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Full Length Article

Productivity of Phosphorus Fertilization in Cowpea-Maize Strip Intercropping under Rainfed Conditions

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Abstract

Crop yields are declined due to low soil fertility, insufficient soil water availability and poorly managed cropping systems in Limpopo province of South Africa. Phosphorus (P) is a major essential nutrient element required by crops for enhanced growth and development. Interactions between different rates of P fertilization and strip intercropping system have not been studied in detail under rainfed conditions in semi-arid region of Limpopo province. Therefore, this study was conducted to assess the performance of four cowpea varieties at four levels (0, 15, 30, 45 kg P ha^{-1}) of P fertilization in a cowpea-maize intercropping system in a split-split plot design during two seasons. Significant interactions were obtained between variety and phosphorus application as well as variety and cropping system for 90% physiological maturity, root mass and grain yield in both seasons. P levels significantly influenced and enhanced grain yield, land equivalent ratio, profit and benefit cost ratio achieved. PAN311 and TVu13464 matured earlier across P levels and they were selected promising cowpea varieties based on their early maturity and high yield. Land equivalent ratio values were greater than 1.0, which indicated performance and advantage of an intercropping system over monocropping system in land utilisation. The optimum P level for cowpea-maize strip intercropping was at 30 kg P ha^{-1} based on yield and financial return. The results showed that P application enhanced the productivity of the cowpea varieties in cowpea-maize strip intercropping in the semi-arid environment of Limpopo province.

Keywords: Benefit cost ratio; Cropping system; Grain yield; Land equivalent ratio; *Vigna unguiculata*

Introduction

In Southern Africa, the intensity and frequency of floods and drought due to climate change have increased resulting in the shift of rainfall onset, and has led to erratic, unpredictable and uneven distributed rainfall (Sikora *et al*. 2020). Farmers are struggling to cope with the persistent effects of climate change. Limpopo province is a semi-arid region prone to drought (Mpandeli *et al*. 2015), characterised by sandy soils with inadequate native nutrient elements, particularly nitrogen and phosphorus (Odhiambo and Nemadodzi 2007). Adeyemi *et al*. (2020) described cowpea (*Vigna unguiculata*) as an important legume crop in less developed countries because it is nutritionally rich in proteins and minerals (Kermah *et al*. 2017; Mafakheri *et al*. 2017), used for both human consumption and livestock feeding. Although it is mainly grown as grain legume crop (Asiwe *et al*. 2020); its young leaves and immature pods are used as a vegetable (Kyei-Boahen *et al*. 2017). Inclusion of cowpea in cropping systems has the potential to increase crop yield due to residual fixed nitrogen (Namatsheve *et al*. 2020; Asiwe and Maimela 2021) and improves soil fertility of smallholder farming systems where little or no synthetic fertiliser is used (Kyei-Boahen *et al*. 2017).

Most smallholder farmers in the Limpopo province Practice mixed cropping system where crops are not planted in definite rows. This traditional practice compromises crop yields in many ways due to the fact that it does not optimise plant population, and secondly, it does not permit mechanisation and application of farm inputs (Asiwe 2009). According to Maitra *et al*. (2020), strip intercropping (growing two or more component crops together in wider strips to facilitate individual crop production, but close enough to improve crop interaction) can increase crop yield beyond monoculture system or other forms of intercropping system because managing the individual crop within the strip is easy and the competition between the component crops is reduced (Gebregergis 2016).

