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Effect on Yield and Weed Dynamics in Maize (*Zea mays* L.) Based Intercropping Systems under Foothill Condition of Nagaland

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Abstract

To study the effect of maize based intercropping with legumes on crop yield and weed dynamics a field experiment was conducted 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 with treatments comprising 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. Two years pooled mean of the data indicated that a sole crop was better than intercropping systems in respect of growth and yield attributing characters. Among the different intercropping systems paired rows (2:2) ratios of maize + soybean performed significantly better with highest pooled mean in terms of yield (1564.21 kg ha^{-1}, 1567.10 kg ha^{-1}) and LER (1.78, 1.78). On weed parameters minimum weed competition with regard to weed density was observed in paired rows (2:2) ratios of maize + sesame (145 m^{-2}, 147.33 m^{-2}), while for weed dry matter (g m^{-2}) the treatment paired rows (2:2) ratios of maize + soybean (47.55 m^{-2}, 52.33 m^{-2}) showed lowest values. The common weed species identified were *Borreria hispida, Amaranthus viridies, Ageratum conyzoides, Mimosa pudica, Cynodon dactylon, Digitaria sanguinalis, Imperata cylindrical* and *Cyperus rotundus*. As for economics, paired rows (2:2) ratios of maize + soybean proved superior to all other treatments in 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: Maize, Sole Crops, Intercropping, Yield, Weeds, LER, Economics

1. Introduction

Intercropping has been recognized as a beneficial system of crop production. Although intercropping can be a potential biological tool to manage weeds, yet the system by itself would not be able to provide an acceptable and satisfactory level of weed control, especially during early stage of crop growth because the crop canopy is inadequate to check weed growth. Use of legumes increases soil conservation through greater ground cover than sole cropping and provides better lodging resistance for crops susceptible to lodging than when grown in monoculture.

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. India is the world's largest producer as well as consumer of pulses. Maize (*Zea mays* L.) is one of the most important cereals grown over diverse environment and geographical ranges for human food, feed and fodder for livestock and raw materials for industries.

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.

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 seed contains all essential amino acids and fatty acids increased grain yield and its quality (Shilpi et al., 2012). Its oil content varies from 46 to 52%. Protein content in seed varies between 20 and 26%. It is grown in an area of 7.54 million hectares with a production of 3.34 million tonnes in the world with a productivity of 443 kg ha^{-1}. India is the largest producer of sesame in the world. It also ranks first in the world in terms of sesame-growing area (24%) with about 1.8 million hectares with a total production of 0.76 million tonnes and productivity of 422 kg ha^{-1} (FAI, 2012).

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. Ricebean is reported to produce 3000 kg seed and up to 8000 kg ha^{-1} dry herbage to meet scarcity of green forage during lean periods i.e. April-June and November-December (Mukherjee et al., 1980). Ricebean seeds, besides being a good source of proteins up to 24% (Chandel et al., 1978) have a very high in vitro digestibility upto 82-85% (Rodriguez and Mendoza, 1991). The legume species used rice bean (*Vigna umbellata)* is native to South and Southeast Asia.

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. As soybean is cultivated in rain-fed conditions in India, the degree of its susceptibility to moisture stresses can be overcome by adopting suitable intercropping systems. Several factors can affect growth of the species used in intercropping including cultivar selection, seedling ratios, and competition between components (Carr et al., 2004). Intercropping of soybean with cereals like maize (*Zea mays* L.), sorghum (*Sorghum bicolor* (L.) Moench.), pearl millet (*Pennisetum glaucum* L.) etc. offers great scope for minimizing the adverse impact of moisture stress in lean rainfall years as well as excess moisture during high rainfall years (Layek et al., 2012).

The weed-suppression efficiency depends largely on the nature of the component crops in an intercropping system. A quick growing component crop with enough canopy may be suitable for this purpose. Weeds, being a serious negative factor in crop production are responsible for marked loss (28-100%) in crop yield (Pandey et al., 2001). Severe weed competition is one of the major constraints in lower productivity of sesame. The competitional stress of weeds on crop for nutrients, water, light and space is responsible for poor yield of sesame. The period from 15-30 days after sowing (DAS) is the most critical period of crop-weed competition in sesame (Venkatakrishan and Gnanamurthy, 1998). Maize is infested by a wide range of weed flora viz., *Echinochloa colona*, *Cyperus rotundus, Commelina benghalensis* and *Trianthema portulacastrum* dominate during early stages of the crop growth whereas *Dactyloctenium aegyptium* towards the tasseling and maturity of the crop (Saini and Angiras, 1998).

