ISSN : 1812-5379 (Print)
ISSN : 1812-5417 (Online)
http://ansijournals.com/ja

JOURNAL OF AGRONOMY

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Journal of Agronomy 7 (3): 237-243, 2008
ISSN 1812-5379

Evaluation of Different Strategies of Intercropping Maize (*Zea mays* L.) and Soya Bean (*Glycine max* (L.) Merrill) Under Small-Holder Production in Sub-Humid Zimbabwe

[1]I.I. Mudita, [2]C. Chiduza, [1]S. Richardson-Kageler and [2]F.S. Murungu
[1]Department of Crop Science, University of Zimbabwe, P.O. Box MP 167, Mt Pleasant, Harare, Zimbabwe
[2]Department of Agronomy, University of Fort Hare, P. Bag X1314, Alice 5700, South Africa

Abstract: This study compared in-row intercropping practiced by some small-holders in Chinyika in Zimbabwe with various options of strip intercropping with the aim of increasing crop diversification and stability of cereal based cropping systems. Other intercropping patterns studied include 1 maize: 1 soya bean; 2 maize: 5 soya bean; 4 maize: 4 soya bean and 5 maize: 2 soya bean rows. Both maize and soya bean were adversely affected by intercropping as shown by partial equivalent ratios (PLER). The adverse effect of competition was greater under low rainfall conditions, but irrigation and high rainfall tended to improve productivity of intercrop systems. Overall, results indicated that intercropping maize with soya bean was more efficient than sole cropping with regard to Land Equivalent Ratio (LER) and income. Strip intercropping was more productive than in-row intercropping but is used by farmers because of perceived advantages of mechanical weeding. The results suggest that from a biological point of view, greater efficiency would be achieved by adopting a strip intercropping arrangement of 5 maize: 2 soya bean rows as a cropping pattern. This arrangement was more productive than sole cropping in a season with 426 mm of rainfall when all other intercropping treatments evaluated achieved LER <1.00.

Key words: Income, intercropping, land equivalent ratios, maize, soya bean

INTRODUCTION

The productivity of small-holder cropping systems in Zimbabwe is in decline as a result of continuous maize monocropping and opportunistic use of fertilizers because of unavailability at the right time, high cost and risks from erratic and low rainfall. Introducing legumes into the cropping systems not only addresses the problem of low soil fertility, a major constraint to increased yields, but has the potential to improve livelihoods of farm households through increased protein in diets and access to cash. Soya bean (*Glycine max* (L.) Merrill) has been promoted in the smallholder (SH) sector with these purposes in mind and there is evidence that the crop is now widely accepted in Zimbabwe as a potential vehicle to sustainable, low-input, crop production in the SH sector (Mpepereki and Makonese, 1996). One draw back to soya bean production in SH areas has been crop damage caused by wild life (Munguri, 1996). Munguri (1996) observed that there was less damage to common bean (*Phaseolus vulgaris* L.) from bushbuck (*Tragelaphus scriptus*) and impala (*Aepyceros melampus*) in SH cropping systems in Chinyika when these were grown in intercrop as opposed to sole crops. The diversity created by intercropping was used to reduce blast disease (*Magnaporthe grisea*) in rice (*Oryza sativa*) in China (Wolfe, 2000). One possible strategy of reducing damage to soya bean would be to intercrop with maize, the staple in SH cropping systems in Zimbabwe.

Intercropping cereals and soya bean is not a new practice and has been tried in a number of countries, for example, Nigeria (Muoneke *et al*., 2007), Canada (Carruthers *et al*., 2000) and the United States of America (Sullivan, 2003). In Madagascar, 3-4 rows of soya bean are planted between rows of maize (Naik, 1986). Soya bean growth, particularly that of promiscuous and indeterminate cultivars is highly leafy and aggressive and there is potential that intercropping such varieties may result in low yield of both maize and soya bean, making the practice uneconomic. Literature on intercropping of maize and soya bean identified a number of factors important to the success of the system. These are row width and spatial arrangement of the component crops in the field (Ullah *et al*., 2007), orientation of rows for good light interception by soya bean, particularly at pod filling (Irigavarapu and Randall, 1986) and differences in the

Corresponding Author: C. Chiduza, Department of Agronomy, Faculty of Science and Agriculture, University of Fort Hare, P. Bag X1314, Alice 5700, South Africa Tel: +27 40 602 2226 Fax: +27 86 628 2370

response of soya bean varieties (Adeniyan and Ayoola, 2006). These factors probably explain the variable response to maize-soya bean intercropping noted in the literature.

