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Effects of Different Maize–Soybean Intercropping Patterns on Yield Attributes, Yield and B: C Ratio

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was carried out to study the "Effects of different maize–soybean intercropping patterns on yield attributes, yield and B: C ratio" at the Agricultural Research Farm, Bhagwant University, Ajmer. Treatment consists of Sole maize (60x20 cm), Sole Soyabean (30x10 cm), Maize-Soybean (1:1) (60X20 cm), Maize-Soybean (1:1) (75X20 cm), Maize-Soybean (1:1) (90X20 cm), Maize-Soybean (1:2) (90X20 cm) and Maize-Soybean (2:6) (Paired row 45/180 cm). There were four replicated blocks and plot sizes measuring 7 m x 4.5 m laid out in a randomized complete block design (RCBD). Results of the experiment showed that the maize-soybean intercropping patterns had significant effect on maize stover and grain yields. Sole maize recorded significantly higher yield than intercropped maize under varying geometry and row proportion. However, it was at par with maize intercropped with soybean in 1:1 row proportion with 60 x 20 cm .The intercropping patterns affected significantly the PAR intercepted and the leaf area index. The soybean sole crop intercepted significantly more light and leaf area index (LAI) than all other treatments and/or crop. Further,, the yield of sole soybean was significantly superior over other intercropped treatments. The highest benefit cost ratio revealed that higher return per unit money invested for inputs used for raising crops. The highest B: C ratio was recorded with maize + soybean in 2:6 paired row (3.57) intercropping system. The least B: C ratio was recorded in sole soybean (2.45).

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1. INTRODUCTION

In intercropping system there is one main crop cultivated with one or more added crops where the main crop is of primary importance due to economic or food production reasons [1]. In the SSA region, cereal and grain legumes intercrop is the most practiced by smallholder farmers [2]. The major reason why these farmers intercrop cereals and grain legumes is because they are particularly important human food as they are rich in protein and are sometimes sold for cash income [2]. In addition, intercrops give them the stability of the yields over several seasons), when one crop fails, the other might still give a reasonable yield [3] Furthermore, grain legumes help maintain and improve soil fertility due to their ability to biologically fix atmospheric nitrogen [4]. Intercropping of maize and legumes is widespread among smallholder farmers due to the ability of the legume to cope with soil erosion and with declining levels of soil fertility. The principal reasons for smallholder farmers to intercrop are flexibility, profit maximization, risk minimization against total crop failure, soil conservation and improvement of soil fertility, weed control and balanced nutrition [5]. Other advantages of intercropping include potential for increased profitability and low fixed costs for land as a result of a second crop in the same field. Furthermore, intercrop can give higher yield than sole crop yields, greater yield stability, more efficient use of nutrients, better weed control, provision of insurance against total crop failure, improved quality by variety, also maize as a sole crop requires a larger area to produce the same yield as maize in an intercropping system without mineral fertilizer on sandy soil in Sub-humid zones of Zimbabwe [6]. Intercropping maize with cowpea has been reported to increase light penetration in the intercrops, reduce water evaporation, and improve conservation of the soil moisture compared with maize alone [7].On the other hand, it is often believed that traditional intercropping systems are better in weeds, pests and diseases control compared to the monocrops, but it must be known that intercropping is an almost infinitely variable, and often complex, system in which adverse effects can also occur. As consequence of these, the optimum productivity of cereal-legume systems is still a big challenge to the stakeholders involved in this sector. This study will therefore contribute to useful information to smallholder farmers and other stakeholders on the optimum intercropping patterns, contribution of the system to the soil and the economic aspect of the maize-soybean cropping system. Maize and Soyabean is the major Kharif crop of the area. Hence an experiment was under taken on Maize and Soyabean intercropping in different patterns.

