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Evaluation of Performance of Improved Cowpea Varieties in Cowpea-maize Strip Intercropping in Bela-Bela, Limpopo Province, South Africa

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Abstract

Background: Mixed intercropping is the commonly practiced cropping system but it is unproductive with a low return on investment. This study was conducted at the Bela-Bela region of Limpopo province, South Africa to assess the performance of improved cowpea varieties in a cowpea-maize strip intercropping in comparison with farmers' traditional cropping practice (mixed intercropping). Strip intercropping is a novel productive cropping system and its productivity has not been tested in study region. There is a dire need to test the productivity of this important novel cropping system practice in the region.

Methods: Five cowpea varieties (TVu 13464, IT86D-1010, Glenda, IT82E-16 and IT87K-499-35) and maize were planted under strip intercropping, monocropping and mixed intercropping as control treatments. Data were collected on growth and yield parameters and were analyzed using Genstat software 20.1.

Result: Strip intercropping significantly improved the yield attributes and land equivalent ratio (LER) of the varieties as compared to the mixed intercropping. Strip intercropping significantly enhanced the grain yield and land equivalent ratio (LER) of IT82E-16, IT86D-1010, TVu 13464 and IT87K-499-35 as compared to Glenda. Adoption of strip intercropping and the high-yielding varieties will enhance crop diversity, food security, and nutrition in Limpopo Province.

Key words: Bela-Bela, Grain yield, Land equivalent ratio, *Vigna unguiculata, Zea mays*.

Introduction

Cowpea (*Vigna unguiculata* L.) is an important grain legume rich in protein, minerals and vitamins hence it justifies its use as food security and nutrition crop in many parts of the world (Asiwe *et al*., 2020 a and b; Nkhoma *et al*., 2020; Gerrano *et al*., 2019; Gondwe *et al*., 2019; Ngalamu *et al*., 2019; Muranaka *et al*., 2016). Cowpea is commonly used to reduce crop failure in many maize intercropping systems because of its versatility in drought tolerance and ability to fix nitrogen (Asiwe and Maimela 2020; Kermah *et al*., 2017; Belane *et al*., 2011).

Intercropping is commonly practiced by small-scale farmers to intensify their cropping system with diverse crops under the limited available land and to reduce risk associated with crop failure due to marginal soil fertility, insect pests, diseases and drought (Anjaly and Isaac, 2019; Kermah *et al*., 2017). In addition, in most black communities in South Africa where arable land for crop production is limited, smallholder farmers plant different crops within the limited available land or garden to produce for their needs (Asiwe *et al*., 2020). Mixed intercropping is commonly practiced in Limpopo Province where crops are broadcasted easily on prepared land without definite row arrangement and optimum plant density (Asiwe and Maimela, 2020; Mucheru-Muna *et al*., 2010). The practice is characterized by low plant density, low productivity and often leads to poor return on investment (Asiwe and Maimela, 2021; Mahapatra, 2011). Therefore, farmers in Limpopo Province particularly in Bela-Bela region will increase their productivity and profit margin if an innovative intercropping system is introduced in their current cropping system. Strip intercropping is a promising intercropping system where crops are planted with a definite row arrangement and have the potential of reducing inter-species competition, optimizing plant population, and increasing crop yield and cash net return (Asiwe *et al*., 2021; Asiwe and Madimabe 2020; Singh and Ajeigbe, 2007). The hypothesis of this study was to investigate whether the performance of the novel strip intercropping system would be better than or same as the traditional mixed intercropping. Therefore, the main objective of this study was to evaluate the comparative performance and the productivity of five

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improved cowpea varieties under a cowpea-maize strip intercropping system and mixed intercropping system in Bela-Bela district, Limpopo Province.