Phosphorus (P) is one of the important essential nutrient elements for crop production (Nkaa *et al*. 2014;

Nongqwenga and Modi 2017) due to its significant role in numerous plant processes including photosynthesis, respiration, cell division and energy transformation (Karikari *et al.* 2015). The work of Adeyemi *et al*. (2020) and Namakka *et al*. (2017) revealed that P plays an important role in the growth, seed development, nitrogen fixation of cowpea and overall yield of the crop. Despite the critical role of P in crops, it remains one of the least available plant nutrient elements (Nziguheba *et al*. 2016) due to its relative immobility and sorption in soils (Mndzebele *et al*. 2020). Many studies have reported that P improves early root formation and development, and therefore enhances drought tolerance of crops (Sudharani *et al*. 2020). Various studies on P application under intercropping have been conducted (Nndwambi *et al*. 2016; Mndzebele *et al*. 2020); however, the application of P under a cowpea-maize (*Zea mays* L.) strip intercropping situation has not been studied in detail in the semi-arid Limpopo region. Therefore, the objective of this study was to assess the effect of P fertilization on four cowpea varieties planted in a strip intercropping with maize. The hypothesis was to find out whether P application would influence the yield components and productivity of the cowpea varieties sown as cowpea-maize strip intercropping systems under rainfed conditions.

Materials and Methods

Description of the study area

The experiment was conducted at the University of Limpopo experimental farm (Syferkuil) located in Mankweng, Capricorn District, Limpopo province, South Africa (23°53′ 9.6″ S and 29°43′ 4.8″ E). The study area is characterised by sandy loam texture belonging to Hutton form, low erratic summer rainfall ranging from 400 to 650 mm (Table 2).

Experimental materials

The trial was planted in a split-split plot design during the 2014/2015 and 2015/2016 planting seasons. A maize variety (WE3127) and four cowpea varieties (PAN311, IT86D-1010, TVu13464 and IT82D-889) were used in a strip intercropping in 2014/15 growing season. Two promising cowpea varieties (PAN311 and TVu13464) were selected and used in the second season trial based on their early maturity and high yielding. The main-plot factor was a single superphosphate (8.1% P) fertiliser at four different levels of 0, 15, 30 and 45 kg P ha^{-1} applied during planting through band placement at a depth of 50 mm below the seed. Subplot factor consisted of four levels of cowpea varieties arranged in cropping systems (monocropping and intercropping) which formed the sub-sub plot. Each plot was 2 m × 3 m with an alley way of 1 m. Maize was spaced at 90 cm × 30 cm, while cowpea was spaced at 75 cm × 20 cm. Four rows of cowpea sandwich between four rows of maize. The trial was replicated three times.

Crop management

The experimental plot was prepared with tractor-mounted implements (disc plough and harrow) to enhance the seed bed for good germination and seedling emergence. The first season trial was planted on 11 February 2015 and on 19 February 2016 for the second season. Herbicide application rates described by Asiwe and Maimela (2021) for Round-up with active ingredient of Glyphosate, N-(phosphonomethyl) glycine, in the form of its isopropylamine salt (240 mL/15 L water knapsack = 3 L ha^{-1}) and Dual gold with active ingredient of S-metolachlor (chloro-acetanilide) (30 mL/15 L water knapsack = 0.5 L ha^{-1}) were applied to control weeds before planting. Manual weeding was done subsequently on growing weeds in the field. Several sprays (3–4) of insecticide were applied on cowpea plants as reported by Asiwe and Maimela (2021). Karate 2.5 EC with active ingredient of lambda-cyhalothrin (pyrethroid) (60 mL/15 L water knapsack = 1 L ha^{-1}) was used to control insect pests (blister beetles and pod-sucking bugs) on cowpea from seedling stage until pod maturity while an Aphox with active ingredient of pirimicarb (carbamate) (4 g/15 L water knapsack = 500 g ha^{-1}) was used to control cowpea aphids.

Soil analysis

Initial soil samples were collected at a depth of 0–15 cm using a soil auger before treatments were applied. The soil cores were thoroughly mixed, and a 1 kg composite sample was then air dried and sieved with a 2 mm mesh sieve. Laboratory analyses were conducted on the soil samples using different recommended laboratory methods to determine pH, N, P and K. Soil pH (H_2O) was determined using 1:2.5 soil-water ratio as described by Eckert (1988), whereas plant available P was determined using the Bray-P1 extractant as described by Kuo (1996). The total N was determined by macro-Kjeldahl digestion method as described by Bremner (1955) while K was extracted using ammonium acetate (1N) as described by Chapman (1965). Soil analysis results are presented in Table 1. Given the critical levels of the nutrients NPK as 10, 20 and 75 mg kg^{-1} Fulton (2010) respectively, it suggests that the soil nutrient content of these major elements was slightly or marginally above the critical levels and therefore offers the plants the opportunity to respond to P application.