2. MATERIALS AND METHODS

An experiment was conducted at Agricultural Research Farm of Bhagwant University, Ajmer during Kharif season of 2018. The soils of experimental farm was sandy loam in texture; acidic in reaction (pH 6.72), poor in nitrogen (available N 202 Kg/ha), poor in phosphorus (19 P_2O_5 Kg/ha) and moderate in potash (236 K_2O Kg/ha). Treatment consists of Sole maize (60x20 cm), Sole Soyabean (30x10 cm), Maize-Soybean (1:1) (60X20 cm), Maize-Soybean (1:1) (75X20 cm), Maize-Soybean (1:1) (90X20 cm), Maize-Soybean (1:2) (90X20 cm) and Maize-Soybean (2:6) (Paired row 45/180 cm). There were four replicated blocks and plot sizes measuring 7 m x 4.5 m laid out in a randomized complete block design (RCBD). The land was prepared thoroughly by ploughing twice with the help of tractor followed by harrowing. The leveling was done to ensure uniform irrigation and proper drainage. Planking was done at the time of final land preparation to keep moisture intact in the soil. The field was cleaned by removing weeds and stubbles of previous crop. Maize and soyabean crop were sown in the first week of July 2018 by dibbling methods. Seeds were sown at 20 kg ha^{-1} at a depth of 2-3 cm, maintaining the row spacing as per treatments, followed by covering with soil. The rate of N, P_2O_5 and K_2O were applied at 20:50:0 kg ha^{-1} in the form of urea and single super phosphate, respectively. The entire dose of fertilizer was applied as basal, and then they were thoroughly mixed with the soil. The first irrigation was given at the time of sowing. The 2nd irrigation was given at 35 DAS. Rainfall helped the crop to avoid further irrigations in between. During the crop season total rainfall received was 179.9 mm. The crop was infested with maruca and powdery mildew at flowering stage. By forecasting the pest, spraying of 5 per cent neem seed kernel extract was done at the initiation of flowering in order to repel the insect from egg lying. Spraying of insecticides quinolphos (0.2 %) + dichlorovas (0.07 %) and chlorpyriphos (0.25 %) + dichlorovas (0.07 %) was sprayed followed by first spray of neem kernel extract at 8-10 days interval. On the onset of powdery mildew, spraying of carbendazim at 0.1 % concentration was done. The crop was harvested at physiological maturity stage in the last week of Sept., 2018. First the borders were harvested and separated. Later, the crop from each net plot was harvested and sun dried for 3 days, bundled, tagged, weighed and transported to threshing floor. Threshing was done for each plot and computed to kg ha^{-1} basis.

3. RESULTS AND DISCUSSION

Data were analysed by guide lines given by Fisher [8]. Data on yield and yield parameters of maize and soyabean as influenced by maize planting geometry and row proportions in maize + soybean intercropping systems are shown in Table 1 and Table 2, respectively. Economics of maize and soybean intercropping system as influenced by planting geometry and row proportions in maize + soybean intercropping systems are presented in Table 3. Production efficiency indices of maize + soyabean intercropping system are reported in Table 3. Per cent light transmission ratio at different growth stages as influenced by maize planting geometry and row proportions in maize + soybean intercropping systems is presented in Table 5. Maize grain yield differed significantly due to planting geometry and row ratios of maize and soybean in intercropping system (Table 1). Sole maize recorded significantly higher yield (70.9 q ha^{-1}) than intercropped maize under varying geometry and row proportion. However, it was at par with maize intercropped with soybean in 1:1 row proportion with 60 x 20 cm (70.0 q ha^{-1}). The maize yield reduced from 70.0 to 46.6 q ha^{-1} in intercropping system. The reduction in maize yield was due to competition between two crops and reduced maize population from 100 to 66 per cent. The increase in yield is attributed to increase in population of maize. One of the reasons for non significant variations in the growth and yield parameters between sole and intercropped maize in different planting geometry row ratios may be due to uniform fertilizer application based on per cent plant population and other management practices in all treatments. Soybean being short duration and short saturated crop with tap root system did not compete with tall maize for growth resources viz., nutrients, light and moisture. The results agree with the findings of Kankeri [9]. There were no significant differences in grain yield per plant and hundred seeds weight.

Further, the yield of sole soybean was significantly superior (21.8 q ha^{-1}) over other intercropped treatments (Table 2). This might be attributed to presence of recommended plant stand under sole cropping as against decreased population under intercropping system (75.3 %). Similar results were reported by Pattanashetti [10]. The yields of intercropped soybean varied with planting geometry and row proportions of maize. Among intercropping treatments, maize intercropped with soybean in paired row of 2:6 row proportion recorded higher grain yield (19.2 q ha^{-1}) than other intercropping. The yield of intercropped soybean decreased from 19.2 to 5.5 q ha^{-1}. This is because of lower availability of resources particularly light due to shading by tall maize crop. The results are in conformity with the findings of Singh *et al*., [11].