MATERIALS AND METHODS

The study was conducted at Bela-Bela (24°25′S, 28°21′E) area during 2016-17 (year 1) and 2017-18 (year 2). The area is characterized by erratic and low rainfall between 450-650 mm per annum which falls predominantly during summer. Crop production in this region is grossly limited by amount of received rainfall, duration and distribution pattern. The experimental materials consisted of five cowpea varieties (Glenda (check), IT87K-499-35, IT82E-16, IT86D-1010, and TVu-13464, a maize cultivar PAN 6479). The experiment was conducted in split-plot design with three replications. The main plot as cropping system (intercrop and monocrop). The mono and mixed cropping systems were included as standard control practices and the sub-plot factor was the varieties. Maize cultivar was planted by using the standard plant spacing of 0.9 m × 0.3 m with 4 m row length, giving a plant population of 52 and 40 plants per intercrop plot for maize and cowpea, respectively and each plot area was 5.6 m × 4.0 m. The intercrop plots consisted of four rows of cowpea sandwiched between two rows of maize. The monocrop plots consisted of six rows of cowpea and maize planted at an inter-row spacing of 0.75 m × 0.2 m and 0.9 m × 0.3 m, respectively. The net plot size for each intercrop was 4.8 m × 4.0 m, while that for monocrop (maize) was 4.8 m × 4.0 m and 3.0 m × 4.0 m for the cowpea monocrop. The experiment was planted on 9th January 2017 during year1 cropping season; while during the year2, it was planted on 18th December 2017. N:P:K fertilizers in the ratio of 3:2:1 were applied respectively at the rate of 50 kg ha^{-1} as basal application at the time of sowing immediately after planting. Roundup (isopropyl amine salt of glyphosate) and Dual (S-Metalachlor) were applied at the rates of 3 L ha^{-1} and 0.5 L ha^{-1}, respectively, to control the weeds before crop emergence. Subsequent weed control was executed manually. Karate (Lambda-Cyhalothrin) and Aphox (Pirimicarb) were sprayed at the rate of 1 L ha^{-1} and 500g ha^{-1}, respectively to control insect pests (aphids and pod-sucking bugs) on cowpea from seedling stage until the full podding stage. The trial was conducted under rain-fed conditions and no irrigation was applied.

Variables measured on cowpea were number of days to 50% flowering and 90% maturity, plant height, pods plant^{-1} and grain yield as described by Asiwe and Maimela, 2020. The LER was calculated from the relative yield of cowpea and maize with their monocropping variables as described by (Asiwe and Maimela, 2020 and Dariush *et al*., 2006).

Data were collected manually during the two years and were subjected to analysis of variance procedure using the GenStat Version 20.1 to assess variation among factors and treatments. Means that showed significant differences were separated using Duncan's new multiple range test (DMNRT) at $P \leq 0.05$ (Steel *et al*., 1997).

RESULTS AND DISCUSSION

Flowering and maturity attributes

The results showed that varieties and cropping systems had significant ($P \leq 0.05$) effects on the number of days to 50% flowering and 90% maturity during year2 (Table 1). During both years, cowpea varieties planted in strip intercropping and monocropping matured later than the mixed intercropping. Three varieties namely, TVu 13464, IT82E-16 and IT86D-1010 matured earlier than the rest varieties. The early maturity of the three varieties is an indication that they exhibited good adaptation for maturity in the region and can be viewed as climate-smart varieties for cultivation in the targeted district. This is a good trait for pest evasion as well as the ability to escape terminal drought (Abadassi, 2015). The findings also provide better opportunity for farmers to make selections based on their physiological maturity which is an important attribute for adaptation (Asiwe and Maimela, 2021). The early flowering and maturity observed during the first season was due to low and poorly distributed rainfall in addition to the constant higher temperatures during the reproductive phase (January-March) of the crop (Table 4). Inadequate rainfall or excess moisture have been reported to influence the flowering and maturity habits of legumes either causing them to flower/ mature early or late (Asiwe *et al*., 2021; Asiwe and Madimabe, 2020; Agoyi *et al*., 2017).

Yield and yield attributes

Results show that plant height (growth attribute) and pod length showed significant differences during year2 (Table 1). Plant height and pod length of the varieties were higher during year2. Mixed intercropping exhibited shorter height than those obtained in strip intercropping and monocropping during year1. However, among the varieties, TVu 13464 exhibited the shortest plant height and pod length than the rest varieties during both years.

Varieties exhibited longer pods in the mixed intercropping plots during both years could be due to low plant population which provided wider spacing for the varieties to tap more resources (space, nutrient and light) as compared to monocropping and strip intercropping which had higher plant densities. The variation obtained among the cropping system indicates that the cropping system was able to discriminate the capability of the varieties to use the available resources for plant height and pod length (Asiwe and Maimela, 2020; Zeruhun 2016; Agyeman *et al*. 2014; Nwosu *et al*. 2013).

The results showed that varieties and cropping system had significant ($P \leq 0.05$) effects on pods plant^{-1} (Table 2). Grain yield was lowest among the varieties planted in the mixed intercropping during both years. Strip intercropping achieved the highest grain yield. During the second year,

Table 1: Effects of varieties and cropping systems on yield components of cowpea.

