertilizer was applied. Cowpeas were thinned 14 days after sowing to one plant per hill and the crops were weeded twice on the 20th and 40th day after sowing.

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2.3 Treatment and Treatment Combinations

The Research design was a Randomized Complete Block Design (RCBD). Nine (9) treatment combinations were obtained including the following:

(i) Four levels of SSP for cowpeas (F_1 = 0 kg/ha; F_2 = 25 kg/ha; F_3 = 50 kg/ha; F_4 = 75 kg/ha);
(ii) Pure stand of cowpeas variety M66(C) with different levels of SSP applied;
(iii) Pure stand of maize variety H 513 (M) with 75 kg/ha SSP applied in each row;
(iv) Cowpeas/maize intercrop in which 75 kg of SSP were applied to maize rows whereas fertilizer levels varied for cowpeas.

The treatment combinations obtained were as given in Table 1.

Table 1: Treatment combinations

Cropping systems	Fertilizer levels			
	F_1	F_2	F_3	F_4
C	CF_1	CF_2	CF_3	CF_4
CM	CF_1M	CF_2M	CF_3M	CF_4M
M				

Key

C: Cowpeas

CM: Cowpeas/maize intercrop with 75 SSP kg/ha applied on maize

F1: 0 kg/ha of SSP for cowpeas

F2: 25 kg/ha of SSP for cowpeas

F3: 50 kg/ha of SSP for cowpeas

F4: 75 kg/ha of SSP for cowpeas

M: Maize + 75 kg/ha of SSP

2.4 Plot Layout

The treatments were distributed into 36 experimental plots grouped into four (4) blocks as shown in the layout given in Figure 1.

Figure 1: Plot layout

M	CF_1 M	CF_3 M	CF_3	CF_2 M	CF_4	CF1	CF_4 M	CF_2
CF1	CF_4 M	M	CF_2 M	CF_4	CF_1 M	CF_2	CF_3 M	CF_3
CF_4	CF_1 M	CF_1	CF_2 M	CF_4 M	CF_3	CF_3 M	CF_2	M
CF_2 M	CF_2	CF_1 M	CF_3	CF_4	M	CF_1	CF_3	CF_4 M

Key

CF1: Cowpeas pure stand + 0 kg/ha of SSP

CF2: Cowpeas pure stand + 25 kg/ha of SSP

CF3: Cowpeas pure stand + 50 kg/ha of SSP

CF4: Cowpeas pure stand + 75 kg/ha of SSP

C F1M: Cowpeas/maize intercrop + 0 kg/ha of SSP

C F2M: Cowpeas/maize intercrop + 25 kg/ha of SSP

C F3M: Cowpeas/maize intercrop + 50 kg/ha of SSP

C F4M: Cowpeas/maize intercrop + 75 kg/ha of SSP

M: Maize pure stand + 75 kg/ha of SSP

2.5 Data Collection

Data was collected on the following parameters: (i) Cowpeas plant height at an interval of 14 DAS from eight tagged randomly selected cowpeas plants in each plot; (ii) Number of cowpeas branches counted at maturity; (iv) Number of cowpeas pods at maturity; (v) Number of cowpeas grains per pod at harvest; (vi) Weight of a hundred (100) cowpeas grains; (vii) Cowpeas grain yields measured after drying; (viii) Maize grain yields measured after drying.

However, this paper presents and discusses the results for cowpeas plant height at maturity, number of cowpeas pods per plant at maturity; cowpeas grain yields measured after drying.

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2.6 Data Analysis

The collected data was summarized in MS Excel and Analysis of Variance (ANOVA) was conducted using SPSS Version 22. Post hoc test was done to separate the means where ANOVA indicated that there were significant differences ($p \leq 0.05$).

3.0 RESULTS AND DISCUSSIONS

3.1 Cowpeas Plant Height

The height of eight randomly selected cowpea plants per plot was measured at two weeks interval from the date of sowing using a metre ruler from the ground level. The plant heights at maturity were as shown in Table 2.