2. Materials and Methods

The present field 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 (Table 1). The experimental site is located at 25°45’43’’ North latitude and 93°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 ºC to 32ºC during summer and rarely goes below 8ºC 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 trials was carried out in randomized block design with 3 replications and 21 treatments comprising of different intercropping ratios *viz*., 1:1, 1:2, 2:1 and 2:2 with maize as the main crop. The intercropping system was carried out in additive series. Though recommended fertilizer doses for maize and pulses are different, the intercropping treatments were fertilized @ 100:80:60 kg of NPK ha^{-1} i.e. the recommended doses of maize, as maize was the main crop in the experiment. For recording growth and yield characters, 5 plants were selected randomly from each plot excluding the border rows and were carefully tagged (Table 1 and 2). Numbers of weeds m^{-2} was counted individually at 25, 50 DAS and at harvest by using a quadrate

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

Treatment	Plant height (cm)			Cob weight (g)			Number of grains cob^{-1}		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_1	298.00	332.50	315.25	143.67	144.67	144.17	555.33	556.00	555.67
T_2	-	-	-	-	-	-	-	-	-
T_3	-	-	-	-	-	-	-	-	-
T_4	-	-	-	-	-	-	-	-	-
T_5	-	-	-	-	-	-	-	-	-
T_6	322.67	323.92	323.29	118.33	119.33	118.83	489.33	490.00	489.67
T_7	330.00	332.50	331.25	131.00	132.00	131.50	531.33	532.00	531.67
T_8	318.00	317.92	317.96	115.33	116.33	115.83	400.00	400.67	400.33
T_9	322.00	324.17	323.08	127.00	128.00	127.50	511.33	512.00	511.67
T_{10}	321.33	323.25	322.29	122.67	123.67	123.17	430.00	430.67	430.33
T_{11}	317.33	318.42	317.88	112.33	113.33	112.83	390.00	390.67	390.33
T_{12}	328.00	330.58	329.29	131.00	132.00	131.50	500.00	500.67	500.33

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Treatment	Plant height (cm)			Cob weight (g)			Number of grains cob^{-1}		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_{13}	333.33	335.25	334.29	126.00	127.00	126.50	460.00	460.67	460.33
T_{14}	324.67	326.92	325.79	133.33	134.33	133.83	472.67	473.33	473.00
T_{15}	341.67	343.50	342.58	137.33	138.33	137.83	501.33	502.00	501.67
T_{16}	309.00	309.67	309.33	112.67	113.67	113.17	336.00	336.67	336.33
T_{17}	331.33	331.92	331.63	128.00	129.00	128.50	389.33	390.00	389.67
T_{18}	334.33	336.25	335.29	128.33	129.33	128.83	466.00	466.67	466.33
T_{19}	323.67	324.33	324.00	120.67	121.67	121.17	432.67	433.33	433.00
T_{20}	310.33	311.33	310.83	114.67	115.67	115.17	359.33	360.00	359.67
T_{21}	338.67	341.17	339.92	137.67	138.67	138.17	496.67	497.33	497.00
SEm±	9.15	2.04	4.69	2.59	2.24	1.71	12.16	12.15	8.60
CD (*p*=0.05)	NS	5.86	13.24	7.46	6.46	4.84	35.03	35.01	24.29

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	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

of 1 m^2 from each plot and weed density (m^{-2}) was calculated for each treatment. Weeds at 25, 50 DAS and at harvest were uprooted from the area of quadrate and dried in the sun and finally oven dried at 75 °C for 48 hours. The weight of the oven dried weeds were recorded when the samples attained a constant weight. The Analysis of Variance was done by using the procedure outlined by Panse and Sukhatme (1978). The significance of treatment differences was tested by 'F' Test. Critical Difference (CD) means at 5% probability level of significance (p=0.05) was worked out for comparison and statistical interpretation of treatments.