In experiments conducted in the USA, intercropping maize with soya bean resulted in soya bean yield reduction of 11-34% depending on row orientation. Yield of maize was enhanced 6-27% depending on row orientation (Irigavarapu and Randall, 1986). In Nepal, soya bean yield declined 22 and 23% in two seasons when intercropped with maize. Inter-cropped maize in the same system yielded 39 and 18% less than sole maize in the same two seasons (Clement *et al.*, 1992). In a study by Chandel *et al.* (1987) the yield of maize was not affected by intercropping, but soya bean yield was reduced by 55-60%. In spite of the decline in yield of component crops, there is general agreement that the productivity of the system increases when assessed by area-time equivalent ratio (Clement *et al.*, 1992) or land equivalent ratio, LER (Adeniyan and Ayoola, 2006; Muoneke *et al.*, 2007).

Differences in leaf inclination and height of the cereal component can result in differences in transmission of radiation to the other component as shown in a number of studies (Squire, 1990). Intercropping advantage of soya bean/cereal can, therefore, be improved by careful selection of varieties to grow in the system. However, intercropping systems also have to take into account practical considerations such as management of weeds in the cropping system. Some small-holders prefer in-row intercropping of legumes such as cowpea (*Vigna unguiculata* (L.) Walp) and common bean with maize. This allows mechanical weeding of the inter-row thereby reducing labour requirement for maize (Munguri, 1996). Intercropping could be an attractive option for farmers starting out in the production of soya bean and who may want to put a small area of their farm to the crop. This study compared various strategies of intercropping maize and soya bean to investigate their impact on the productivity of the system under SH production conditions in Zimbabwe.

MATERIALS AND METHODS

Study sites: This study was carried out at Chinyika, Thornpark farm and a Save Valley Experiment Station (SVES). The SH farming area of Chinyika is 1380 m above sea level (masl) with a mean annual rainfall of 700-800 mm and at longitudes 32° 05' and 32° 44' East and latitudes 18° 00' and 18° 20' South. Soils in Chinyika are classified as Haplic Acrisol using FAO classification (Nyamapfene, 1991). Thornpark farm is at 1510 masl at longitude 31° East and 17° 30' South with a mean annual rainfall of 800 mm. The soils are classified as Chromic Luvisol using FAO classification (Nyamapfene, 1991). The SVES is at an altitude of 435 masl at latitude 32° 23' East and longitude 20° 21' South with mean annual rainfall of 300 mm. Soils at SVES are classified as Chromic Cambisols using the FAO classification (Nyamapfene, 1991).

Experimental design: The experiment compared seven treatments: sole maize; sole soya bean; in-row intercropping of soya bean and maize; planting soya bean between maize rows at ratio of 1:1; strip intercropping maize and soya bean at ratios of 4:4; 5:2 and 2: 5. The in-row intercropping was included in the trial to act as a local check as farmers prefer it for ease of weed control using animal-drawn cultivators. The maize cultivar used was SC 513, a white, dent hybrid with semi-erectophile leaves. The soya bean cultivar was Storm, with a determinate growth habit. The trial was laid out as a randomised complete block design with three replications at all sites. The gross plot size was 6.0×4.5 m and the net plot was 4.8×0.9 m for sole maize and soya bean and for all the intercrop treatments.

Crop management and records of observations: Two on-farm trials at Chinyika and one trial at SVES were carried out in the 2002/03. In 2003/04, two farm sites in Chinyika were used with one trial at Thornpark farm. Maize was planted by hand at between-row spacing of 0.9 m and soya bean at 0.45 m apart to achieve target populations of 37,000 plants ha^{-1} for maize and 100,000 plants ha^{-1} for soya bean. Basal fertiliser was applied as compound L (5% N: 17% P_2O_5: 10% K_2O + 8% S + 0.25% B) at a rate of 150 kg ha^{-1}. Nitrogen topdressing was applied to maize as ammonium nitrate (34.5% N) applied at 250 kg ha^{-1} at six weeks after crop emergence.