Data collection

Data on days to flowering were recorded by counting the days from the date of emergence to the date when 50% of the plant population had flowered. Physiological maturity was calculated by counting the days from the date of emergence to when 90% of the plant population had attained physiological maturity in each subplot. At podding stage, five plants from the middle rows were randomly

Table 1: Initial selected physical and chemical properties of the experimental field site during first and second growing seasons

Soil properties	Season 1	Season 2
Physical properties		
Silt (%)	26.39	20.73
Clay (%)	3.85	8.35
Sand (%)	69.76	60.92
Texture class	Sandy loam	Sandy loam
Chemical properties		
pH (H_2O)	6.71	6.53
Available P (Bray1) (mg kg^{-1})	25.70	23.28
Total N (mg kg^{-1})	15.2	18.4
K (mg kg^{-1})	90.3	92.5

P= Phosphorus; N= Nitrogen; K= Potassium

Table 2: The average monthly rainfall, minimum (Tn) and maximum (Tx) temperature during the two growing seasons at Syferkuil experimental farm

Month	Season 1			Season 2		
	Tx (°C)	Tn (°C)	Rainfall (mm)	Tx (°C)	Tn (°C)	Rainfall (mm)
Jan	28.37	15.65	43.68	25.57	17.30	87.36
Feb	29.88	15.56	24.13	29.12	17.54	57.13
Mar	28.32	14.62	14.47	28.14	15.83	126.73
Apr	25.27	11.24	81.28	26.84	11.65	0.18
May	26.27	5.91	0.25	21.69	7.28	0.00
Jun	21.75	2.75	4.57	21.40	3.87	0.00

Source: University of Limpopo Experimental Farm Weather Station

selected and carefully dug out by using a digging fork and cut at the soil surface level with minimal damage to the roots. The fresh roots from five randomly selected plants were separately shaken off the clogging soil particles and weighed using a weighing scale, and the average weight was obtained to represent root weight per plant.

Plant harvesting

At physiological maturity, cowpea pods were harvested in late May of each year. Two middle rows of cowpea were manually harvested (excluding plants that were designated for sampling) as net plot and pods were threshed manually. After threshing, the seeds were weighed using a weighing scale to determine net shelled seed weight. Two middle rows of maize were manually harvested in July when the cobs are dry and the cobs were threshed manually to obtain the net shelled maize grain weight. The grain weight of cowpea and maize per net plot were calculated and extrapolated as yield in kg ha^{-1} using the following formula:

$$\text{Grain yield (kg ha}^{-1}) = (\text{Grain weight [kg]}) / (\text{area harvested [m}^2]) \times 10000\ \text{m}^2$$

Land equivalent ratio (LER)

The productivity of the intercropping system was determined by computing LER. The total LER was calculated from the relative yield of cowpea and maize with their monocropping variables as described by Dariush *et al.* (2006) using the formula:

$$\text{Total LER} = \sum(\text{Ypi/Ymi})$$

Where Yp represents the yield of individual crops in the intercropping system and Ym is the yield of the crop in the monoculture system. An advantageous intercropping system was attained when LER was greater than 1.00, which indicates greater efficiency of land utilisation in an intercropping system (Asiwe and Maimela 2021). The LER for the crop mixtures for each year was calculated and the combined average was computed for the crop mixtures.