Table 2: Effect of fertilizer levels on cowpeas mean plant height at maturity, number of pods, number of grains per pod and grain yields for the two cropping systems

Fertilizer level	Cropping system	Plant height at maturity (cm)	Mean number of pods per plant	Cowpeas yield (kg/ha)
0	Pure stand	42.375±.4802	16.50±.957	413.50±2.754
	Intercrop	40.750±.4787	12.00±.816	386.50±1.500
25	Pure stand	42.925±.5121	22.75±1.377	506.25±3.750
	Intercrop	41.925±.2869	19.00±.577	487.50±4.500
50	Pure stand	43.325±.1797	30.00±.408	604.00±5.715
	Intercrop	42.675±.2496	24.75±1.702	582.00±1.414
75	Pure stand	45.475±.3038	31.50±3.571	705.75±2.175
	Intercrop	44.600±.2449	29.75±1.109	694.00±2.309

When ANOVA was done (see summary in Table 3), it proved that there were significant differences between the mean heights of groups under different fertilizer levels and cropping systems ($p < 0.05$). Mean comparison using LSD (Table 4) showed that application of 75 kg/ha recorded the tallest plants (45.475 cm). However with means heights of 43.000 cm and 42.425 cm at maturity respectively plants that received 50 kg/ha and 25 kg/ha did not show any significant difference but they were significantly taller than the ones that had not received any SSP fertilizer as seen in Table 4. The reason may be attributed to the fact that phosphorus is needed in large amounts in shoot and root tips where metabolism is high and cell division is rapid (Ndakidemi & Dakora, 2007). The fact that the plants under pure stand were significantly taller than the ones under intercrop is an indication that the sole cowpea utilized the phosphorus fertilizer judiciously in growth and development processes without much competition from maize. This can been attributed to the important role P plays in both nodulation, nitrogen fixation and plant growth processes through enhanced root development and root hair formation (Nziguheba et al., 2016).

Table 3: ANOVA summary for the effect of fertilizer levels on cowpeas mean plant height, number of pods, number of grains per pod, and cowpeas grain yields for the two cropping systems

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.
Blocks	Plant height (cm)	.301	3	.100	.171	.915
	Number of pods	63.844	3	21.281	2.397	.097
	Cowpeas Grain Yield (kg/ha)	112.375	3	37.458	.824	.495
Fertilizer level	Plant height (cm)	52.386	3	17.462	29.780	.000
	Number of pods	1264.344	3	421.448	47.479	.000
	Cowpeas Grain Yield (kg/ha)	396860.125	3	132286.708	2911.590	.000
Cropping system	Plant height (cm)	8.611	1	8.611	14.686	.001
	Number of pods	116.281	1	116.281	13.100	.002
	Cowpeas Grain Yield (kg/ha)	3160.125	1	3160.125	69.553	.000
Fertilizer level * Cropping system	Plant height (cm)	1.046	3	.349	.595	.625
	Number of pods	13.594	3	4.531	.510	.679
	Cowpeas Grain Yield (kg/ha)	245.125	3	81.708	1.798	.178
Error	Plant height (cm)	12.314	21	.586		
	Number of pods	186.406	21	8.876		
	Cowpeas Grain Yield (kg/ha)	954.125	21	45.435		
Total	Plant height (cm)	74.659	31			
	Number of pods	1644.469	31			
	Cowpeas Grain Yield (kg/ha)	401331.875	31			

Table 4: Comparison of cowpeas mean plant height under different fertilizer levels

Fertilizer level (kg/ha)	Mean plant height (cm)
0	41.563c
25	42.425b
50	43.000b
75	45.038a
Sig.	0.000

3.2 Number of Pods per Plant

All cowpea pods from the sampled plants were counted at harvest the data was recorded and summarized as shown in Table 5. The number of pods increased with increase in fertilizer level irrespective of the cropping system.

When ANOVA was conducted (see summary in Table 3), it proved that there were significant differences ($p < 0.05$) between the mean number of pods for both fertilizer levels and cropping systems. A comparison of the group means for different fertilizer levels was conducted using LSD and the results as shown in Table 5 confirmed that 75 kg/ha produced the highest number of pods followed by 50 kg/ha, 25 kg/ha and 0 kg/ha respectively. Similarly, ANOVA showed that sole cowpeas produced significantly more pods compared to cowpeas intercropped with maize and this result agrees with Ndakidemi and Dakora (2007) whose findings recorded a reduction in cowpea number of pods per plant under intercropping system compared to sole cropping.

Table 5: Comparison of cowpeas mean number of pods per plant for different fertilizer levels

Fertilizer level	Mean number of pods
0	14.25d
25	20.88c
50	27.38b
75	30.63a
Sig.	.000

These results show that Phosphorous had a significant effect on number of pods per plant and these results agree with the findings of Nkaa et al. (2014) which showed that increased P fertilizer application increased number of pods per plant probably because Phosphorus stimulates root and plant growth development in crop production and cowpea is not an exception.

