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EFFECT OF INTERCROPPING MAIZE AND BEANS ON *STRIGA* INCIDENCE AND GRAIN YIELD.

G.D. Odhiambo[1] and E.S. Ariga[2]

[1]Kenya Agricultural Research Institute (Kibos), P.O. Box 44, Kisumu, Kenya.
[2]Crop Protection Department, University of Nairobi, P.O. Box 29053, Nairobi, Kenya.

ABSTRACT

Intercrops can smother weeds in cereal crops and improve the overall productivity. Although intercropping with beans has long been practised in the region, a practical bean population and arrangement is required in the management of *Striga*, other weeds and soil fertility to increase maize and bean yields. To study whether parasitic weeds like *Striga hermonthica* can be suppressed and controlled by intercropping, on-farm experiments were conducted in farmers' fields, at Nyadwera, Emabwi, Emuhaya and Kaura in Western Kenya to evaluate maize/bean inter-cropping practices that reduce *Striga* infestation and increase maize and bean yields during the 1999 cropping seasons. Maize was planted simultaneously with beans using different bean planting patterns. The planting system of beans had no influence on *Striga* infestation on maize in Nyadwera and Emuhaya during both seasons. Intercropping significantly influenced the parasite infestation on maize in Emabwi during both seasons. In Kaura, the influence of the intercrop on *Striga* infestation depended on the season. However, in Emabwi and Kaura grain yields were significantly higher under farmers' practices and under intercropping, particularly two rows of beans between two maize rows. During the long rains in Emabwi, intercropping maize with beans with two bean rows between two maize rows increased maize grain yields, significantly, by 51.2% and 61.4% over farmer's practice and intercropping with one row of beans, respectively. Whereas planting arrangements had no significant influence on parasite counts in Kaura, pure maize significantly produced lower grain yield compared to intercropping treatments and farmer's practice. Intercropping maize and beans in the same hole had the highest grain yield, which was 78.6% above yield in pure maize stand. Intercropping maize and beans increased total grain yields in Kaura and Emuhaya during both seasons and in Nyadwera and Emabwi during long rains (LER>1). This shows that cropping practices that can be adopted by farmers to reduce *Striga* incidence and increase maize grain yields are feasible.

Key words: Bean inter-crop, maize, parasitic weed, *Striga*

INTRODUCTION

The major maize production constraints in western Kenya are weeds including *Striga hermonthica* parasitism, labour to control them during peak labour requirement in the season and low soil fertility. The parasite starts emerging 6 weeks after maize planting and therefore evades the first weeding done within the first 4 weeks. Weeding coincides with the period when children are in school while most husbands are also involved in some off-farm activities to supplement family incomes. This leaves women to do most of agricultural activities besides other household duties. Therefore the second weeding to control *Striga* (peak emergence occurs at 12 weeks) is never, in most cases, undertaken. It is also recommended that the parasite plants should be rogued, every 2 weeks, at flowering but before seeding to reduce the parasite seed bank in the soil during the next season (Ransom and Odhiambo, 1994). This is, however, never achieved due to lack of labour.

Intercropping maize and beans is the most common cropping system in *Striga* endemic regions of Kenya. Obilana (1998) explained that intercropping is one of the *Striga* control practices that requires only minor adjustments in the farming systems without any additional inputs. He suggested that the practice should be accompanied by a supplementary hand weeding which would be easier to practice with the few emergent *Striga* plants. Barbiker and Hamdoun (1990) observed that intercropping sorghum with Dolichos bean, cowpea and groundnut invariably reduced *Striga* infestation. This could be due to the shading effect (Oswald *et. al*., 1998). However, a practical bean population and arrangement is required in the management of weeds, *Striga* and soil fertility to increase maize and bean yields. The aim of this study was therefore to evaluate different bean populations and planting arrangements in a maize bean intercropping system on *Striga* infestation, soil fertility, and the overall productivity of maize and bean.

MATERIALS AND METHODS

On-farm experiments were conducted for two seasons during long and short rains of 1999. Six contact farmers were chosen in Western Kenya with the help of the field extension staff in the region. Farmers were selected based on availability of *Striga*-sick plots for intercropping, willingness to grow the crop combinations, availability of labour to carry out treatment operations in time as required and allowing access of demonstration farm to other farmers. The trials targeted farms managed by women who were members of women's groups. Maize (H511) was planted at a spacing of 75 X 50 cm (two seeds per hole) after application of DAP to provide 40 kg P_2O_5 and 18 kg N ha^{-1}. Rosecoco beans (popular in the region) were planted after application of fertilizer at the same rate with maize. Maize was top-dressed with CAN at 40 kg N ha^{-1}. Other recommended agronomic practices were undertaken. One weeding was undertaken 3 weeks after crop germination. The design was a RCBD, with two replications per farmer.