Economic analysis

A benefit-cost analysis was conducted as described by Asiwe and Maimela (2021) to estimate the economic achievements of the different crop mixtures in the intercropping systems as influenced by P application rates. The production costs of cowpea and maize included the cost of field preparation, seed, sowing, fertiliser, crop protection measures, harvesting, and processing. The total cost and revenue were estimated using the prevailing average market prices in Rand for the grain yield of cowpea (R 40.00 kg^{-1}) and maize (R 8.00 kg^{-1}) in South Africa. The amount in Rand was converted to USD by dividing with the average exchange rate of 14.01 ZAR/$. The total profit was calculated by subtracting the total cost from the total revenue, while the benefit-cost ratio (BCR) was calculated by dividing the total profit by the total cost.

Statistical Analysis

The data generated on growth and yield parameters were subjected to analysis of variance (ANOVA) procedure using a three-way ANOVA to determine variation among the factors and treatment means using GENSTAT 20.1 version. Fisher's Protected Least Significance Difference (LSD) was used to separate the means that showed significant differences at $P \leq 0.05$.

Results

The results showed that interactions were not significant in some of the variables recorded for the factors. However, the main effects (P application level, variety and cropping system) as well as interactions had non-significant effect ($P \geq 0.05$) on the number of days to 50% flowering during both seasons. However, the varieties significantly ($P \leq 0.05$) differed in the number of days to attain 90% physiological maturity (Table 3) during both seasons but for the cropping system, significant difference was only observed during the second season. The interactions between variety and cropping system showed significant difference during both seasons. Cropping system significantly influenced the varieties in the number of days to attain 90% physiological maturity during the second season, and the intercropping matured earlier than the monocropping. Mean number of days to maturity was also observed to be consistently longer during the second season than the first season. There was a

Table 3: Effect of phosphorus application and cropping system and its interactive effect on number of days to 50% flowering, 90% physiological maturity and plant height of cowpea varieties

Treatment	Season 1			Season 2		
	Days to 50% flowering (days)	Days to 90% maturity (days)	Plant height (cm)	Days to 50% flowering (days)	Days to 90% maturity (days)	Plant height (cm)
Phosphorus (P; kg ha^{-1})						
0	56.17^{NS}	99.17^{NS}	49.44^{NS}	60.61^{NS}	102.44^{NS}	50.12a
15	56.42	101.87	48.75	60.78	101.61	51.70a
30	55.92	99.63	49.58	60.22	101.67	54.33b
45	56.25	99.83	50.83	59.83	103.11	55.19b
Varieties (V)						
IT82D-889	58.00^{NS}	95.32a	58.33a			
PAN311	53.67	93.46a	50.00b	59.58a	97.12a	65.41a
IT86D-1010	58.83	104.87b	52.50b			
TVu13464	54.25	101.67b	36.88c	60.83a	109.46b	40.06b
Cropping system (CS)						
Monocrop	56.47^{NS}	98.60^{NS}	49.90^{NS}	60.39^{NS}	103.65a	53.46^{NS}
Intercrop	56.19	99.06	49.17	60.31	99.32b	52.29
Interactions						
V × P	0.59	0.82	0.96	0.84	0.07	0.94
V × CS	0.15	0.01	0.32	0.20	0.01	0.04
V × P × CS	0.83	0.89	0.80	0.32	0.15	0.97

Means in the same column followed by the same letter are not significantly different at $P \leq 0.05$. NS= non-significant at $P \leq 0.05$

significant ($P \leq 0.05$) interaction between the cropping system and variety for plant height during the second season (Table 3). With regards to the main effects, significant differences were observed among the varieties during both seasons while among the among the P levels it was observed only during the first season.

