Effect on Growth and Economics in Maize (*Zea mays* L.) Based Intercropping Systems

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Article History

Article ID: IJEP115
Received in 12th November, 2016
Received in revised form 17th November, 2016
Accepted in final form 22nd November, 2016

Abstract

A study was conducted on the effect on growth and economics in maize (*Zea mays* L.) based intercropping systems at the experimental farm of School of Agricultural Sciences and Rural Development (SASRD) Nagaland University, Medziphema Campus, Nagaland under rainfed condition during 2015 and 2016. The treatments comprised of different row ratios *i.e.* (1:1), (1:2), (2:1) and (2:2) respectively of maize intercropped with perilla, sesame, ricebean and soybean along with sole crops of maize, perilla, sesame, ricebean and soybean. The experiment was laid in RBD with 3 replications and 21 treatments. Among the different sole crops sole maize performed better with respect to growth and yield. Among the different intercropping systems paired rows (2:2) ratios of maize + soybean performed significantly better in terms of yield (1564.21 kg ha^{-1}, 1567.10 kg ha^{-1}, 1565.65 kg ha^{-1}). As for economics, paired rows (2:2) ratios of maize + soybean proved superior to all other treatments in LER (1.78, 1.78), net return (INR 1,42,612.6, INR 1,44,779.4), gross return (INR 1,72,612.6, INR 1,74,779.4) and B:C ratio (4.75 and 4.82).

Keywords: Economics, growth, intercropping, LER, maize, yield

1. Introduction

The availability of land for agriculture is shrinking day by day as it is being utilized for many non agricultural purposes. Intercropping has been recognized as a beneficial system of crop production. Most common advantage of intercropping is the production of greater yield on a given piece of land by making more efficient use of the available growth resources using a mixture of crops of different rooting ability, canopy structure, height and nutrient requirements based on the complementary utilization of growth resources by the component crops. Of the 2 types of intercropping, additive series is growing of intercrop between the rows of main crop without any adjustment in the spacing of the main crop whereas in paired series, the spacing of the main crop is reduced and equal opportunity is given to the intercrop for better growth. The crops are grown in pair of 2 in case of paired series. Legumes are known to fix atmospheric nitrogen, thus enriching soil fertility and helping to meet the N needs of cereals (Manna et al., 2003). Pulses being rich source of protein form an integral part of vegetarian diet in Indian sub continent. They maintain soil fertility through biological nitrogen fixation, improve soil organic matter content by leaf fall at the time of maturity and occupy prominent place in various cropping systems and crop mixtures. Thus pulses play a vital role in providing protein rich food to human beings and in sustaining both soil health and crop production on long-term basis. The progressive decline in total factor productivity and soil health necessitates crop diversification through inclusion of pulses in the system. An intensive cropping system is not only highly productive and profitable but also stable and sustainable over time. In India, maize and soybean are the 2 major crops grown under rainfed eco-systems during rainy (*Kharif*) season.

Maize (*Zea mays* L.) is one of the important cereal crops next to wheat and rice in the world and maize-pulse cropping system is most important food legume based system in the country. Maize or corn is the third most important crop in India after rice and wheat grown over 8.67 million ha with 22.26 million tonnes production having an average productivity of 2566 kg ha^{-1}, contributing 8% in national food basket (DACNET, 2014). Maize (*Zea mays* L.) is important food crop of the world both in terms of area (139 million hectare) and production (600 metric tonnes). The area, production and productivity of maize for the year 2012-2013 under Nagaland was 63530 ha, 124580 metric tonnes and 1960 kg ha^{-1} (*Kharif*) and 5140 ha, 10070 metric tonnes and 1960 kg ha^{-1} (*Rabi*) (DOA, 2014).

Perilla frutescens (L.) Britt., belonging to the family Lamiaceae (Labiatae), is native to mountainous areas of China and

India and is grown mainly in Asia. *Perilla frutescens* with red coloured leaves is an edible plant, frequently used as one of the most popular spices and food colorants in some Asian countries such as China, Japan and India. *Perilla frutescens* (L.) have been used as an important traditional herbal medicine for treating various disease including depression, anxiety, tumor, cough, antioxidant, allergy, intoxication, and some intestinal disorders**.** In northern India the stem of the plant is traditionally used as an analgesic and anti-abortive agent.