Table 1a. Influence of planting system on *Striga* emergence and maize and bean grain yields at farmer's field in Nyadwera during the long rains 1999.

Treatment*	*Striga* emergence Plants m^{-2}	Grain Yield ($t\ ha^{-1}$) Maize	Beans	LER **	Gross Income **** US $ ha^{-1}
Beans (P)	-	-	2.67	-	2,055
Maize (P	13	0.56	-	-	145
M + B (1)	13	1.56	0.62	3.0	875
M + B (2)	8	1.72	0.69	3.3	970
M + B (S)	9	1.40	0.43	2.7	690
Farmer(P)***	1	1.81	0.25	3.3	655
LSD (0.05)	**NS**	**NS**	**1.00**		

* **Bean (P)** = Beans planted in pure stand; **Maize (P)** = Maize planted in pure stand; **M + B (1)** = Maize intercropped with beans with one bean row between maize rows; **M + B (2)** = Maize intercropped with beans with two bean rows between maize rows; **M + B (S)** = Maize intercropped with beans in the same hole.

** **LER = Land Equivalent Ratio.**

*** **Farmer (P)** = Farmer's practice. The farmer in this season planted pure beans (Rosecoco var.) in one plot while intercropping 2 rows of beans between maize rows in the other plot.

**** **Gross Income =** Sum of the market value of maize at KShs. 20.00 kg^{-1} and that of beans at KShs. 60 kg^{-1} respectively (**Exchange rate of 1 US $ to KShs. 78.00**).

Table 1b. Influence of planting system on *Striga* emergence and maize and bean grain yields at farmer's field in Nyadwera during the short rains 1999.

Treatment*	*Striga* emergence Plants m^{-2}	Grain Yield ($ton\ ha^{-1}$) Maize	Beans	LER**	Gross Income **** US $ ha^{-1}
Beans (P)	-	-	1.85	-	1,420
Maize (P	18	0.72	-	-	185
M + B (1)	22	1.38	0.27	0.7	305
M + B (2)	16	1.37	0.72	30.9	650
M + B (S)	12	1.62	0.62	1.2	635
Farmer(P)***	2	1.66	1.06	1.5	985
LSD (0.05)	**NS**	**NS**	**NS**		

*** **Farmer (P)** = Farmer's practice. The farmer in this season planted pure beans (Rosecoco var.) in one plot while intercropping 2 rows of beans between maize rows in the other plot.

The plot size per farmer varied and depended on the availability of land. Treatments included, 1) Pure maize, 2 seeds per hill, spaced 75 X 50 cm, 2) Pure beans, 1 seed per hill, spaced 50 X 15 cm, 3) Single row of beans between maize rows, 1 bean per hill, spaced 15 cm apart, 4) Double row of beans between maize rows, 1 bean per hill, spaced 15 cm within bean rows, 5) Maize and beans planted in the same hole, 2 and 4 seeds per hill of maize and beans respectively, spaced 75 X 50 cm, 6) Farmer's practice.

Data collected included *Striga* emergence, maize and bean yields. Data was subjected to statistical analysis and means separated by Least Significance Difference (LSD) at $p \leq 0.05$, using General Linear Model of SAS (SAS Institute.1989). The best bean population and arrangement that reduced *Striga* infestation, and increased both maize and bean crop yields were established. Land Equivalent Ratios (LER) were calculated to determine the most beneficial population.

$$LER = \frac{\text{Yield of intercropped maize} + \text{Yield of intercropped beans}}{\text{Yield of monocropped maize} + \text{Yield of monocropped beans}}$$

LER = 1: No advantage of intercropping
LER <1: Intercropping reduces total yield
LER >1: Intercropping increases total yield thus beneficial.

RESULTS AND DISCUSSION

The planting pattern of beans had no significant influence on *Striga* infestation on maize and ultimate grain yield in Nyadwera during both the long and short rains (Table 1a and 1b). However, farmer's practice and intercropping maize with beans with two bean rows between maize rows had low *Striga* emergence which was reflected in high, though non- significant maize grain yield. Beans planted in pure stand had significantly higher yields than beans planted under intercrop with maize. The rest of the intercropping systems produced equivalent bean yield. Intercropping was beneficial to the farmer since it increased total yield as indicated by LER>1 during the long rains.