Phosphorus application significantly ($P \leq 0.05$) influenced root mass production (Table 4), where P application at 30 and 45 kg P ha^{-1} achieved the highest root mass during both seasons. The interactive effect between variety and phosphorus application was significant for both seasons while between the variety and cropping system, significant interaction was obtained only during the second season. The intercropping exhibited higher root mass than the monocropping during both seasons. The 100-seed weight differed significantly ($P \leq 0.05$) only among the varieties during both seasons (Table 4). For the grain yield, there were significant difference ($P \leq 0.05$) for the main effects and interactions (Table 4). Increasing P application increased mean grain yield during both seasons. PAN311 and TVu13464 achieved higher yield during the two seasons. Intercropping exhibited significant effect over monocropping during both seasons. The results also showed significant difference in the interaction between the variety and cropping system during both seasons and between variety and phosphorus application during first season only.

Table 5 shows that P application significantly ($P \leq 0.05$) influenced the LER among the cowpea varieties intercropped with maize. LER values ranged from 1.90 to 2.87 during the first season and from 1.0 to 1.80 in the second season. The LER values for PAN311 and IT82D-889 increased from 0–30 kg P ha^{-1} during both seasons but beyond that point it decreased while the LER values of IT86D-1010 increased with the increasing P levels. The results also showed that the LER mean values declined at 45 kg P ha^{-1} during both seasons.

The summary of the effect of P application on the monetary values obtained from grain yield of cowpea-maize crop mixtures are shown in Table 6. The profit obtained was in direct relationship with the amount of P applied. However, the value of BCR peaked at 30 kg P ha^{-1} and declined at 45 kg P ha^{-1}. The Profit and BCR achieved by the intercropping were higher than that achieved by monocropping.

Discussion

This study has demonstrated that P application influenced the achievement of the varieties and the cropping systems with respect to the grain yield, profit and other yield components studied, and earns great potential in improving the productivity of farmers in Limpopo Province. Although, the significant interaction between variety and cropping system may indicate that cropping system influenced the maturity of the varieties but this trend was not obtained as the intercrop was not significantly different from monocropping but may have exerted its influence on the varieties where differences were observed. In the light of this, two varieties (PAN311 and TVu13464) matured earlier and were more adapted to micro-environment created by the intercropping system than the other two varieties (IT82D-889 and IT86D-1010). The maturity of the varieties under the various P applications and the cropping system were longer during the second season due to higher precipitation received during the crop growth period. Cowpea varieties tend to extend their flowering and pod production under favourable rainfall duration which leads to asynchrony of flowering and podding phases that directly prolong maturity period.

The significant interaction obtained between variety and P application for the root mass during both seasons suggests that root mass of the varieties was influenced by P application. Root mass increased with P application rates

Table 4: Effect of phosphorus application and cropping system and its interactive effect on root mass, 100 seed mass and grain yield of plant height of cowpea varieties

Treatment	Season 1			Season 2		
	Root mass (g plant^{-1})	100 seed mass (g)	Grain yield (kg ha^{-1})	Root mass (g plant^{-1})	100 seed mass (g)	Grain yield (kg ha^{-1})
Phosphorus (P; kg ha^{-1})						
0	21.96a	15.43^{NS}	1275.00a	17.60a	16.93^{NS}	1598.15a
15	24.29b	15.51	1356.94a	17.44a	16.57	1551.85a
30	24.93b	15.08	1350.00a	18.28a	16.92	1709.26b
45	27.91c	15.02	1643.06b	23.84b	16.96	1912.96b
Varieties (V)						
IT82D-889	29.29a	17.46a	1208.26a			
PAN311	22.47b	15.11b	2123.31b	21.40a	17.62a	1902.78a
IT86D-1010	29.42a	17.06a	802.64c			
TVu13464	17.91c	13.10c	1293.06a	15.20b	14.88b	1248.61b
Cropping system (CS)						
Monocrop	22.51a	15.19a	1399.31a	18.56a	16.72^{NS}	1570.37a
Intercrop	25.03b	15.40a	1863.19b	20.72b	16.97	1938.43b
Interaction						
V × P	< 0.01	0.38	0.04	0.05	0.34	0.31
V × CS	0.45	0.11	0.03	0.01	0.25	0.05
V × P × CS	0.25	0.47	0.09	0.15	0.17	0.63