Variety	50% flowering			90% Maturity			Plant height (cm)			Pod length (cm)		
	Y1	Y2	Mean	Y1	Y2	Mean	Y1	Y2	Mean	Y1	Y2	Mean
Glenda	51.00	66.11	58.56	85.67	90.22	87.95	42.46	57.73	50.10	13.53	15.33	14.43
TVu 13464	48.50	61.44	54.97	73.37	77.89	75.63	36.53	51.20	43.87	14.56	13.33	13.95
IT82E-16	52.67	61.22	56.95	77.00	76.11	76.56	41.07	47.33	44.20	14.08	17.22	15.65
IT86D -1010	46.50	61.67	54.09	84.00	81.56	82.78	53.77	60.13	56.95	14.30	16.89	15.60
IT87K-499-35	57.83	67.22	62.53	82.00	85.67	83.84	41.26	39.93	40.60	12.88	16.78	14.83
SEM ±	4.34	2.89	3.34	5.11	5.75	5.18	6.42	8.13	6.46	0.67	1.61	0.74
P≤0.05	0.001	0.001		0.002	0.001		0.01	0.002		0.79	0.01	
Cropping system												
Monocropping	52.43	64.47	58.45	84.83	82.73	83.78	52.15	56.87	54.51	12.96	15.07	14.02
Strip intercropping	51.27	62.80	57.04	79.80	83.13	81.47	53,22	58.27	58.27	13.63	15.53	14.58
Mixed intercropping	53.67	63.33	58.50	76.62	81.00	78.81	49.27	54.00	51.64	15.27	17.13	16.20
SEM ±	1.20	0.85	0.83	4.14	1.13	2.49	2.04	2.18	3.33	1.19	1.08	1.13
P≤0.05	0,9493	0.22		0,04	0.006		0,01	0.03		0.04	0.001	
Variety × cropping system												
P≤0.05	0.66	0.09		0.52	0.4		0.01	0.001		0.01	0.04	

Table 2: Effects of varieties and cropping systems on yield components of cowpea.

Variety	Pods plant^{-1}			Grain yield kg ha^{-1}			100 seed weight (g)		
	Year1	Year2	Mean	Year1	Year2	Mean	Year1	Year2	Mean
Glenda	11.53	17.78	14.66	420	1514.4	967.20	14.17	15.22	14.70
TVu 13464	12.8	17.11	14.96	766.57	1784.4	1275.49	13.31	13.76	13.54
IT82E-16	13.27	14.67	13.97	693.33	2564.4	1628.87	14.25	16.7	15.48
IT86D -1010	11.2	15.89	13.55	576.67	2425.7	1501.19	15.03	12.23	13.63
IT87K-499-35	10.2	15.78	12.99	410	1577.8	993.90	15.83	18.3	17.07
SEM ±	1.24	1.22	0.80	159.64	489.07	295.86	0.95	2.38	1.46
P≤0.05	0.81	0.28		0.008	0.02		0.06	0.05	
Cropping system									
Monocropping	12.43	13.27	12.85	568.97	1917.8	1243.39	14.17	16.03	15.10
Strip intercropping	11.29	18.3	14.80	530.78	2535.6	1533.19	14.52	15.17	14.85
Mixed intercropping	11.67	21.67	16.67	379.94	1466.7	923.32	14.84	17.53	16.19
SEM ±	0.58	4.23	1.91	99.95	536.61	305.06	0.34	1.19	0.76
P≤0.05	0.94	0.001		0.02	0.001		0.92	0.65	0.79
Variety × cropping system									
P≤0.05	0.78	0.07		0.84	0.06		0.001	0.22	

*Means with P-value greater than 0.05 are not significantly different at P≤0.05.

no significant difference (P≤0.05) was observed among the varieties for the number of pods plant^{-1} but it was observed in the case of cropping system in which mixed intercropping exhibited the highest number of pods plant^{-1} (Table 2).

Grain yield is an important variable to assess the performance and adaptation of varieties in any test environment. Varieties that are well adapted to the environment tend to produce higher grain. Higher grain yield that was observed among TVu 13464, IT82E-16, IT86D-1010 and IT87K-499-35 than the local check (Glenda). It indicates that these varieties are well adapted and are better in resource utilization (Agoyi *et al*. 2017; Zeruhun, 2016; Gerrano *et al*., 2015). Mean performance of the cropping systems indicates that strip intercropping out-performed the monocropping as shown in the performance of the varieties for grain yield which was as a result of better resource utilization and creation of micro-environment that favoured other growth and yield attributes (plant height, canopy width, pod length and number of pods plant^{-1}). Previous results have shown that strip intercropping and monocropping which supported higher plant height and pod numbers resulted higher grain yield (Asiwe and Maimela, 2021; Mango *et al*., 2018). However, the number of pods which was higher in mixed intercropping plots was due to wide plant spacing or less optimal plant population.

Results on hundred seed weight showed that no significant (P≤0.05) interaction between the varieties and the cropping system (Table 2) was observed. However,

Table 3: Land equivalent ratio of cowpea/maize crop mixtures.