Sesame or gingelly (*Sesamum indicum* L.) commonly known as *til* (Hindi) is an ancient oilseed crop grown in India and perhaps the oldest oilseed crop in the world. It is one of the important edible oilseeds cultivated in India. The area, production and productivity of sesamum for the year 2012-2013 under Nagaland was 3540 ha, 2130 metric tonnes and 601 kg ha^{-1} (*Kharif*) (DOA, 2014).

Ricebean (*Vigna umbellata*) a new introduction in the country, is a versatile crop. It is a good food grain, a fodder, and a cover crop. However, its economic utility and complete production technology is yet to be determined (Ahmed and Ashiq, 1992). The area, production and productivity of ricebean for the year 2012-2013 under Nagaland was 4630 ha, 5060 metric tonnes and 1092 kg ha^{-1} (*Kharif*) (DOA, 2014).

Soybean (*Glycine max* (L.) Merrill) is an important and a major oilseed crop of the world. Soybean is an important oilseed crop gaining importance in India and is considered as golden bean. In Nagaland, The area, production and productivity of soybean for the year 2012-2013 under Nagaland was 24.67 thousand ha, 30880 metric tonnes and 1251 kg ha^{-1} (*Kharif*) (DOA, 2014). It is one of the most popular food items of majority of the people of Nagaland and is utilized as a pulse crop and as fermented products locally called as 'Akhuni'. Soybean is a thermo sensitive crop and usually grown in environment with temperature ranges between 10° to 40°C (Whighum, 1983).

2. Materials and Methods

The experiment was conducted at the experimental farm of School of Agricultural Sciences and Rural Department, Department of Agronomy, Medziphema Campus during the *Kharif* of 2015 and 2016 under rainfed condition. The experimental site is located at 25^{o}45'43'' North latitude and 93^{o}53'04'' East longitude at an altitude of 310 meter above mean sea level. The climate of the experimental farm represents sub-humid tropical climate zone with relative humidity, moderate temperature with medium to high rainfall. The mean temperature ranges from 21 °C to 32 °C during summer and rarely goes below 8 °C in winter due to high atmospheric humidity. The average rainfall varies between 2000-2500 mm starting from April and ends with the month of September while the period from October to March remains complete dry. The soil of the experimental plot was categorized as sandy loam and well drained. The experiment was conducted in randomized block design with 3 Replications and 21 Treatments. The treatments comprised of sole crops of maize (Table 1, 2, 3 and 4), perilla, sesame, ricebean and soybean with different intercropping treatments of 1:1, 1:2,

Table 1: Effect of maize (*Zea mays* L.) based intercropping systems on growth in maize

Treatment	Plant height (cm)			Leaf Area Index (LAI)			Stem thickness (cm)		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_1	298.00	332.50	315.25	2.23	2.22	2.23	2.44	2.45	2.44
T_2	-	-	-	-	-	-	-	-	-
T_3	-	-	-	-	-	-	-	-	-
T_4	-	-	-	-	-	-	-	-	-
T_5	-	-	-	-	-	-	-	-	-
T_6	322.67	323.92	323.29	2.05	2.05	2.05	2.39	2.40	2.40
T_7	330.00	332.50	331.25	1.93	1.92	1.93	2.50	2.51	2.50
T_8	318.00	317.92	317.96	1.82	1.81	1.82	2.23	2.24	2.24
T_9	322.00	324.17	323.08	2.14	2.13	2.13	2.47	2.48	2.48
T_{10}	321.33	323.25	322.29	2.13	2.13	2.13	2.31	2.32	2.31
T_{11}	317.33	318.42	317.88	1.91	1.90	1.90	2.13	2.14	2.14
T_{12}	328.00	330.58	329.29	2.28	2.28	2.28	2.51	2.52	2.52
T_{13}	333.33	335.25	334.29	2.20	2.20	2.20	2.45	2.46	2.46
T_{14}	324.67	326.92	325.79	2.26	2.26	2.26	2.36	2.37	2.36
T_{15}	341.67	343.50	342.58	2.28	2.27	2.28	2.49	2.50	2.50
T_{16}	309.00	309.67	309.33	2.09	2.08	2.08	2.30	2.31	2.30