Means in the same column followed by the same letter are not significantly different at $P \leq 0.05$. NS= non-significant at $P \leq 0.05$

Table 5: Total land equivalent ratio for the component crops in the intercrop at different phosphorus rates (0, 15, 30, 45 kg P ha^{-1})

Variety	Season 1				Season 2			
	0	15	30	45	0	15	30	45
IT82D-889 + WE3127	1.98a	2.09b	2.38d	2.51d	-	-	-	-
IT86D-1010+WE3127	2.15c	1.99a	2.17c	2.66e	-	-	-	-
PAN311 + WE3127	1.90a	2.71e	2.87e	1.96a	1.40b	1.70c	1.80c	1.20^{NS}
TVu13464 + WE3127	2.17c	2.05b	2.18c	2.05b	1.00a	1.10a	1.20c	1.20

Means in the same column followed by the same letter are not significantly different at $P \leq 0.05$. NS= non-significant at $P \leq 0.05$

Table 6: Interactive effect of P application and intercropping systems on economic analysis of cowpea and maize yield

Phosphorus (kg ha^{-1})	Maize relative yield (kg ha^{-1})	Maize revenue (US$ ha^{-1})	Cowpea relative yield (kg ha^{-1})	Cowpea revenue (US$ ha^{-1})	Total revenue (US$ ha^{-1})	Total cost (US$ ha^{-1})	Total profit (US$ ha^{-1})	BCR
0	2555.65	1459.33	1282.65	3662.10	5121.43	2052.63	3068.80	1.50
15	2568.30	1466.55	1325.25	3783.73	5250.28	1998.17	3252.11	1.63
30	3863.10	2205.91	1469.70	4196.15	6402.06	1992.86	4409.20	2.21
45	5029.15	2871.75	1586.10	4528.48	7400.23	2367.34	5032.89	2.13
Intercropping	3462.71	1977.28	1437.35	4103.78	6081.06	1871.15	4209.91	2.25
Monocropping	3602.32	2057.00	1159.40	3310.20	5367.21	1697.46	3669.75	2.16

BCR= Benefit-cost ratio; 1 USD= 14.01 ZAR

thus indicating that P is an important nutrient for root growth and development in plants. High root mass enhances plants' ability to absorb nutrients, water and increases stability to resist lodging (Namakka *et al*. 2017; Agoyi *et al*. 2017; Bawa 2020). Root mass was higher in the intercrop plots than the monocrop plots. However, root mass was lower during the second season which may suggest that rainfall must have negatively influenced the varieties to partition the applied P for the production of above ground plant parts such as the leaves, pods and flowers since the root mass was determined at plant maturity. That significant interaction was obtained between the cropping system and variety for plant height only during the second season is an indication of the sensitivity of the varieties to adequate moisture available as compared to when there is no enough moisture during the first season. This is the reason why the varieties could not discriminate their abilities under the various P application rates during the first season. Phosphorus is not a mobile nutrient like N (Nziguheba *et al*. 2016) and therefore needs enough moisture for its sorption and uptake. Plant height was positively influenced by P application and cropping system during second season than the first thus indicating the impact soil moisture could play in enhancing P uptake in plants (Nkaa *et al*. 2014; Karikari *et al*. 2015; Yasser *et al*. 2018).

Similarly, the 100-seed weight and grain yield followed similar trend and were under the influence of rainfall abundance and distribution which were better during the second season. The significant interaction obtained between the variety and cropping system indicates that grain yield of varieties was influenced by the cropping system. Intercrop plots outperformed monocrop plots in terms of in grain yield thus suggesting that the intercropping environment enhanced the performance of the varieties (Asiwe and Maimela 2021). The differences obtained in the 100-seed and grain yield between the two seasons were probably due to differences in the distribution and amount of rainfall received during the crop growth period as well as their genetic constitution. The study of Makoi (2019) found that varieties differed significantly on 100-seed weight and this was attributed to their genetic differences. Furthermore, two varieties (PAN311 and TVu13464) performed better than IT82D-889 and IT86D-1010. PAN311 and TVu13464 offer promising cash returns to farmers not only due to their high grain yield but also their good adaptation to mature early in drought-prone region like Limpopo province. In other words, PAN311 and TVu13464 were able to utilise the available growth resources such as water, nutrient and light for grain yield production as well as their plant architecture being an erect cowpea type with open canopy which exposes most of their leaves to attract sunlight for better photosynthetic advantage and capacity than other varieties.