Maize equivalent yield (MEY) was significantly higher with maize + soybean paired row in 2:6 row proportion (94.70 q ha^{-1}). This was due to higher yield from the intercrop soybean component and higher prices of soybean in the market. Least MEY was recorded in sole soybean (54.5 q ha^{-1}). The net income was higher in maize + soybean in 2:6 paired row intercropping system (57,926 ha^{-1}) than those of other intercropping systems. The highest benefit cost ratio revealed that higher return per unit money invested for inputs used for raising crops. The highest B: C ratio was recorded with maize + soybean in 2:6 paired row (3.57) intercropping system. The least B: C ratio was recorded in sole soybean (2.45). This is due to lower cost of cultivation and also due to higher net returns in these treatments due to higher market price of soybean (Table 3). Similarly, higher net returns were also recorded by Mohan [11] with maize and soybean intercropping.

A perusal of data Table 4 indicates that among the intercropping systems, land equivalent ratio (LER) was the highest with maize intercropped with soybean in 2:6 paired row system (1.54). The higher LER with intercropping maize and soybean in 2:6 row ratio may be due to better performance of both the crops due to least competition for all growth resources in general and light in particular by greater complementary soybean. Such increase in LER in intercropping system was also observed by the earlier workers with maize + soybean [12].

Further, intercropping system of maize + soybean in 2:6 paired row system (50:75) resulted in significantly higher Area Time

Table 1. Yield and yield parameters of maize as influenced by maize planting geometry and row proportions in maize + soybean intercropping systems

Treatments	Population		Series	Seed yield (g plant^{-1})	100 seeds weight (g)	Grain yield (q ha^{-1})	Stover yield (q ha^{-1})	Harvest index (%)
	Maize	Soybean						
T_1: Maize + soybean (1:1) (60 x 20 cm)	100	50	A	132.0	33.6	70.0	88.8	44.0
T_2: Maize + soybean (1:1) (75 x 20 cm)	75	33	R	132.0	34.9	61.5	80.3	42.0
T_3: Maize + soybean (1:1) (90 cm 20 cm)	66	30	R	131.6	35.0	53.2	70.6	44.0
T_4: Maize + soybean (1:2) (90 x 20 cm)	66	58	R	131.3	36.6	46.6	67.1	41.0
T_5: Maize + soybean (2:6) (Paired row 45/180 cm)	50	75	R	133.3	35.0	49.3	69.6	43.0
T_6: Sole Maize (60 x 20 cm)	100	-	-	134.0	36.6	49.3	69.6	
S.Em.±				0.99	1.20	1.75	2.4	0.01
C.D. (P=0.05)				NS	NS	5.52	7.5	NS

**DAS: Days after sowing, NS: Non significant, A: Additive series, R: Replacement series*

Table 2. Yield and yield parameters of soybean as influenced by maize planting geometry and row proportions in maize + soybean intercropping systems

Treatments	Population		Series	Seed yield (g plant^{-1})	100 seeds weight (g)	Grain yield (q ha^{-1})	Stover yield (q ha^{-1})	Harvest index (%)
	Maize	Soybean						
T_1: Maize + soybean (1:1) (60 x 20 cm)	100	50	A	2.65	12.4	5.5	7.5	42.0
T_2: Maize + soybean (1:1) (75 x 20 cm)	75	33	R	2.80	13.1	6.5	8.6	43.0
T_3: Maize + soybean (1:1) (90 cm 20 cm)	66	30	R	3.00	13.9	8.4	9.9	46.0
T_4: Maize + soybean (1:2) (90 x 20 cm)	66	58	R	3.30	14.1	11.8	13.1	47.0
T_5: Maize + soybean (2:6) (Paired row 45/180 cm)	50	75	R	3.0	14.6	19.2	20.9	48.0
T_6: Sole Soyabean (60 x 20 cm)	100	-	-	3.57	14.9	21.8	22.6	50.0
S.Em.±				0.18	1.16	0.39	0.49	0.01
C.D. (P=0.05)				NS	NS	1.23	1.50	NS

**DAS: Days after sowing, NS: Non significant, A: Additive series, R: Replacement series*

Table 3. Economics of maize and soybean intercropping system as influenced by planting geometry and row proportions in maize + soybean intercropping systems