Treatment	Plant height (cm)			Leaf Area Index (LAI)			Stem thickness (cm)		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_{17}	331.33	331.92	331.63	2.25	2.25	2.25	2.30	2.31	2.31
T_{18}	334.33	336.25	335.29	2.23	2.23	2.23	2.44	2.45	2.45
T_{19}	323.67	324.33	324.00	2.12	2.11	2.12	2.35	2.36	2.35
T_{20}	310.33	311.33	310.83	2.12	2.11	2.12	2.20	2.21	2.21
T_{21}	338.67	341.17	339.92	2.52	2.52	2.52	2.51	2.52	2.52
SEm±	9.15	2.04	4.69	0.07	0.07	0.05	0.03	0.03	0.02
CD (*p*=0.05)	NS	5.86	13.24	0.20	0.20	0.14	0.08	0.08	0.06

T_1-Sole Maize;T_2-Sole Perilla; T_3-Sole Sesame; T_4-Sole Ricebean; T_5-Sole Soybean; T_6-Maize +Perilla (1:1); T_7-Maize +Perilla (1:2); T_8-Maize +Perilla (2:1); T_9-Maize +Perilla (2:2); T_{10}-Maize +Sesame (1:1); T_{11}-Maize +Sesame (1:2); T_{12}-Maize +Sesame (2:1); T_{13}-Maize +Sesame (2:2); T_{14}-Maize +Ricebean (1:1); T_{15}-Maize +Ricebean (1:2); T_{16}-Maize +Ricebean (2:1); T_{17}-Maize +Ricebean (2:2); T_{18}-Maize +Soybean (1:1); T_{19}-Maize +Soybean (1:2); T_{20}-Maize +Soybean (2:1); T_{21}-Maize +Soybean (2:2);

Table 2: Effect of maize (*Zea mays* L.) based intercropping systems on yield in maize

Treatment	No. of cobs plant^{-1}			Cob weight (g)			No. of grains cob^{-1}		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_1	1.87	1.97	1.92	143.67	144.67	144.17	555.33	556.00	555.67
T_2	-	-	-	-	-	-	-	-	-
T_3	-	-	-	-	-	-	-	-	-
T_4	-	-	-	-	-	-	-	-	-
T_5	-	-	-	-	-	-	-	-	-
T_6	1.65	1.70	1.68	118.33	119.33	118.83	489.33	490.00	489.67
T_7	1.77	1.93	1.85	131.00	132.00	131.50	531.33	532.00	531.67
T_8	1.53	1.60	1.57	115.33	116.33	115.83	400.00	400.67	400.33
T_9	1.70	1.80	1.75	127.00	128.00	127.50	511.33	512.00	511.67
T_{10}	1.62	1.68	1.65	122.67	123.67	123.17	430.00	430.67	430.33
T_{11}	1.57	1.60	1.58	112.33	113.33	112.83	390.00	390.67	390.33
T_{12}	1.80	1.87	1.83	131.00	132.00	131.50	500.00	500.67	500.33
T_{13}	1.68	1.80	1.74	126.00	127.00	126.50	460.00	460.67	460.33
T_{14}	1.68	1.77	1.73	133.33	134.33	133.83	472.67	473.33	473.00
T_{15}	1.80	1.93	1.87	137.33	138.33	137.83	501.33	502.00	501.67
T_{16}	1.53	1.62	1.58	112.67	113.67	113.17	336.00	336.67	336.33
T_{17}	1.67	1.77	1.72	128.00	129.00	128.50	389.33	390.00	389.67
T_{18}	1.68	1.77	1.73	128.33	129.33	128.83	466.00	466.67	466.33
T_{19}	1.67	1.70	1.68	120.67	121.67	121.17	432.67	433.33	433.00
T_{20}	1.63	1.67	1.65	114.67	115.67	115.17	359.33	360.00	359.67
T_{21}	1.83	1.90	1.87	137.67	138.67	138.17	496.67	497.33	497.00
SEm±	0.03	0.03	0.02	2.59	2.24	1.71	12.16	12.15	8.60
CD (*p*=0.05)	0.09	0.10	0.06	7.46	6.46	4.84	35.03	35.01	24.29