Intercropping achieved higher grain yield than monocropping due to several factors; crops under intercropping system tend to use natural resources more efficiently for growth and development, which might have partly resulted in an increased yield (Shah *et al.* 2019; Namatsheve *et al*. 2020; Maitra *et al.* 2020). Cowpea production in a diversified agro-ecosystem can be a reservoir for the naturally occurring biological control agents (Masvaya *et al*. 2017) that could reduce insect infestation, and thereby minimise yield loss due to insect pests (Sikora *et al*. 2020). In addition, soil moisture, soil temperature and microclimate are normally higher in an intercropping system compared to a monocropping system (Seran and Brintha 2010) and these factors when in abundance play a major role to enhance crop growth and development that can result in increased yield (Mndzebele *et al*. 2020). In addition, the faster ground cover often observed in the intercrop plots reduces weed growth, raindrop impact and soil water evaporation, thereby conserving soil moisture for effective crop growth and build-up of natural enemies (Muoni *et al*. 2020).

One of the findings from this study is that increasing P application rates (30–45 kg P ha^{-1}) increased the LER values and financial returns. The calculated LER values for both growing seasons were greater than 1.0 (Nyasasi and Kisetu 2014; Asiwe and Maimela 2021). This implies a comparative advantage of intercropping maize with cowpea over growing each crop separately (Namatsheve *et al*. 2020), which suggests that there is a greater efficiency of land utilisation in the intercropping system (Kermah *et al*. 2017). This further shows that the same area of land under intercropping will produce nearly a double fold of grain yield or financial return than the same area of land under monocropping. The results from previous worker, Masvaya *et al.* (2017) reported that profit and LER values were higher for cowpea-maize intercrop and could vary from 1.8 to 2.5. The LER values achieved in this study ranged from 1.9 to 2.87 which are in conformity with previous results (El-Salam and El-Lateef 2015) who reported that intercropping was significantly better than in-row intercropping with respect to LER. Greater efficiency of land utilisation indicated by the LER > 1 suggests resources were used more effectively under intercropping than monocropping systems (Khan *et al*. 2012; Masvaya *et al*. 2017). Although the profit increased with increasing P levels; however, since the BCR value declined at 45 P kg ha^{-1}, it suggests that the associated marginal profit at this P level does not justify the extra cost of production thus indicating that the optimum level for profit maximization was achieved at 30 P kg ha^{-1}.

Conclusion

Phosphorus application influenced the performance of cowpea varieties, cropping system for better grain yield and the optimum P level for cowpea-maize strip intercropping was 30 kg P ha^{-1} during both seasons. Strip intercropping system was advantageous as compared to growing each crop separately; and showed greater efficiency of land utilisation in the intercropping system, and potential to increase household food security and income. Two promising cowpea varieties (PAN311 and TVu13464) performed well and were selected for intercropping system based on their early maturity and high yield.

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Author Contributions

All the authors contributed relevantly in the execution of the study and preparation of the manuscript and subsequent revisions

Conflict of Interest

There was no conflict of interest from my institution or from other organizations neither from the stations that research was conducted.

Data Availability

The data used in this publication are original and has not been used eslwhere and the right has been transferred to IJAB/FS to publish it with terms and conditions observed.

Ethics Approval

All ethical considerations were observed and there was no issues raised against the conduct of the study and publication of the data obtained from the study.

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