During the short rains, there was no significant difference between pure beans and those planted under intercrop systems. Yield of pure beans during short rains was half that obtained during the long rains while maize in the intercrop yielded less than half that harvested in the long rains indicating a poor season at this site. Total grain yield was only increased when maize and beans were planted in the same hole and under farmers' practice (Table 1b). Planting M+B (1) and 2 rows of beans between maize rows reduced the total yield during the short rains. Results indicate that the benefit of intercropping maize and beans was more pronounced in the long rains than in the short rains. This was perhaps due to adequate moisture availability to the intercrops that did not result into competitive behaviour during the long rains season. Although intercropping maize and beans was beneficial during the long rains, gross income from pure beans was the highest during both seasons (Table 1a and 1b) due to the higher market value of beans which was 3 times higher than that of maize. *Striga* pressure during both seasons was low and therefore the parasitism did not influence maize yield in any of the treatments. Planting maize and beans in the same hole is still practised by farmers. Farmers reported that it is faster and easier to plant and weed. Although planting up to 4 seeds together with maize in the same hole had no effect on the final yield during both seasons, dumping together of seeds in the same hole should be discouraged to avoid competition for space. Farmers' practice in Nyadwera was similar to the treatments by researchers.

During the short rains, intercropping maize with beans with two bean rows between maize rows and farmer's practice resulted in significantly lower parasite infestation than under intercropping maize with beans with one bean row between maize rows in Emabwi (Table 2a). Intercropping maize with with beans with two bean rows between two maize rows increased maize grain yields, significantly, by 51.2% and 61.4

Table 2a. Influence of planting system on *Striga* emergence and maize and bean grain yields at farmer's field in Emabwi during the long rains 1999.

Treatment	*Striga* emergence Plants m^{-2}	Grain Yield ($t\ ha^{-1}$) Maize	Beans	LER	Gross Income US \$ ha^{-1}
Beans (P)	-	-	0.32	-	245
Maize (P	6	1.26	-	-	323
M + B (1)	16	0.64	0.18	1.1	300
M + B (2)	2	1.66	0.13	1.7	525
M + B (S)	3	1.42	0.12	1.5	455
Farmer(P)***	2	0.81	1.44	5.1	1,315
LSD (0.05)	**5**	**0.75**	**0.47**		

*** **Farmer (P)** = Farmer's practice. The farmer in this season used a local maize variety while bean (Small type var.) was broadcast between the maize rows.

Table 2b. Influence of planting system on *Striga* emergence and maize and bean grain yields at farmer's field in Emabwi during the short rains 1999.

Treatment	*Striga* emergence Plants m^{-2}	Grain Yield ($t\ ha^{-1}$) Maize	Beans	LER	Gross Income US \$ ha^{-1}
Beans (P)	-	-	1.30	-	1,000
Maize (P	14	0.52	-	-	130
M + B (1)	16	0.12	0.55	0.7	455
M + B (2)	11	0.60	0.24	1.3	340
M + B (S)	11	0.75	0.08	1.5	255
Farmer(P)***	1	0.47	0.36	1.2	400
LSD (0.05)	**5**	**0.50**	**0.19**		

*** **Farmer (P)** = Farmer's practice. The farmer in both seasons planted local white maize variety while local beans (Punda var.) were broadcast after emergence of maize.

Table 3a. Influence of planting system on *Striga* emergence and maize and bean grain yields at farmer's field in Emuhaya during the long rains 1999.

Treatment	*Striga* emergence Plants m^{-2}	Grain Yield ($t\ ha^{-1}$) Maize	Beans	LER	Gross Income US \$ ha^{-1}
Beans (P)	-	-	0.28	-	215
Maize (P	8	1.15	-	-	295
M + B (1)	4	1.06	0.26	1.9	470
M + B (2)	9	0.93	0.27	1.8	445
M + B (S)	4	0.73	0.12	1.1	280
Farmer(P)***	0	-	-	-	
LSD (0.05)	**NS**	**NS**	**NS**		

*** **Farmer (P)** = Farmer's practice. The farmer in this season used a local maize variety while bean (Small type var.) was broadcast between the maize rows.

Table 3b. Influence of planting system on *Striga* emergence and maize and bean grain yields at farmer's field in Emuhaya during short rains 1999.

Treatment	*Striga* emergence Plants m^{-2}	Grain Yield ($t\ ha^{-1}$) Maize	Beans	LER	Gross Income US \$ ha^{-1}
Beans (P)	-	-	0.46	-	350
Maize (P	24	0.19	-	-	50
M + B (1)	20	0.34	0.39	2.6	300
M + B (2)	25	0.16	0.29	1.5	265
M + B (S)	2	0.22	0.13	1.4	155
Farmer(P)***	2	1.00	-	-	255
LSD (0.05)	**NS**	**0.38**	**NS**		

*** **Farmer (P)** = Farmer's practice. The farmer in this seasons planted maize only with farmyard manure then top dressed with calcium ammonium nitrate (CAN).

61.4% over farmer's practice and intercropping with one row of beans respectively. Intercropping increased total yield of maize and beans. However, planting one row of beans between maize rows reduced the total yield during the short rains (LER of 0.70).