2:1 and 2:2 respectively. The field was initially cleaned and then ploughed by tractor drawn disc plough followed by two light ploughing with power tiller. Then the field was leveled properly and as per statistical design the plots were laid out in the field. During initial ploughing of the soil well decomposed FYM @ 10 t ha^{-1} was applied in all the plots and thoroughly mixed. Spacing for sole maize was maintained at 60 × 25 cm while for other intercrop it was 30 × 20 cm. For recording

Table 3: Effect of maize (*Zea mays* L.) based intercropping systems on yield in maize

Treatment	Shelling percentage (%)			Grain yield (kg ha^{-1})			Stover yield (kg ha^{-1})		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_1	81.00	80.67	80.83	4230.00	4330.12	4280.06	5196.82	5396.82	5296.82
T_2	-	-	-	-	-	-	-	-	-
T_3	-	-	-	-	-	-	-	-	-
T_4	-	-	-	-	-	-	-	-	-
T_5	-	-	-	-	-	-	-	-	-
T_6	72.33	72.00	72.17	3609.67	3710.33	3660.00	4710.50	4910.83	4810.67
T_7	76.67	76.33	76.50	3902.33	4002.33	3952.33	5003.00	5203.46	5103.23
T_8	66.67	66.33	66.50	3357.33	3457.67	3407.50	4457.67	4715.34	4586.50
T_9	73.67	73.33	73.50	3809.00	3909.33	3859.17	4910.00	5093.80	5001.90
T_{10}	67.67	67.33	67.50	3810.00	3910.33	3860.17	4911.00	5111.11	5011.05
T_{11}	67.00	66.67	66.83	3340.33	3440.67	3390.50	4440.67	4640.69	4540.68
T_{12}	76.67	76.33	76.50	3948.33	4048.67	3998.50	5049.33	5249.64	5149.49
T_{13}	73.33	73.00	73.17	3796.67	3896.33	3846.50	4896.67	5096.68	4996.67
T_{14}	67.33	67.00	67.17	3836.67	3936.33	3886.50	4936.67	5137.09	5036.88
T_{15}	76.00	75.67	75.83	3995.67	4094.67	4045.17	5329.00	5529.58	5429.29
T_{16}	68.67	68.33	68.50	3311.67	3530.00	3420.83	4530.33	4730.16	4630.25
T_{17}	67.67	67.33	67.50	3678.00	3778.00	3728.00	4778.00	4978.35	4878.18
T_{18}	78.33	78.00	78.17	3730.00	3829.33	3779.67	4830.00	5030.30	4930.15
T_{19}	73.00	72.67	72.83	3467.33	3567.00	3517.17	4567.33	4767.68	4667.51
T_{20}	71.00	70.67	70.83	3112.33	3212.00	3162.17	4212.33	4412.70	4312.52
T_{21}	79.00	78.67	78.83	3999.59	4104.33	3987.83	5038.00	5238.10	5138.05
SEm±	1.89	1.71	1.27	193.81	162.93	126.60	164.46	157.55	113.88
CD (*p*=0.05)	5.44	4.92	3.60	558.30	469.35	357.67	473.76	453.86	321.72

Table 4: Effect of maize (*Zea mays* L.) based intercropping systems on growth in perilla

Treatment	Plant height (cm)			Leaf Area Index (LAI)			No. of primary branches plant^{-1}			Stem thickness (cm)		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_2	118.92	117.67	118.29	1.98	1.98	1.98	10.42	10.33	10.38	1.59	1.59	1.59
T_6	112.75	111.75	112.25	1.91	1.90	1.90	8.75	8.67	8.71	1.38	1.39	1.39
T_7	116.83	115.83	116.33	1.96	1.95	1.95	9.58	9.50	9.54	1.36	1.36	1.36
T_8	109.58	108.25	108.92	1.88	1.88	1.88	8.17	8.08	8.13	1.37	1.38	1.37
T_9	115.08	114.42	114.75	1.94	1.93	1.94	9.33	9.25	9.29	1.41	1.41	1.41
SEm±	0.35	0.50	0.31	0.01	0.01	0.00	0.12	0.11	0.08	0.02	0.02	0.01
CD (*p*=0.05)	1.15	1.64	0.92	0.02	0.02	0.01	0.39	0.34	0.24	0.06	0.05	0.04

growth and yield parameters, 5 plants were selected randomly from each plot excluding the border rows and were carefully tagged. The shelling %age (SP) was calculated as grain weight divided by the total pod or cob weight and represented as % (Table 5 and 6).