Trials were rain-fed at Thornpark and Chinyika and under full irrigation at SVES. Performance of the intercrops was evaluated using the LER method (Mead and Wiley, 1980). Analysis of variance was performed on soya bean and maize grain yields and net income after testing the data for normality using MSTATC statistical package (Michigan State University, 1994). Net income was calculated based on Grain Marketing Board producer prices for 2003 in Chinyika. Variable costs were based on 2002 market prices in Chinyika. Means were separated using least significance difference at 5% level.

RESULTS

Rainfall (mm): Rainfall received at Thornpark in 2003/04 was 90% of the seasonal average with below normal

Table 1: Performance of maize-soya bean cropping systems with regards to land equivalent ratio (LER), income, maize and soya bean grain yield

			Grain yield (kg ha^{-1})	
Cropping system	LER	Income ([1]US $ ha^{-1})	Maize	Soya bean
Sole maize	1.00	1,644.43	7,407.0	-
Sole soya bean	1.00	550.10	-	1,290.0
In-row soya bean intercropping	1.22	1,545.23	5,928.0	529.0
One maize row: one soya bean row	1.24	1,512.31	5,585.0	629.0
Four maize rows: four soya bean rows	1.24	1,450.01	5,086.0	743.0
Five maize rows: two soya bean rows	1.81	2,075.65	7,255.0	1,013.0
Two maize rows: five soya bean rows	1.57	1,846.79	6,626.0	833.0
[2]LSD (0.05)	0.08	308.67	139.0	121.0
[3]CV (%)	18.50	14.30	14.5	22.7

[1]Exchange rate of US $1.00 = ZWD1,300.00. [2]CV = Coefficient of variation; [3]LSD = Least Significant Difference

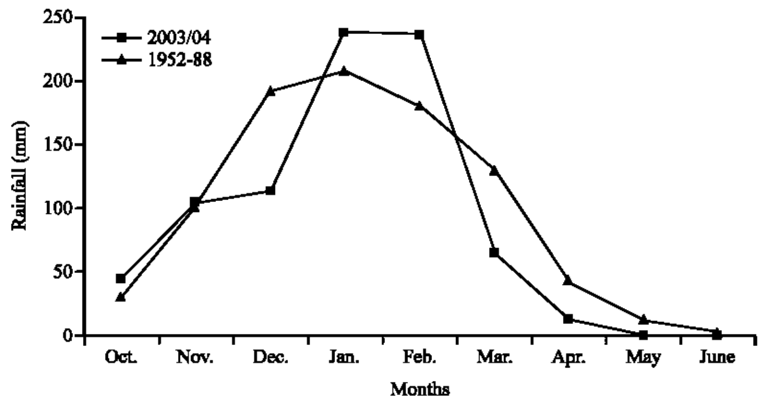

Fig. 1: Rainfall at Thornpark in the 2003/04 season in relation to long-term seasonal average

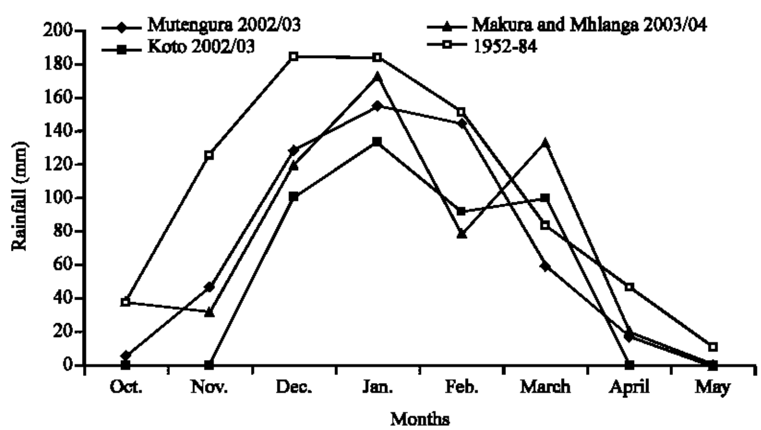

Fig. 2: Rainfall at sites in Chinyika in 2002/03 and 2003/04 seasons in relation to long-term seasonal average

rainfall at the start of the season (Fig. 1). In Chinyika, the Koto site received 426 mm or 54% of seasonal average whilst the Mutengura site received 556 mm or 71% of seasonal average in 2002/03. In 2003/04, rainfall received at the Mhlanga and Makura sites was 593 mm or 75% of seasonal average (Fig. 2). However, in both seasons, there was low rainfall at the start (Fig. 2) during the crop establishment and early growth phases and the Koto site had the lowest amount of rainfall during early phases of crop growth.