Crop mixture	Strip intercropping		Mixed intercropping		
	Year1	Year2	Year1	Year2	Mean
Glenda + Pan 6479	-	1.13	-	0.93	1.03
TVu 13464 + Pan 6479	-	2.16	-	1.12	1.64
IT82E-16 + Pan 6479	-	2.43	-	1.47	1.95
IT86D -1010 + Pan 6479	-	2.3	-	1.21	1.755
IT86D-499-35 + Pan 6479	-	2.25	-	1.1	1.675
SEM ±	-	0.53	-	0.20	0.35
P≤0.05	-	0.04	-	0.81	

Table 4: Monthly mean rainfall and temperature Bela-Bela.

Month	Rainfall (mm)			Temp (°C)		
	Year1	Year2	Mean	Year1	Year2	Mean
Dec	-	38.35	38.35	-	32.35	32.35
Jan	102.11	173.73	137.92	35.34	31.29	33.315
Feb	65.28	117.86	91.57	35.49	30.8	33.145
Mar	33.78	43.43	38.605	32.2	31.96	32.08
April	37.84	33.02	35.43	31.67	29.88	30.775
May	20.06	37.34	28.7	26.27	27.55	26.91
June	12.45	38.35	25.4	24.49	32.35	28.42

*Source: Agricultural Research Council-ISCW, Pretoria.

significant (P≤0.05) difference was observed among the varieties during the second year. TVu 13464 exhibited the least seed weight (13.54 g). The variation among the varieties for 100-seed weight was due to the genetic make-up of the varieties, the difference in seed weight between the first and second year was due to weather variations (rainfall and temperature) which were more favourable during the second year. Seed weight is an important quality trait that determines seed size which greatly influences consumers' preferences (Gondwe *et al*., 2019). In South Africa, large seed size is often preferred by some consumers because it cooks faster and attain better cooking quality and texture (Ajeigbe *et al*., 2008; Singh, 2001). On this basis, IT82E-16, IT86D-1010 and IT87K-499-35 will be prime varieties for consumers in the region as their seed sizes are larger than the local check (Glenda).

Results on LER only showed significant (P≤0.05) difference among the crop mixtures under the strip intercropping during the second year (Table 3). IT82E-16, IT86D-1010, TVu 13464 and IT87K-499-35 exceedingly performed better than Glenda in LER of both strip intercropping and mixed intercropping (Table 3).

LER is a function of grain yield, and it measures the productivity of any intercrop system. The excellent performance of strip intercropping over the mixed intercropping in all the crop mixtures is an indication that strip intercropping is more efficient in resource utilization. When the LER value is greater than 1, it implies that more productive and efficient land resource utilisation was achieved by strip intercropping as compared to mixed intercropping (Asiwe *et al*., 2021; Asiwe and Maimela 2020; Chapagain *et al*., 2018; Dahmardeh, 2013). In other words, the same area of land under strip intercropping will produce about two-fold grain yield or economic return from the same area of land under monocropping (Asiwe and Maimela, 2021). Furthermore, the superior performance of strip intercropping over mixed intercropping in LER could be associated with the summative effects and the overwhelming performance of strip intercropping in other yield/growth attributes such as plant height, pod length, number of pods and grain yield. The findings from previous workers (Asiwe and Maimela, 2021; Asiwe and Madimabe, 2020) showed that LER values were higher in cowpea-maize intercropping than mixed intercropping. In this study, maize mixture with IT82E-16, IT86D-1010, TVu 13464 and IT87K-499-35 remarkably performed better than maize mixture with Glenda thus indicating that the formers are superior over Glenda in adaptation to intercrop environment as well as better resource utilization. Adoption of these resource-use efficient and high yield varieties will enhance food security and nutrition in the region (Nkhoma *et al*., 2020; Thanga *et al*., 2019; Sujatha and Babalad, 2018; Chivenge *et al*., 2015; Shetty, 2015).

CONCLUSION

The performance of improved cowpea varieties was assessed under three cropping systems in this study and found that three varieties (IT82E-16, IT86D-1010 TVu 13464) were climate-smart with the inherent ability to mature early and evade possible drought or early frost damage. Furthermore, IT82E-16, IT86D-1010 TVu 13464 and IT87K-499-35 exceedingly performed better than Glenda variety in grain yield as well as LER due to better adaptation to intercrop environment and resource utilization. Therefore, these varieties are recommended for cultivation under strip intercropping system. Strip intercropping performed better in terms of grain yield and LER than the mixed intercropping. Performance of varieties and cropping systems were better during the second year when rainfall and temperature were adequate and optimum. Adoption of this prominent cropping practice and resource-use efficient and high yielding varieties will not only reduce crop failure but also enhance their crop diversity, dietary intake, income generation of the communities in the region and attainment of food security and nutrition in Limpopo Province.

Conflict of interest: None.

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