3. Results and discussion

3.1. Growth parameters

There was significant variation among the various treatments during the early growth period. 1:2 row ratio of maize + rice bean recorded the maximum plant height in all the growth stages in both the years as compared to all other intercropping treatments. The increase in the plant height might be due to

Table 5: Effect of maize (*Zea mays* L.) based intercropping systems on yield in perilla

Treatment	No. of capsules plant^{-1}			No. of seeds capsule^{-1}			Seed yield (kg ha^{-1})			Stover yield (kg ha^{-1})		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_2	148.75	149.42	149.08	38.92	39.25	39.08	890.91	892.26	891.58	1468.01	1494.95	1481.48
T_6	142.17	142.83	142.50	34.58	34.92	34.75	642.13	644.16	643.15	1154.40	1177.49	1165.95
T_7	145.83	146.50	146.17	37.58	37.92	37.75	715.73	717.75	716.74	1235.21	1258.30	1246.75
T_8	140.83	141.50	141.17	34.25	34.58	34.42	551.23	553.24	552.24	1079.36	1102.45	1090.91
T_9	144.25	144.92	144.58	35.92	36.25	36.08	675.32	677.34	676.33	1194.80	1217.89	1206.35
SEm±	0.50	0.38	0.31	0.45	0.45	0.32	19.32	19.30	13.65	18.28	18.25	12.91
CD (p=0.05)	1.15	1.64	0.92	1.46	1.46	0.95	63.02	62.93	40.93	59.61	59.52	38.72

Table 6: Effect of maize (*Zea mays* L.) based intercropping systems on growth in sesame

Treatment	Plant height (cm)			Leaf area index (LAI)			No. of primary branches plant^{-1}			Stem thickness (cm)		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_3	208.33	208.00	208.17	1.51	1.51	1.51	16.33	16.27	16.30	1.86	1.87	1.86
T_{10}	192.00	191.67	191.83	1.24	1.23	1.24	12.33	12.27	12.30	1.60	1.61	1.61
T_{11}	186.33	186.00	186.17	1.13	1.12	1.13	11.33	11.27	11.30	1.56	1.57	1.57
T_{12}	199.33	199.00	199.17	1.32	1.32	1.32	15.00	14.93	14.97	1.81	1.82	1.81
T_{13}	197.00	196.67	196.83	1.35	1.35	1.35	13.67	13.60	13.63	1.76	1.78	1.77
SEm±	2.11	2.11	1.49	0.02	0.02	0.02	0.51	0.45	0.34	0.07	0.08	0.05
CD (p=0.05)	6.88	6.88	4.47	0.07	0.08	0.05	1.65	1.47	1.02	NS	NS	0.16

the reason that maize was sown early as compared to the component intercrop and which provides better opportunity for elongation of stem to compete and take up more of moisture, nutrients and other growth factors. The maximum LAI was reported in 2:2 paired row ratios of maize and soybean which showed increase till up to 90 DAS and then gradually decline or there was lesser increase in LAI as it reaches to maturity. The higher value of LAI at early growth stages was due to better growth and productivity of the crop. In a similar study, Alhaji (2008) found that intercropping of different varieties of cowpea with maize was significant in affecting the plant height, leaf area and leaf area indices of maize. Sole maize performed better or reported maximum stem thickness as compared to other intercropping treatments.