Treatments	Population		Series	Cost of cultivation	Gross returns	Net returns	B: C ratio
	Maize	Soybean					
T_1: Maize + soybean (1:1) (60 x 20 cm)	100	50	A	25637	72352	46715	2.82
T_2: Maize + soybean (1:1) (75 x 20 cm)	75	33	R	23377	67182	43805	2.87
T_3: Maize + soybean (1:1) (90 cm 20 cm)	66	30	R	21929	63830	41901	2.91
T_4: Maize + soybean (1:2) (90 x 20 cm)	66	58	R	23263	67556	44293	2.90
T_5: Maize + soybean (2:6) (Paired row 45/180 cm)	50	75	R	22571	80479	57926	3.57
T_6: Sole Maize (60 x 20 cm)	100	-	-	23206	61638	38432	2.66
T_7: Sole Soybean (30 x 10 cm)	-	100	-	18256	44683	26427	2.45
S.Em.±	-	-	-	-	1497	1497	0.06
C.D. (P=0.05)	-	-	-	-	4613	4613	0.19

**DAS: Days after sowing, NS: Non significant, A: Additive series, R: Replacement series*

Table 4. Production efficiency indices of maize + soyabean intercropping system

Treatments	Population		Series	LER	ATER	MEY (q ha^{-1})
	Maize	Soybean				
T_1: Maize + soybean (1:1) (60 x 20 cm)	100	50	A	1.24	1.18	83.87
T_2: Maize + soybean (1:1) (75 x 20 cm)	75	33	R	1.17	1.09	77.92
T_3: Maize + soybean (1:1) (90 cm 20 cm)	66	30	R	1.14	1.04	74.31
T_4: Maize + soybean (1:2) (90 x 20 cm)	66	58	R	1.24	1.10	78.84
T_5: Maize + soybean (2:6) (Paired row 45/180 cm)	50	75	R	1.54	1.32	94.70
T_6: Sole Maize (60 x 20 cm)	100	-	-	1.00	1.00	70.92
T_7: Sole Soybean (30 x 10 cm)	-	100	-	1.00	1.00	54.50
S.Em.±	-	-	-	0.03	0.02	1.92
C.D. (P=0.05)	-	-	-	0.09	0.08	5.92

**DAS: Days after sowing, NS: Non significant, A: Additive series, R: Replacement series*

Table 5. Per cent light transmission ratio at different growth stages as influenced by maize planting geometry and row proportions in maize + soybean intercropping systems

Treatments	Population		Series	30 DAS*	60 DAS	90 DAS
	Maize	Soybean				
T_1: Maize + soybean (1:1) (60 x 20 cm)	100	50	A	63.27	32.57	28.55
T_2: Maize + soybean (1:1) (75 x 20 cm)	75	33	R	62.95	31.22	28.27
T_3: Maize + soybean (1:1) (90 cm 20 cm)	66	30	R	60.53	31.47	27.59
T_4: Maize + soybean (1:2) (90 x 20 cm)	66	58	R	60.21	31.97	27.59
T_5: Maize + soybean (2:6) (Paired row 45/180 cm)	50	75	R	59.73	31.22	27.13
T_6: Sole Maize (60 x 20 cm)	100	-	-	63.97	32.82	28.82
T_7: Sole Soybean (30 x 10 cm)	-	100	-	65.37	34.52	30.57
S.Em.±	-	-	-	0.03	0.05	0.22
C.D. (P=0.05)	-	-	-	0.10	0.16	0.67

**DAS: Days after sowing, NS: Non significant, A: Additive series, R: Replacement series*

Equivalent Ratio (ATER) (1.32) indicating higher per day productivity from the system (Table 4). This was possibly due to greater temporal and spatial complementarily. These results agree with the results of Gardner and Kisakye [13] in maize + *Phaseolus vulgaris* intercropping system.

The results data Table 5 revealed that, among all intercropping systems maize intercropped with soybean in 2:6 paired row system recorded least light transmission ratio compared to sole and other treatments. The average light transmission ratio (LTR) at 30 DAS decreased from 65.37 per cent in sole maize (60 x 20 cm in) to 59.73 - 63.27 per cent in maize and soybean intercropping in different planting geometry and row ratios. The corresponding LTR per cent at 60 and 90 DAS were 34.52 to 31.22 and 30.57 to 27.13 per cent respectively. This resulted in improvement of average light interception at different phenological stages of maize. Thus, intercropping systems of maize and soybean with lower LTR was able to intercept more light compared to sole maize.

4. CONCLUSION

From the above study, it can be concluded that the maize-soybean intercropping patterns had significant effect on maize grain and stover yields. Sole maize recorded significantly higher yield than intercropped maize under varying geometry and row proportion. However, it was at par with maize intercropped with soybean in 1:1 row proportion with 60 x 20 cm. Further, the yield of sole soybean was significantly superior over other intercropped treatments. The highest B: C ratio was recorded with maize + soybean in 2:6 paired row (3.57) intercropping system.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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