During the short rains, farmers' practice had significantly lower *Striga* emergence than all other treatments. This was not, however, reflected in improved yield of the maize crop (Table 2b). Maize planted with beans in the same hole was significantly higher than one row of beans between maize by 6 times. Pure beans was significantly higher than all the intercrops including farmers' practice. Maize yield was 50% higher in the long rains than in the short rains with less *Striga* emergence in the farmers' plots than in the latter. Bean yield was also better in the long rains compared to the short rains.

Farmers' practice resulted in significant reduction of *Striga* infestation in maize during both seasons. However, maize yield was reduced while bean yield was enhanced. The high population of beans could have reduced *Striga* growth and development through shading effect while reducing maize yield through competition. Increase in gross income under farmers' practice during the long rains was due to high yields realised from beans. There was no significant difference in *Striga* emergence although farmer's practice and planting single row of beans between maize rows in Emuhaya resulted in lower *Striga* emergence than the rest of the treatments (Table 3a and 3b). This was reflected in significantly higher maize yield in farmers' practice during short rains only (Table 3b). Maize under farmers' practice outyielded all other cropping systems including monoculture maize during the short rains (Table 3b). Whereas maize yield was better in the long rains than in the short rains, bean yields were comparable in both seasons. Maize yield during the long rains and bean yield during both long and short rains in farmers' practice was not determined. The LER indicated that total yield was enhanced when maize and beans were intercropped irrespective of the method of planting the beans during both the long and short rains. During short rains in Emuhaya, the farmer planted with farmyard manure and top- dressed with CAN. This explains the low *Striga* infestation and

Table 4a. Influence of planting system on *Striga* emergence and maize and bean grain yields at farmer's field in Kaura during the long rains 1999.

Treatment	*Striga* emergence Plants m^{-2}	Grain Yield (t ha^{-1}) Maize	Beans	LER	Gross Income US \$ ha^{-1}
Beans (P)	-	-	1.20	-	925
Maize (P	13	0.15	-	-	40
M + B (1)	7	0.40	0.17	2.8	230
M + B (2)	7	0.54	0.28	3.8	350
M + B (S)	4	0.70	0.16	4.8	300
Farmer(P)***	2	0.57	0.12	3.9	240
LSD (0.05)	**NS**	**0.24**	**0.27**		

***** Farmer (P)** = Farmer's practice. The farmer in both seasons planted local maize variety then intercropped with a single row of beans (Rosecoco var.) between the maize rows.

Table 4b. Influence of planting system on *Striga* emergence and maize and bean grain yields at farm and field in Kaura during the short rains 1999.

Treatment	*Striga* emergence Plants m^{-2}	Grain Yield (t ha^{-1}) Maize	Beans	LER	Gross Income US \$ ha^{-1}
Beans (P)	-	-	1.10	-	845
Maize (P	31	0.04	-	-	10
M + B (1)	14	0.29	0.26	7.5	375
M + B (2)	8	0.25	0.36	6.6	340
M + B (S)	7	0.37	0.28	9.5	310
Farmer(P)***	4	0.37	0.40	9.6	400
LSD (0.05)	**20**	**0.26**	**NS**	**-**	

***** Farmer (P)** = Farmer's practice. The farmer in both seasons planted local maize variety then intercropped with a single row of beans (Rosecoco var.) between the maize rows.

significantly higher maize yields (Odhiambo and Ransom, 1997). However, the heavy input failed to increase his gross income due to low market value of maize.

Although planting arrangements had no significant influence on *Striga* emergence in Kaura, pure maize significantly produced lower grain yield than all other treatments including farmer's practice during both seasons (Table 4a and 4b). This was due to higher *Striga* emergence where maize was planted as a pure stand. Maize plus beans in the same hole or one or two rows between maize rows also significantly reduced *Striga* emergence compared to pure maize. Bean yield was significantly higher in pure stand compared to intercrop in the long rains only. Although maize yield was higher in the long rains only, bean yield was, however, comparable in both seasons. Intercropping maize and beans in the same hole had the highest grain yield, which was 78.6% above yield in pure maize stand. Kaura site benefited most in the total yield harvested when maize was intercropped with beans during both seasons.

Striga infestation was low and not significant during the long rains in Kaura. During the short rains, infestation was high and significant in pure maize where yield and gross margin were meagre. *Striga* infestation is serious under low rainfall season. Higher soil moisture content for extended period causes *Striga* seeds to undergo wet dormancy, thereby reducing infestation. High soil moisture content also reduces soil temperature below the optimum requirement for *Striga* germination, growth and development of 23-30^{o}C.

Intercropping maize and beans was beneficial in the region. Although farmers used their own treatments, they also adopted a lot of recommendations from researchers. These included plant population, spacing, planting along contours and fertilizer application.

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