3. Results and Discussion

3.1. Growth attributes

There was significant variation among the various treatments during the early growth period. 1:2 row ratio of Maize+Ricebean recorded the maximum plant height in all the growth stages in both the years as compared to all other intercropping treatments. 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. Sole Perilla recorded the tallest plant height in all the growth stages as compared to different intercropping treatments (Table 3 and 4). This might be due to the reason of absence of intercrop competition in sole Perilla. Sole sesame recorded the tallest plant height in all the growth stages as compared to different intercropping treatments. This might be due to the reason of absence of intercrop competition in sole sesame. The result was in agreement with those of findings by De et al. (2002) who did on sesame and mung bean intercropping system. 1:2 row ratio of Maize+Sesame recorded the minimum plant height in all the growth stages. Significantly a taller plant was observed in Sole Soybean than the various intercropping treatments at different successive growth stages. This may be due absence of intercrop competition. The result corresponds with those of Kithan (2012), Aye (2013); Yhokha (2015). Among the different intercropping treatments paired row ratios of 2:2 (Maize+ Soybean) recorded the tallest plant height. This might be due to better spatial complementary of the component crops that led to better utilization of growth resources.

3.2. Yield attributes

Sole Maize recorded significantly higher values in regard to number of cobs $plant^{-1}$ than all the different intercropping treatments. 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,

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

Treatment	Plant height (cm)			No. of primary branches $plant^{-1}$			No. of capsules $plant^{-1}$		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_2	118.92	117.67	118.29	10.42	10.33	10.38	148.75	149.42	149.08
T_6	112.75	111.75	112.25	8.75	8.67	8.71	142.17	142.83	142.50
T_7	116.83	115.83	116.33	9.58	9.50	9.54	145.83	146.50	146.17
T_8	109.58	108.25	108.92	8.17	8.08	8.13	140.83	141.50	141.17
T_9	115.08	114.42	114.75	9.33	9.25	9.29	144.25	144.92	144.58
SEm±	0.35	0.50	0.31	0.12	0.11	0.08	0.50	0.38	0.31
CD (p=0.05)	1.15	1.64	0.92	0.39	0.34	0.24	1.64	1.23	0.94

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

Treatment	Number of seeds $capsule^{-1}$			Seed yield (kg ha^{-1})			Stover yield (kg ha^{-1})		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_2	38.92	39.25	39.08	890.91	892.26	891.58	1468.01	1494.95	1481.48
T_6	34.58	34.92	34.75	642.13	644.16	643.15	1154.40	1177.49	1165.95
T_7	37.58	37.92	37.75	715.73	717.75	716.74	1235.21	1258.30	1246.75
T_8	34.25	34.58	34.42	551.23	553.24	552.24	1079.36	1102.45	1090.91
T_9	35.92	36.25	36.08	675.32	677.34	676.33	1194.80	1217.89	1206.35
SEm±	0.45	0.45	0.32	19.32	19.30	13.65	18.28	18.25	12.91
CD (p=0.05)	1.46	1.46	0.95	63.02	62.93	40.93	59.61	59.52	38.72

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 that intercropping reduced the values of yield attributes and Kaushal et al. (2015) who did on maize (*Zea mays*)- based intercropping systems. 2:2 paired row ratio of Maize + Soybean recorded the highest grain yield among all the different intercropping. 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). Sole Sesame recorded the highest seed yield showing that sesame suffered from interspecific competition in the intercropping treatments (Table 5 and 6). Similar findings was reported by Ghosh et al. (1995) in sesame, greengram and blackgram intercropping systems, De et al. (2002) in sesame and mung bean intercropping systems, Prajapat et al. (2012) in mung bean and sesame intercropping system and Puste et al. (2014) in greengram and sesame intercropping system. Seed yield of Ricebean under intercropping was significantly low as compared with the Sole Ricebean (Table 7 and 8). Competition for light may have effect on Ricebean yield in maize-ricebean intercropping (Fisher et al., 1986). Sole Soybean recorded the highest seed yield since it suffered from inter specific competition in the intercropping treatments. Similar results was reported by Sawargi and Tripathi (1999) in rice and soybean intercropping system,

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

Treatment	Plant height (cm)			No. of primary branches plant^{-1}			No. of capsules plant^{-1}		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_3	208.33	208.00	208.17	16.33	16.27	16.30	188.67	190.33	189.50
T_{10}	192.00	191.67	191.83	12.33	12.27	12.30	165.33	168.33	166.83
T_{11}	186.33	186.00	186.17	11.33	11.27	11.30	160.67	158.00	159.33
T_{12}	199.33	199.00	199.17	15.00	14.93	14.97	182.33	184.00	183.17
T_{13}	197.00	196.67	196.83	13.67	13.60	13.63	175.33	178.67	177.00
SEm±	2.11	2.11	1.49	0.51	0.45	0.34	5.89	6.46	4.37
CD (p=0.05)	6.88	6.88	4.47	1.65	1.47	1.02	19.19	21.07	13.10