Maize grain yield (kg ha^{-1}): Sole maize yielded significantly higher ($p<0.05$) than inter-cropped maize across sites and seasons, as shown in Table 1. Sole maize cropping system averaged 7,407 kg ha^{-1} compared to 6,126 kg ha^{-1} for inter-cropping, a yield advantage of 21%. The best-performing inter-crop treatment was the 5 maize rows: 2 soya bean rows which yielded 7,255 kg ha^{-1} but was significantly ($p<0.05$) lower than sole maize yield. However, in the 2002/03 season (Table 2), the 5 maize rows: 2 soya bean rows intercrop system was the same as the sole maize at all three sites. Strip inter-cropping at ratio of 2 maize rows: 5 soya bean rows was as good as sole maize at two sites, SVES and Koto farm. In-row inter-cropping was the same as sole only at SVES in 2002/03. The 1 maize row: 1 soya bean row and 4 maize rows: 4 soya bean rows treatments tended to be the lowest yielding at all three sites (Table 2).

In 2003/04, sole maize was only equal to the 5 maize rows: 2 soya bean rows strip inter-cropping treatment at Thornpark but was the highest yielding treatment ($p<0.01$) at sites in Chinyika (Table 3). The trend observed in the performance of treatments was similar to that in 2002/03 in that the 1 maize row: 1 soya bean row and 4 maize rows: 4 soya bean rows treatments tended to be the lowest yielding.

Soya bean grain yield (kg ha^{-1}): Soya bean grain yield analysed across sites and seasons was highest in the sole crop, yielding significantly ($p<0.05$) better than in intercrop (Table 1). The sole crop yielded 1,290 kg ha^{-1} compared to 749 kg ha^{-1} for all intercrops, a yield advantage of 72%. Soya bean in strip intercropping yielded 804 kg ha^{-1} compared to 529 kg ha^{-1} in in-row intercropping, a yield advantage of 52%. The least depression in soya bean grain yield was in the strip-intercropping with the 5 maize rows: 2 soya bean rows cropping system which yielded 1,012 kg ha^{-1} and was 27% lower than sole soybean yield (Table 1). There was no significant difference in yield between sole and intercropped soya bean at all sites in 2002/03 and 2003/04 seasons (Table 4, 5). In both seasons, trends were similar, with lowest yield in in-row intercropping, highest yield in sole soya bean followed by strip intercropping at 5 maize rows: 2 soya bean rows.

Partial Land Equivalent Ratios (PLER): Generally, intercropping depressed maize yields at all sites in 2002/03 and 2003/04 as shown in Table 6. The effect was more severe at Koto and Mutengura farms in 2002/03. Cropping systems differed significantly ($p<0.05$) with respect to maize PLER at both Koto and Mutengura (Table 6). The best performing cropping system was strip intercropping 5 maize: 2 soya bean rows which had significantly higher ($p<0.05$) PLER compared to other treatments. At SVES, maize grown in strip intercropping at ratio of 5 maize: 2 soya bean rows was equal to sole cropped maize with a PLER of 1.00. In 2003/04 the same trend was observed (Table 6). There was no significant difference in PLER of soya bean in the various intercrop treatments as shown in Table 7. However, the trend indicated that PLER increased with strip intercropping and favoured the 5 maize rows: 2 soya bean row treatment. Soya bean grown in the maize row ranked the lowest in PLER.