3.2. *Yield parameters*

Sole Maize recorded significantly higher values in regard to number of cobs plant^{-1} than all the different intercropping treatments (Table 7). Introduction of intercrops in maize reduces the yield attributes of maize however, less reduction was noted in 2:1 row ratio of maize + perilla as compared to other different intercropping treatments. It may be because of the reason that the peak demand periods of the 2 crops for light, nutrients and water were different and there was optimum utilization of physical resources. This was in conformity with the findings by Padhi (2001) who reported

Table 7: Effect of maize (*Zea mays* L.) based intercropping systems on yield in sesame

Treatment	No. of capsules plant^{-1}			No. of seeds capsule^{-1}			Seed yield (kg ha^{-1})			Stover yield (kg ha^{-1})		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_3	188.67	190.33	189.50	23.33	23.33	23.33	1562.29	1542.09	1552.19	2171.72	2151.51	2161.62
T_{10}	165.33	168.33	166.83	22.67	21.67	22.17	1177.49	1154.40	1165.95	1483.40	1463.20	1473.30
T_{11}	160.67	158.00	159.33	22.00	22.67	22.33	961.04	940.72	950.88	1367.96	1350.65	1359.31
T_{12}	182.33	184.00	183.17	22.33	22.75	22.54	1318.90	1301.59	1310.24	1751.80	1708.51	1730.16
T_{13}	175.33	178.67	177.00	22.00	22.33	22.17	1229.20	1212.23	1220.71	1575.75	1558.44	1567.10
SEm±	5.89	6.46	4.37	1.31	1.23	0.90	10.19	11.89	7.83	72.99	73.79	51.89
CD (p=0.05)	19.19	21.07	13.10	NS	NS	NS	33.22	38.76	23.47	238.02	240.65	155.58

that intercropping reduced the values of yield attributes and Kaushal et al. (2015) who did on maize (*Zea mays*) based intercropping systems. The highest cob weight was recorded in sole maize with mean of 143.67 g, 144.67 g and pooled of 144.17 g. Sole Maize with mean of 555.33, 556.00 and pooled of 555.67 recorded the maximum number of grains cob^{-1}. Sole Maize with mean of 81%, 80.67% and pooled of 80.83% observed the highest shelling % age. Significantly highest grain yield was obtained in Sole crop of Maize. Intercropping of maize with different intercrops resulted in statistically at par results with all treatments except at 1:2 row ratio of maize+ricebean which recorded the lowest grain yield (Table 8 and 9). 2:2 paired row ratio of maize + soybean recorded the highest grain yield among all the different intercropping

Table 8: Effect of maize (*Zea mays* L.) based intercropping systems on growth and yield in ricebean

Treatment	Plant height (cm)			Stem thickness (mm)			No. of pods plant^{-1}			Number of seeds pod^{-1}		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_4	148.75	148.42	148.58	5.88	5.89	5.89	125.33	126.00	125.67	8.57	8.90	8.73
T_{14}	145.08	144.75	144.92	4.69	4.70	4.69	117.00	117.67	117.33	7.87	8.20	8.03
T_{15}	146.75	146.42	146.58	5.22	5.23	5.23	122.33	123.00	122.67	8.40	8.73	8.57
T_{16}	141.50	141.17	141.33	4.71	4.72	4.71	107.00	107.67	107.33	7.07	7.37	7.22
T_{17}	144.00	143.67	143.83	4.79	4.80	4.79	111.67	112.33	112.00	7.37	7.63	7.50
SEm±	0.43	0.45	0.31	0.12	0.12	0.08	1.97	1.95	1.39	0.16	0.25	0.15
CD (p=0.05)	1.42	1.48	0.94	0.38	0.39	0.25	6.44	6.37	4.16	0.51	0.80	0.44

Table 9: Effect of maize (*Zea mays* L.) based intercropping systems on yield in ricebean

Treatment	Seed yield (kg ha^{-1})			Stover yield (kg ha^{-1})		
	2015	2016	Pooled	2015	2016	Pooled
T_4	1505.05	1515.15	1510.10	1713.80	1723.90	1718.85
T_{14}	1148.63	1157.29	1152.96	1321.79	1339.10	1330.45
T_{15}	1220.78	1229.44	1225.11	1393.94	1402.60	1398.27
T_{16}	981.24	998.55	989.90	1160.17	1194.80	1177.49
T_{17}	1119.77	1128.43	1124.10	1298.70	1307.36	1303.03
SEm±	17.65	17.00	12.25	18.30	15.90	12.12
CD (p=0.05)	57.55	55.43	36.73	59.68	51.85	36.34