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

Treatment	Number of seeds capsule^{-1}			Seed yield (kg ha^{-1})			Stover yield (kg ha^{-1})		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_3	23.33	23.33	23.33	1562.29	1542.09	1552.19	2171.72	2151.51	2161.62
T_{10}	22.67	21.67	22.17	1177.49	1154.40	1165.95	1483.40	1463.20	1473.30
T_{11}	22.00	22.67	22.33	961.04	940.72	950.88	1367.96	1350.65	1359.31
T_{12}	22.33	22.75	22.54	1318.90	1301.59	1310.24	1751.80	1708.51	1730.16
T_{13}	22.00	22.33	22.17	1229.20	1212.23	1220.71	1575.75	1558.44	1567.10
SEm±	1.31	1.23	0.90	10.19	11.89	7.83	72.99	73.79	51.89
CD (p=0.05)	NS	NS	NS	33.22	38.76	23.47	238.02	240.65	155.58

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

Treatment	Plant height (cm)			Stem thickness (mm)			Number of pods plant^{-1}		
	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
T_{14}	145.08	144.75	144.92	4.69	4.70	4.69	117.00	117.67	117.33
T_{15}	146.75	146.42	146.58	5.22	5.23	5.23	122.33	123.00	122.67
T_{16}	141.50	141.17	141.33	4.71	4.72	4.71	107.00	107.67	107.33
T_{17}	144.00	143.67	143.83	4.79	4.80	4.79	111.67	112.33	112.00
SEm±	0.43	0.45	0.31	0.12	0.12	0.08	1.97	1.95	1.39
CD (p=0.05)	1.42	1.48	0.94	0.38	0.39	0.25	6.44	6.37	4.16

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

Treatment	No. of seeds pod^{-1}			Seed yield (kg ha^{-1})			Stover yield (kg ha^{-1})		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_4	8.57	8.90	8.73	1505.05	1515.15	1510.10	1713.80	1723.90	1718.85
T_{14}	7.87	8.20	8.03	1148.63	1157.29	1152.96	1321.79	1339.10	1330.45
T_{15}	8.40	8.73	8.57	1220.78	1229.44	1225.11	1393.94	1402.60	1398.27
T_{16}	7.07	7.37	7.22	981.24	998.55	989.90	1160.17	1194.80	1177.49
T_{17}	7.37	7.63	7.50	1119.77	1128.43	1124.10	1298.70	1307.36	1303.03
SEm±	0.16	0.25	0.15	17.65	17.00	12.25	18.30	15.90	12.12
CD (p=0.05)	0.51	0.80	0.44	57.55	55.43	36.73	59.68	51.85	36.34

Kithan (2012) in maize and soybean intercropping system, Aye (2013) in sunflower and soybean and Yhokha (2015) in soybean based intercropping. Among the intercropping treatments 2:2 paired row ratios of Maize + Soybean was found to be giving the highest seed yield. 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).

3.3. *Weed parameters*

Differences in number of total weeds due to planting geometry and weed management was found significant during both the years at all the growth stages. Lowest weed population was recorded in 2:2 paired row ratios of Maize+Soybean (Table 9 and 10). This was probably due to more shading effect of soybean canopy owing to more number of soybean plants per unit area. The findings also confirms by Pandey and Prakash (2002) and Dwivedi and Shrivastava (2011). Pandey and Prakash (2002) reported that maize and legume intercropped either as paired rows + two rows of legume or one row of legume in between two rows of maize adversely affected the weed growth and caused 22.4 and 31.9% weed growth suppression as compared with sole maize respectively (Table 11). Pandey et al. (1999) also reported similar findings. Sole ricebean recorded the maximum weed dry matter and which might be due to its nature to grow as a climber. While minimum weed dry matter was recorded in 2:2 paired row

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

Treatment	Plant height (cm)			No. of primary branches plant^{-1}			No. of root nodules plant^{-1}		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_5	97.33	96.00	96.67	10.38	10.31	10.34	24.25	24.75	24.50
T_{18}	91.00	89.67	90.33	10.13	10.09	10.11	21.25	21.75	21.50
T_{19}	88.00	86.67	87.33	9.96	9.92	9.94	20.33	20.83	20.58
T_{20}	84.00	83.67	83.83	9.83	9.75	9.79	20.08	20.58	20.33
T_{21}	95.33	94.00	94.67	10.26	10.22	10.24	22.58	23.08	22.83
SEm±	1.95	2.37	1.54	0.27	0.31	0.21	0.25	0.23	0.17
CD (p=0.05)	6.36	7.74	4.60	NS	NS	NS	0.82	0.75	0.51