Table 2: Grain yield (kg ha^{-1}) of sole and intercropped maize in Chinyika and SVES in the 2002/03 season

	Chinyika		
Cropping system	Koto farm	Mutengura farm	SVES
Sole maize	4,310	4,342	11,310
In-row soya bean intercropping	3,074	2,345	10,074
One maize: one soya bean row	2,969	2,240	9,636
Four maize: four soya bean rows	2,423	1,694	9,089
Five maize: two soya bean rows	4,786	4,057	11,119
Two maize: five soya bean rows	3,772	3,043	10,772
[1]Significance	*	*	**
[2]CV (%)	20.0	25.4	4.1
[3]LSD (0.05)	1,280	1,280	776

[1]* = Significant at 5% level, ** = Significant at 1% level; [2]CV = Coefficient of variation; [3]LSD = Least Significant Difference

Table 3: Grain yield (kg ha^{-1}) of sole and intercropped maize in Chinyika and Thornpark in the 2003/04 season

	Chinyika		
Cropping system	Makura farm	Mhlanga farm	Thornpark
Sole maize	6,101	5,990	10,644
In-row soya bean intercropping	4,178	4,067	9,076
One maize: one soya bean row	3,740	3,629	8,638
Four maize: four soya bean rows	3,194	3,083	8,091
Five maize: two soya bean rows	5,223	5,112	10,121
Two maize: five soya bean rows	4,876	4,765	9,774
[1]Significance	**	**	**
[2]CV (%)	9.7	10.0	4.5
[3]LSD (0.05)	776	776	776

[1]* = Significant at 5% level, ** = Significant at 1% level; [2]CV = Coefficient of variation; [3]LSD = Least Significant Difference

Table 4: Grain yield (kg ha^{-1}) of sole and intercropped soya bean in Chinyika and SVES in the 2002/03 season

	Chinyika		
Cropping system	Koto farm	Mutengura farm	SVES
Sole soya bean	1,283	1,219	1,314
In-row soya bean intercropping	533	521	546
One maize: one soya bean row	633	608	646
Four maize: four soya bean rows	746	724	761
Five maize: two soya bean rows	1,010	973	1,033
Two maize: five soya bean rows	837	811	851
[1]Significance	ns	ns	ns
[2]CV (%)	25.6	27.4	25.2
[3]LSD (0.05)	-	-	-

[1]ns = non significant; [2]CV = Coefficient of variation; [3]LSD = Least Significant Difference

Table 5: Grain yield (kg ha^{-1}) of sole and intercropped soya bean in Chinyika and Thornpark in the 2003/04 season

	Chinyika		
Cropping system	Makura farm	Mhlanga farm	Thornpark
Sole soya bean	1,183	1,354	1,425
In-row soya bean intercropping	415	586	657
One maize: one soya bean row	515	686	757
Four maize: four soya bean rows	630	801	872
Five maize: two soya bean rows	902	1,073	1,144
Two maize: five soya bean rows	720	891	962
[1]Significance	ns	ns	ns
[2]CV (%)	30.4	24.0	22.0
[3]LSD (0.05)	-	-	-

[1]ns = non significant; [2]CV = Coefficient of variation; [3]LSD = Least Significant Difference

Table 6: Effect of cropping systems on partial land equivalent ratios (PLER) of maize at sites in 2002/03 and 2003/04 seasons

	2002/03 season			2003/04 season		
Cropping system	Koto	Mutengura	SVES	Makura	Mhlanga	Thornpark
In-row soya bean intercropping	0.28	0.55	0.91	0.71	0.71	0.82
One maize: one soya bean row	0.27	0.53	0.87	0.63	0.63	0.78
Four maize: four soya bean rows	0.22	0.39	0.82	0.54	0.56	0.73
Five maize: two soya bean rows	0.43	0.93	1.00	0.89	0.89	0.91
Two maize: five soya bean rows	0.34	0.71	0.97	0.82	0.82	0.88
[1]Significance	*	*	**	**	**	**
[2]CV (%)	19.00	24.40	4.30	10.10	10.80	4.90
[3]LSD (0.05)	0.10	0.29	0.08	0.14	0.14	0.08

[1]* = Significant at 5% level, ** = Significant at 1% level; [2]CV = Coefficient of variation; [3]LSD = Least Significant Difference

Table 7: Effect of cropping systems on partial land equivalent ratios (PLER) of soya bean at sites in 2002/03 and 2003/04 seasons