(Table 10 and 11). The reason for maximum grain yield in paired row planting may be due to decreased competition between plants because of equivalent spatial arrangement of plant. Similar finding was also reported by Maitra et al. (2000). Intercropping significantly affected grain yield of maize crop. Intercropped maize provided slightly lower grain yield than sole cropping on mean basis. This decline in the grain yield despite similar plant population in sole and intercropped stand may be attributed to change in the planting pattern, which induced more inter-species and intra-species competition in the intercropped stand, both underground and above-ground (Jain et al., 2015) (Table 12).

Table 10: Effect of maize (*Zea mays* L.) based intercropping systems on growth in soybean

Treatment	Plant height (cm)			No. of primary branches plant^{-1}			Stem thickness (cm)		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_5	97.33	96.00	96.67	10.38	10.31	10.34	1.46	1.47	1.47
T_{18}	91.00	89.67	90.33	10.13	10.09	10.11	1.44	1.44	1.44
T_{19}	88.00	86.67	87.33	9.96	9.92	9.94	1.37	1.38	1.38
T_{20}	84.00	83.67	83.83	9.83	9.75	9.79	1.29	1.29	1.29
T_{21}	95.33	94.00	94.67	10.26	10.22	10.24	1.46	1.47	1.47
SEm±	1.95	2.37	1.54	0.27	0.31	0.21	0.02	0.02	0.01
CD (p=0.05)	6.36	7.74	4.60	NS	NS	NS	0.06	0.07	0.04

Table 11: Effect of maize (*Zea mays* L.) based intercropping systems on yield in soybean

Treatment	Number of root nodules plant^{-1}			Number of pods plant^{-1}			Seed yield (kg ha^{-1})		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_5	24.25	24.75	24.50	52.00	53.17	52.58	1838.38	1841.75	1840.07
T_{18}	21.25	21.75	21.50	47.33	48.50	47.92	1518.04	1520.92	1519.48
T_{19}	20.33	20.83	20.58	44.45	45.62	45.03	1460.32	1463.20	1461.76
T_{20}	20.08	20.58	20.33	44.00	45.17	44.58	1419.91	1422.80	1421.35
T_{21}	22.58	23.08	22.83	50.58	51.75	51.17	1564.21	1567.10	1565.65
SEm±	0.25	0.23	0.17	1.82	1.57	1.20	17.86	15.72	11.89
CD (p=0.05)	0.82	0.75	0.51	5.94	5.13	3.61	58.23	51.27	35.66

Table 12: Effect of maize (*Zea mays* L.) based intercropping systems on yield in soybean

Treatment	Stover yield (kg ha^{-1})			Test weight (g)		
	2015	2016	Pooled	2015	2016	Pooled
T_5	2922.56	2912.46	2917.51	35.06	35.37	35.22
T_{18}	2329.00	2323.23	2326.12	32.92	33.24	33.08
T_{19}	2271.28	2265.51	2268.40	32.71	33.25	32.98
T_{20}	2150.07	2144.30	2147.18	32.84	33.73	33.29
T_{21}	2401.15	2395.38	2398.27	33.52	33.93	33.72
SEm±	37.12	37.67	26.44	0.53	0.65	0.42
CD (p=0.05)	121.06	122.85	79.28	NS	NS	NS

3.3. Economics

The data on gross return revealed that it was highest in all the intercropping as compared to their respective sole crop treatments. This may be attributed to higher total yield of the component crops over the sole crop. Maize and Soybean at 2:2 paired row ratio recorded the highest gross return which can be attributed to the higher seed yield of soybean (Table 13). The highest net return among the different intercropping treatments was recorded in 2:2 paired row ratios of Maize + Soybean. The results are in close conformity with the findings

Table 13: Effect of maize (*Zea mays* L.) based intercropping systems on yield in soybean