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

Treatment	Number of pods plant^{-1}			Seed yield (kg ha^{-1})			Stover yield (kg ha^{-1})		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_5	52.00	53.17	52.58	1838.38	1841.75	1840.07	2922.56	2912.46	2917.51
T_{18}	47.33	48.50	47.92	1518.04	1520.92	1519.48	2329.00	2323.23	2326.12
T_{19}	44.45	45.62	45.03	1460.32	1463.20	1461.76	2271.28	2265.51	2268.40
T_{20}	44.00	45.17	44.58	1419.91	1422.80	1421.35	2150.07	2144.30	2147.18
T_{21}	50.58	51.75	51.17	1564.21	1567.10	1565.65	2401.15	2395.38	2398.27
SEm±	1.82	1.57	1.20	17.86	15.72	11.89	37.12	37.67	26.44
CD (p=0.05)	5.94	5.13	3.61	58.23	51.27	35.66	121.06	122.85	79.28

Table 11: Effect of maize (*Zea mays* L.) based intercropping systems on weed dynamics

Treatment	Weed density (m^{-2})			Weed dry matter ($g\ m^{-2}$)		
	2015	2016	Pooled	2015	2016	Pooled
T_1	182.33 (13.52)	189.00 (13.77)	185.67 (13.64)	50.29 (7.13)	54.89 (7.44)	52.59 (7.28)
T_2	222.33 (14.93)	223.67 (14.97)	223.00 (14.95)	56.67 (7.56)	60.99 (7.84)	58.83 (7.70)
T_3	172.67 (13.16)	177.33 (13.34)	175.00 (13.25)	51.00 (7.18)	55.63 (7.49)	53.31 (7.33)
T_4	267.33 (16.37)	269.33 (16.43)	268.33 (16.40)	60.59 (7.82)	65.44 (8.12)	63.01 (7.97)
T_5	179.33 (13.41)	187.33 (13.71)	183.33 (13.56)	51.33 (7.20)	56.32 (7.54)	53.83 (7.37)
T_6	188.33 (13.74)	195.67 (14.01)	192.00 (13.87)	52.33 (7.27)	57.26 (7.60)	54.80 (7.43)
T_7	177.00 (13.32)	178.33 (13.37)	177.67 (13.35)	51.00 (7.18)	55.96 (7.51)	53.48 (7.35)
T_8	194.00 (13.95)	197.00 (14.05)	195.50 (14.00)	52.00 (7.25)	56.95 (7.58)	54.47 (7.41)
T_9	162.00 (12.75)	166.33 (12.92)	164.17 (12.83)	49.67 (7.08)	53.96 (7.38)	51.81 (7.23)
T_{10}	168.00 (12.98)	167.67 (12.97)	167.83 (12.97)	50.67 (7.15)	55.33 (7.47)	53.00 (7.31)
T_{11}	157.67 (12.58)	158.00 (12.59)	157.83(12.58)	50.00 (7.11)	54.94 (7.45)	52.47 (7.28)
T_{12}	172.67 (13.16)	176.33 (13.30)	174.50 (13.23)	51.00 (7.18)	55.98 (7.52)	53.49 (7.35)
T_{13}	145.00 (12.06)	147.33 (12.16)	146.17 (12.11)	47.33 (6.92)	52.32 (7.27)	49.83 (7.09)
T_{14}	256.33 (16.03)	258.00 (16.08)	257.17 (16.05)	59.33 (7.74)	64.32 (8.05)	61.83 (7.89)
T_{15}	259.33 (16.12)	263.67 (16.25)	261.50 (16.19)	59.67 (7.76)	64.62 (8.07)	62.14 (7.91)
T_{16}	264.67 (16.28)	267.67 (16.38)	266.17 (16.33)	60.00 (7.78)	64.67 (8.07)	62.33 (7.93)
T_{17}	245.33 (15.68)	247.67 (15.75)	246.50 (15.72)	58.33 (7.67)	63.33 (7.99)	60.83 (7.83)
T_{18}	175.33 (13.26)	177.67 (13.35)	176.50 (13.30)	51.33 (7.20)	56.32 (7.54)	53.83 (7.37)
T_{19}	166.00 (12.90)	168.33 (12.99)	167.17 (12.95	50.00 (7.11)	54.97 (7.45)	52.49 (7.28)
T_{20}	163.00 (12.79)	165.00 (12.86)	164.00 (12.83)	50.00 (7.11)	54.67 (7.43)	52.33 (7.27)
T_{21}	139.67 (11.84)	145.00 (12.06)	142.33 (11.95)	47.55 (6.93)	52.33 (7.27)	49.94 (7.10)
SEm±	0.08	0.05	0.05	0.03	0.03	0.02
CD (p=0.05)	0.23	0.16	0.14	0.09	0.10	0.07