3.3 Cowpeas Grain Yields

Cowpea pods harvested from each plot were threshed and the grains dried to a moisture content of 13% and the dried grains were then weighed and the weight was recorded for every plot. The records were then converted to kg/ha for ease of comparison and the results were as shown in Table 2 where the results suggest that in both cropping systems, cowpea grain yields were higher when 75 kg/ha was applied followed by 50 kg/ha, 25 kg/ha whereas 0 kg/ha had the lowest

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yields. Similarly intercropping cowpeas with maize seems to have produced lower cowpeas grain yields for the same fertilizer level compared to cowpeas under pure stand.

From the ANOVA (see Table 3), both fertilizer levels and cropping systems showed significant difference ($p<0.05$). A post hoc test was done for the comparison of the mean grain yields under different fertilizer levels and the results are given in Table 6.

Table 6: Comparison of cowpeas grain yields for different fertilizer levels

Fertilizer level	Grain yields (kg/ha)
0	400.000d
25	496.875c
50	593.000b
75	699.875a
Sig.	.000

The post hoc test results showed that there were significant differences between 0 kg/ha, 25 kg/h 50 kg/ha and 75 kg/ha as shown in Table 6. This is in conformity with the findings of Haruna and Usman (2013) who reported significant increase in yield of cowpea in response to phosphorus application. This is because P is required in large amounts by leguminous plants not only for growth but also in promoting leaf area, biomass, grain yield, number and mass of nodules (Wakeel et al., 2011).

3.4 Land Equivalent Ratio

As is recommended when dealing with intercropping, Land equivalent ratios were calculated and used to compare yields of cowpeas and maize under the two cropping systems. The formula used in calculating LER is:

$$LER_{total} = \frac{Cowpea\ yields\ in\ intercrop}{Cowpeas\ yields\ in\ pure\ stand} + \frac{Maize\ yields\ in\ intercrop}{Maize\ yields\ in\ pure\ stand}$$

The Land Equivalent Ratios calculated for the different treatments used in this study are given in Table 7.

It can be seen from the results in Table 7 that even under intercrop, both maize and cowpeas have high partial LER's ranging from a lowest value of 0.7998 to a highest value of 0.9834. Intercropping cowpeas and maize at 75 kg/ha SSP gave the highest partial LER for both cowpeas and maize and the highest total LER of 1.9305. Total LER for all cowpeas/maize intercrops is higher than 1.

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Table 7: Calculated Land Equivalent Ratios for the different treatments used

Cropping system	Fertilizer level (kg/ha)	Crop	Mean yields(kg/ha)	Partial LER Cowpeas	Partial LER Maize	Total LER
Pure stand		Maize	1739.25			1
	0	Cowpeas	413.5			1
	25		506.25			1
	50		604			1
	75		705.75			1
Cowpeas +Maize intercrop		Maize	1525.05		0.8768	1.8115
	0	Cowpeas	386.5	0.9347		
		Maize	1408.05		0.8096	1.7726
	25	Cowpeas	487.5	0.9630		
		Maize	1391		0.7998	1.7634
	50	Cowpeas	582	0.9636		
		Maize	1647.33		0.9471	1.9305
	75	Cowpeas	694	0.9834		

4.0 CONCLUSION

Based on the results of the investigation, both phosphorous levels and cropping systems showed significant differences in cowpeas height, cowpeas plant height at maturity, number of cowpeas pods per plant at maturity and cowpeas grain yields. Application of 75 kg/ha showed a significant effect on the three parameters discussed in this paper and i was followed by 50 kg/ha.

Sole cowpeas cropping system performed significantly better than cowpeas intercropped with maize both in terms of final plant height and in terms of yields under the same fertilizer levels. However, the land equivalent ratios calculated in this study have shown that intercropping allows to produce more from the same piece of land thus offering a viable alternative under conditions of land scarcity.

5.0 RECOMMENDATIONS

Based on the results of this study, intercropping cowpeas and maize using SSP at a rate of 75 kg/ha is recommended for cowpeas and maize intercropping systems for increased yields in the phosphorous deficient soils of Tigania West. However, more work needs to be done to determine effects of intercropping cowpeas with cereal crops other than maize.

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