Treatment	Cost of cultivation (₹ ha^{-1})		Gross return (₹ ha^{-1})		Net return (₹ ha^{-1})	
	2015	2016	2015	2016	2015	2016
T_1	24500	24500	84600	86602.4	60100	62102.4
T_2	21000	21000	53454.6	53535.6	32454.6	32535.6
T_3	21846	21846	93737.4	92525.4	71891.4	70679.4
T_4	21335	21335	90303	90909	68968	69574
T_5	24000	24000	110302.8	110505	86302.8	86505
T_6	29000	29000	110721.2	112856.2	81721.2	83856.2
T_7	30000	30000	120990.4	123111.6	90990.4	93111.6
T_8	29000	29000	100220.4	102347.8	71220.4	73347.8
T_9	30000	30000	116699.2	118827	86699.2	88827
T_{10}	29846	29846	146849.4	147470.6	117003.4	117624.6
T_{11}	31000	31000	124469	125256.6	93469	94256.6
T_{12}	29846	29846	158100.6	159068.8	128254.6	129222.8
T_{13}	31000	31000	149685.4	150660.4	118685.4	119660.4

Continue...

Treatment	Cost of cultivation (₹ ha^{-1})		Gross return (₹ ha^{-1})		Net return (₹ ha^{-1})	
	2015	2016	2015	2016	2015	2016
T_{14}	29335	29335	145651.2	148164	116316.2	118829
T_{15}	30000	30000	153160.2	155659.8	123160.2	125659.8
T_{16}	29335	29335	125107.8	130513	95772.8	101178
T_{17}	30000	30000	140746.2	143265.8	110746.2	113265.8
T_{18}	29000	29000	165682.4	167841.8	136682.4	138841.8
T_{19}	30000	30000	156965.8	159132	126965.8	129132
T_{20}	29000	29000	147441.2	149608	118441.2	120608
T_{21}	30000	30000	172612.6	174779.4	142612.6	144779.4

Table 14: Effect of maize (*Zea mays* L.) based intercropping systems on yield in soybean

Treatment	LER		Benefit cost ratio (B:C) grain yield (kg ha^{-1})	
	2015	2016	Pooled	2015
T_1	1	1	2.45	2.53
T_2	1	1	1.54	1.55
T_3	1	1	3.29	3.23
T_4	1	1	3.23	3.26
T_5	1	1	3.59	3.60
T_6	1.57	1.57	2.82	2.89
T_7	1.72	1.72	3.03	3.10
T_8	1.41	1.41	2.45	2.53
T_9	1.66	1.66	2.89	2.96
T_{10}	1.65	1.65	3.92	3.94
T_{11}	1.4	1.4	3.01	3.04
T_{12}	1.77	1.77	4.30	4.33
T_{13}	1.69	1.69	3.83	3.86
T_{14}	1.67	1.67	3.96	4.05
T_{15}	1.75	1.75	4.10	4.19
T_{16}	1.43	1.43	3.26	3.45
T_{17}	1.61	1.61	3.69	3.77
T_{18}	1.7	1.7	4.71	4.79
T_{19}	1.61	1.61	4.23	4.30
T_{20}	1.5	1.5	4.08	4.16
T_{21}	1.78	1.78	4.75	4.82

of Shivay et al. (2001), Padhi and Panigrahi (2006) and Kaushal et al. (2015). Similar finding was reported by Panwar et al. (2016) on beneficial of paired row ratios. The data revealed that 2:2 paired row ratio of Maize + Soybean gave maximum B:C ratio which might be due to the highest net return. Similar finding was reported by Panwar et al. (2016) and Kithan (2012) on beneficial of paired row ratios. The highest LER value was obtained from 2:2 paired row ratio of Maize + Soybean. This finding was in accordance with Mahapatra and Pradhan (1992) who observed in intercropping on maize and soybean and Khan et al. (1992). Rapso et al. (1995) also reported higher LER in the intercrops than in the monocrops with 2:2 row proportions recorded the highest value in Brazil. Similar finding was reported by Panwar et al. (2016) on beneficial of paired row ratios.

4. Conclusion

All the individual sole crops performed better while sole maize was the best. Among the different intercropping systems paired row (2:2) ratios of maize+soybean was the best combination for getting advantages in intercropping when compared with other row arrangements such as (1:1), (1:2), (2:1) and (2:2) as judged by the favourable economic indices like net return, gross return, B:C ratio and Land Equivalent Ratio (LER).

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