The figures in the parenthesis are mean square root transformed values and those in the table are original values

ratio of Maize+Sesame which might be due to better canopy that reduced the weed population. Weed population and weed dry weight reflect the growth potential of the weeds and are the important indicators of its competition ability with the crops. Chalka and Nepalia (2005) evaluated the effect of weed control on production potential and economics of maize (*Zea mays* L.)- legume intercropping system. Cowpea and soybean as intercrop reduced the weed dry matter significantly. The findings also confirms by Pandey and Prakash (2002) and Dwivedi and Shrivastava (2011). The common weed species identified were *Borreria hispida, Amaranthus viridies, Ageratum conyzoides, Mimosa pudica, Cynodon dactylon, Digitaria sanguinalis, Imperata cylindrical* and *Cyperus rotundus*.

3.4. 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. 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 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). Similar finding was reported by Panwar et al. (2016) on beneficial of paired row ratios (Table 12). LER greater than 1 in all the intercropping treatments was reported by Buragohain and Buruah (1992).

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

Treat-ment	Gross return (₹ ha^{-1})		Net return (₹ ha^{-1})		LER		Benefit cost ratio (B:C)	
	2015	2016	2015	2016	2015	2016	2015	2016
T_1	84600	86602.4	60100	62102.4	1	1	2.45	2.53
T_2	53454.6	53535.6	32454.6	32535.6	1	1	1.54	1.55
T_3	93737.4	92525.4	71891.4	70679.4	1	1	3.29	3.23
T_4	90303	90909	68968	69574	1	1	3.23	3.26
T_5	110302.8	110505	86302.8	86505	1	1	3.59	3.60
T_6	110721.2	112856.2	81721.2	83856.2	1.57	1.58	2.82	2.89
T_7	120990.4	123111.6	90990.4	93111.6	1.72	1.72	3.03	3.10
T_8	100220.4	102347.8	71220.4	73347.8	1.41	1.42	2.45	2.53
T_9	116699.2	118827	86699.2	88827	1.66	1.66	2.89	2.96
T_{10}	146849.4	147470.6	117003.4	117624.6	1.65	1.65	3.92	3.94
T_{11}	124469	125256.6	93469	94256.6	1.4	1.4	3.01	3.04
T_{12}	158100.6	159068.8	128254.6	129222.8	1.77	1.77	4.30	4.33
T_{13}	149685.4	150660.4	118685.4	119660.4	1.69	1.69	3.83	3.86
T_{14}	145651.2	148164	116316.2	118829	1.67	1.67	3.96	4.05
T_{15}	153160.2	155659.8	123160.2	125659.8	1.75	1.75	4.10	4.19
T_{16}	125107.8	130513	95772.8	101178	1.43	1.47	3.26	3.45
T_{17}	140746.2	143265.8	110746.2	113265.8	1.61	1.61	3.69	3.77
T_{18}	165682.4	167841.8	136682.4	138841.8	1.7	1.7	4.71	4.79
T_{19}	156965.8	159132	126965.8	129132	1.61	1.61	4.23	4.30
T_{20}	147441.2	149608	118441.2	120608	1.5	1.51	4.08	4.16
T_{21}	172612.6	174779.4	142612.6	144779.4	1.78	1.78	4.75	4.82

4. Conclusion

On 2 years of experimentation, the study can be concluded that intercropping of maize with legumes (soybean) positively complimented the seed yield, associated competition between the component crops (maize and soybean) and monetary returns compared to solitary cropping of the same species. 2:2 Paired row ratios of Maize + Soybean proved good and the best option viewing yield advantages, optimum exploitation of the environmental resources, weed control efficiencies, LER and monetary values.

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