	2002/03 season			2003/04 season		
Cropping system	Koto	Mutengura	SVES	Makura	Mhlanga	Thornpark
In-row soya bean intercropping	0.41	0.44	0.42	0.35	0.44	0.46
One maize: one soya bean row	0.48	0.51	0.49	0.44	0.51	0.54
Four maize: four soya bean rows	0.57	0.61	0.58	0.54	0.60	0.62
Five maize: two soya bean rows	0.77	0.80	0.79	0.76	0.79	0.80
Two maize: five soya bean rows	0.64	0.68	0.65	0.62	0.67	0.68
[1]Significance	ns	ns	ns	ns	ns	ns
[2]CV (%)	25.00	26.10	24.60	29.70	23.20	21.40
[3]LSD (0.05)	-	-	-	-	-	-

[1]ns = non significant; [2]CV = Coefficient of variation; [3]LSD = Least Significant Difference

Land Equivalent Ratio (LER): Intercropping was significantly better ($p<0.05$) than sole cropping in terms of LER (Table 1). Strip intercropping was significantly better ($p<0.05$) than in-row intercropping with respect to LER, when grown in ratios of 5 maize rows: 2 soya bean rows and 2 maize rows: 5 soya bean rows, but did not differ to in-row intercropping when a ratio of 4 maize rows: 4 soya bean rows was used (Table 1). The 5 maize: 2 soya bean treatment achieved an LER of 1.81, which was significantly higher ($p<0.05$) than the 1.57 achieved by the 2 maize: 5 soya bean rows treatment (Table 1).

Net income: Intercropping realized significantly higher income ($p<0.05$) than sole cropping (Table 1). Sole soya bean was the lowest-performing cropping system, which differed significantly from the rest ($p<0.05$). Strip-intercropping was marginally better than in-row intercropping realizing 11% more income. In-row intercropping was equal to strip-intercropping but differed ($p<0.05$) with the 5 maize rows: 2 soya bean rows treatment which yielded 34% more income (Table 1).

DISCUSSION

The evaluation of in-row and strip intercropping treatments reported in this paper was done under contrasting rainfall environments that ranged from dry in 2002/03 in Chinyika to adequate under irrigation at SVES. This gives a measure of confidence with regards to how this technology would perform under small-holder conditions in Zimbabwe that tend to exhibit high variability in amount and distribution of rainfall. The least amount of rainfall of 426 mm was received at Koto farm in Chinyika in 2002/03 (Fig. 1). The data in Table 6 shows that there was high competition between maize and soya bean at this site. PLER of maize at Koto were the lowest of all sites in the 2002/03 season. At this site, sole cropping was better than all other intercropping treatments evaluated in the trial, with the exception of the 5 maize: 2 soya bean strip intercropping treatment which achieved a LER of 1.21 and was 21% better than sole cropping in a very dry season. Zegada-Lizarazu *et al.* (2006) showed that under limited water environments, competition for soil water between intercropped plants may be strong, possibly explaining the performance of intercropping at Koto in 2002/03 season. However, the probability of receiving >500 mm in Chinyika and at Thornpark was calculated to be 81 and 96%, respectively and that of receiving >750 mm, as 51 and 75%, respectively (Anonymous, 1990). Therefore, rainfall condition experienced at Koto in 2002/03 is the exception rather than the norm and intercropping is less likely to be affected by such adverse rainfall condition in Chinyika.

In this trial, intercropping generally decreased maize grain except at SVES in 2002/03 (Table 2). Maize grain yield was also high at Thornpark in 2003/04 (Table 3) with a seasonal rainfall amount of 812 mm. The experiment at SVES was irrigated whilst rainfall at Thornpark was 90% of normal in 2003/04. Oljaca *et al.* (2000) found that irrigation was an important measure for increasing maize-beans intercrop productivity under often-expressed dry periods on a chernozem. LER was consistently greater than 1.0 and maximum total grain yield was achieved in irrigated maize-bean intercrop (Oljaca *et al*., 2000). Rao and Mathuva (2000) found maize yields that were 17 and 24% higher than continuous sole maize in maize-cowpea sequential and pigeon pea/maize intercropping respectively and attributed this to a rotation and soil fertility effect. Another mechanism that could explain improved yield of cereal in intercrop is hydraulic lift. Sekiya and Yano (2004) showed that pigeon pea (*Cajanus cajan* (L.) Millsp) and sesbania (*Sesbania sesban* (L.) Merrill) can lift water from deep soil layers and transfer it to a maize intercrop. The water supply from the pigeon pea to the maize was enhanced by the shading treatment on pigeon pea, implying the possibility of regulating the function of the hydraulic lift by suppressing transpiration. Sullivan (2003) cited higher cereal yield with strip intercropping compared to sole cropping and noted that narrow strips accommodate the pest management and soil building advantages of rotations and the yield boost of border rows. It is likely that farmers who adopt maize/soya bean intercropping would benefit from a rotation effect if this is continued in the same field over time but this was not measured in this experiment.

In all instances, soya bean grain yield was depressed by intercropping with maize in this experiment. Sullivan (2003) noted higher yield depression in border rows and attributed this to shading but also observed that yield of middle rows of soya bean was higher than they would be in a solid field and attributed this to a possible windbreak effect. In this experiment, soya bean yields were lowest in in-row intercropping highlighting the effect of maize shading on the soya bean crop. Though the maize variety used in this trial, SC 513 is a semi-erectophile and was selected with the objective of improving availability of light to the soya bean, the productivity of maize/soya bean might be improved by evaluating dwarf maize varieties with more erect leaves. One way of reducing shading of soya bean by maize would be to grow the two crops in strips. In this experiment, strip intercropping generally reduced competition between maize and soya bean as shown by results of PLER in Table 6 and 7. In this experiment, 5 maize rows to 2 soya bean rows was the best combination based on the grain yield performance of both maize and soya bean. The advantage of strips in reducing shading has been observed by for example Sullivan (2003) but the ratio of cereal: legumes that are appropriate vary, depending on plant architecture and shading effect of cereal cultivars selected. Though soya bean grows a large canopy which is aggressive, the overall effect of intercropping with maize was shown to be positive on the productivity of the cropping system as has been the case with other short statured legumes such as beans when grown in association with maize in the same environment (Munguri, 1996).

Though farmers were reported to prefer in-row intercropping for purposes of weed control (Munguri, 1996), strip intercropping was generally better in terms of grain yield of maize, PLER, LER and income. This was particularly true with strip-intercropping systems using five maize rows: two soya bean rows and two maize rows: five soya bean rows. Planting in strips also makes mechanical weeding feasible but might entail investment in equipment suited to cultivating narrow rows by small-holder farmers interested in adopting the technology. As observed in this trial, more attention can be devoted to weeding the maize strips and less to the soya bean strips as the latter crop quickly develops a canopy to smother weeds. It is commonly cited that intercropping can be an efficient means of weed control. Steiner (1984) reported that intercropping maize with groundnut (*Arachis hypogaea* L.), mungbean (*Vigna radiata* L.) or sweet potato (*Ipomoea batatas* L. Lam.) reduced weed growth, yield losses and time required for weeding.

We can conclude from this study that strip intercropping generally performs better than in-row intercropping practiced by some farmers in Chinyika. In particular, strip intercropping at a ratio of 5 maize: 2 soya bean rows would be more productivity even under conditions of limiting soil moisture that are experienced sometimes in Chinyika. Though some authors claim that the performance of intercropping is enhanced by stress, such as limited soil moisture (Natarajan and Wiley, 1986; Reddy and Willey, 1981), we can conclude from this study that this would depend on the spatial arrangement of plants in the field as shown by the superiority of the 5 maize: 2 soya bean strip intercropping system in this trial.

ACKNOWLEDGMENTS

We thank the Rockefeller Foundation for financing this research through Grant No. 2002 FS 121 under its Forum program. We also thank farmers in Chinyika, staff at Save Valley Experiment Station and Thornpark Farm for their assistance.

REFERENCES

Adeniyan, O.N. and O.T. Ayoola, 2006. Growth and yield performance of some improved soybean varieties as influenced by intercropping with maize and cassava in two contrasting locations in Southwest Nigeria. African J. Biotech., 5 (20): 1886-1889.

Anonymous, 1990. Agro-climatology applied to crop production in Zimbabwe. Department of Agricultural, Technical and Extension Services, Crop Production Branch, National Early Warning Unit for Food Security, Harare.

Carruthers, K., B. Prithiviraj, Q. Cloutier, D. Fe, R.C. Martin and D.L. Smith, 2000. Intercropping corn with soybean, lupin and forages: Yield component responses. Eur. J. Agron., 12 (2): 103-115.

Chandel, A.S., V.K. Singh and S.C. Saxena, 1987. Suitability of soyabean varieties for maize/soyabean intercropping. Indian J. Agric. Sci., 57 (5): 330-335.

Clement, A., F.P. Chaulifour, M.P. Bharati and G. Gendron, 1992. Effects of nitrogen supply and spatial arrangement on the grain yield of a maize/soybean intercrop in a humid subtropical climate. Can. J. Plant Sci., 72 (1): 57-67.

Irigavarapu, T.K. and G.W. Randall, 1986. Border effects on yields in a strip-intercropped soybean, corn and wheat production system. J. Prod. Agric., 9 (1): 101-107.

Mead, R. and R.W. Wiley, 1980. The concept of Land Equivalent ratio and advantages in yields from intercropping. Exp. Agric., 16: 217-228.

Michigan State University, 1994. MSTATC Microcomputer Statistical Program. Michigan State University, East Lansing, Michigan, USA.

Mpepereki, S. and F. Makonese, 1996. Exploiting Promiscuous Nodulation as a Vehicle for Integrating Soyabeans (*Glycine max* (L.) Merrill) into Small-Holder Cropping Systems of Zimbabwe. In: Soyabean in Small-Holder Cropping Systems of Zimbabwe: Potential Contributions from Biological Nitrogen Fixation, Mpepereki, S., K.E. Giller and F. Makonese (Eds.). Proceedings of a Preparatory Workshop. University of Zimbabwe with SoilFertNet, Harare, Zimbabwe, pp: 77-84.

Munguri, M.W., 1996. Inorganic fertiliser and cattle manure management for dryland maize (*Zea mays* L.) production under low input conditions. M.Phil Thesis, University of Zimbabwe.

Muoneke, C.O., M.A.O. Ogwuche and B.A. Kalu, 2007. Effect of maize planting density on the performance of maize/soybean intercropping system in a guinea savannah agroecosystem. Afr. J. Agric. Res., 2 (12): 667-677.

Naik, D.M., 1986. Country Reports. In: Soyabeans in Southern Africa, Cole, D.C. (Ed.). Department of Crop Science, University of Zimbabwe, pp: 90-196.

Natarajan, M. and R.W. Wiley, 1986. The effects of water stress on yield advantages of intercropping systems. Field Crop Res., 13: 117-131.

Nyamapfene, K., 1991. Soils of Zimbabwe. Nehanda Publishers, Harare, Zimbabwe.

Oljaca, S., R. Cvetkovic, D. Kovacevic, G. Vasic and N. Momirovic, 2000. Effect of plant arrangement pattern and irrigation on efficiency of maize (*Zea mays*) and bean (*Phaseolus vulgaris*) intercropping system. J. Agric. Sci., 135 (3): 261-270.

Rao, M.R. and M.N. Mathuva, 2000. Legumes for improving maize yields and income in semi-arid Kenya. Agric. Ecosyst. Environ., 78 (2): 123-137.

Reddy, M.S. and R.W. Willey, 1981. Growth and resource use studies in an intercrop of pearl millet/groundnut. Field Crop Res., 4: 12-24.

Sekiya, N. and K. Yano, 2004. Do pigeon pea and sesbania supply groundwater to intercropped maize through lift?-Hydrogen stable isotope investigation of xylem waters. Field Crop Res., 86 (2): 167-173.

Squire, G.R., 1990. The Physiology of Tropical Crop Production. CAB International, Wallingford, UK., pp: 236.

Steiner, K.G., 1984. Intercropping in tropical smallholder agriculture with special reference to West Africa. Gesselleschaft fur Technische Zusammenarbeit (GTZ), Eschborn, Germany.

Sullivan, P., 2003. Intercropping principles and production practices. http://attra.ncat.org/attra-pub/PDF/intercrop.pdf. (Accessed 11 March 2008).

Ullah, A., M.A. Bhatti, Z.A. Gurmani and M. Imran, 2007. Studies on planting patterns of maize (*Zea mays* L.) facilitating legumes intercropping. J. Agric. Res., 45 (2): 113-118.

Wolfe, M.S., 2000. Crop strength through diversity. Nature, 406 (6797): 681-682.

Zegada-Lizarazu, W., Y. Izumi and M. Iijima, 2006. Water competition of intercropped pearl millet with cowpea under drought and soil compaction stresses. Plant Prod. Sci., 9 (2): 123-132.