SAARC J. Agri., 12(1), 117-126(2014)

EVALUATION OF MAIZE (*Zea mays*)-LEGUMES INTERCROPPING SYSTEM UNDER RED AND LATERITIC TRACT OF WEST BENGAL

M. K. Mandal[1], M. Banerjee[2] and H. Banerjee

Institute of Agriculture, Visva-Bharati, Sriniketan, Birbhum, West Bengal, 731236, India

ABSTRACT

A field experiment was carried out during kharif season of 2010 and 2011 at Sriniketan Research Farm, Visva-Bharati, West Bengal, India. The yield attributes and growth parameters were significantly higher in case of sole maize and intercropping treatments with legumes. The maximum total chlorophyll (chlorophyll a + chlorophyll b) was observed on sole maize, which was statistically at par with maize crop under intercropping system. In the middle canopy, highest light interception (%) was observed in maize + groundnut (2:4). The grain yield (2.48 t ha^{-1}) and stover yield (5.07 t ha^{-1}) of maize were significantly higher in sole maize than either of its intercropping systems with legumes. The legume yield was highest in maize + groundnut (1:2) followed by sole groundnut. The maize equivalent yield (7.06 t ha^{-1}) was highest in maize + groundnut (2:4) followed by maize + groundnut (1:2). The highest benefit cost ratio maize + groundnut (1:2) closely followed by maize + soybean (1:2). The total N uptake by sole maize was significantly higher and under intercropping systems, the highest N concentrations in grain and straw, and protein content in grains were obtained in maize + soybean (1:2) and maize + groundnut (2:4) treatment.

Keywords: Intercropping, Maize, Legume, Nutrient uptake, Chlorophyll, Yield

INTRODUCTION

Intercropping in recent years has received great attention of the farming community, because of potential advantages in respect of improved utilization of growth resources by the crops and sustaining productivity. Maize is an unexploited food crop for intercropping and grown at wider spacing. Slow growth in initial stages and monocarpic nature makes it highly suitable for intercropping. Rao (2004) reported increase in cropping intensity (200%) of rainfed maize through inter cropping of field bean in paired

***Corresponding author email:** malaymandal86@gmail.com

[1]Research scholar, Department of Agronomy, BCKV,

[2]Assistant Professor, Department of ASEPAN, Visva-Bharati, Sriniketan

Assistant Professor, Department of Agronomy, BCKV

Received: 16.09.2013

rows of maize. In intercropping systems when a legume is grown in association with other crop (intercrop) commonly a cereal, the nitrogen of the associated crop may be improved by direct nitrogen transfer from legume to cereal (Giller & Wilson, 1991). Legumes with their adaptability to different cropping patterns and their ability to fix nitrogen, may offer opportunities to sustain increased productivity (Jeyabel & Kuppuswamy, 2001). Legumes, both alone and as intercrop with cereals, have been advocated not only for yield augmentation but also for maintenance of soil health, particularly in degraded soil. The present study was conducted to evaluate maize (Zea mays) with legumes as intercropping system under red and lateritic tract of West Bengal.

MATERIALS AND METHODS

The field experiment was conducted during two consecutive kharif seasons of 2010 and 2011 at Sriniketan Research Farm ($23^0 39'$ N latitude, $87^0 42'$ E longitude and 58.9 m above mean sea level) of Institute of Agriculture, Visva-Bharati, Birbhum, West Bengal. The area has a typical sub-humid sub-tropical climate with low temperature during winter, hot-dry summer and rainy season. During the period of experimentation, the maximum and minimum temperature ranged from 29.9 to 34.7 °C and 19.0 to 26.9 °C, respectively. Crops received total 508.4 and 640.1 mm rainfall during July to November in 2010 and 2011, respectively. On an average crop received 2.91 to 9.13 hours sunshine hours per day and relative humidity varied from 75.0 to 89.6%, which was quite higher than long-term average. The soil of the experimental plot was sandy loam in texture, acidic in reaction (pH 5.5), with medium level of organic carbon (0.71 %), available P (24.7 kg ha^{-1}) but low level of available N (188.16 kg ha^{-1}) and K (110.20 kg ha^{-1}). The experiment was laid out in a randomized block design with seven treatments replicated four. Treatments comprised viz., T_1: sole maize, T_2: sole groundnut, T_3: sole soybean, T_4: Maize + groundnut (1:2), T_5: Maize + soybean (1:2), T_6: Maize + groundnut (2:4) and T_7: Maize + soybean (2:4). The main crop was maize var. 'Shakti hybrid' and the intercrops were groundnut var. 'TAG 24' and Soybean var. 'Birsa Soybean1'. Maize was sown with a seed rate of 20 kg ha^{-1} with spacing 75 cm x 25 cm(5 plant/m^2) in sole maize and for paired row was 50 cm x 25 cm(8 plant/m^2), sown on 3rd week of July. Intercrops i.e. groundnut and soybean was sown with 25 cm x 10 cm (40 plant/m^2) spacing in east-west direction having 2-3 cm seeding depth. The fertilizer doses for maize and grain legumes were 150 kg N, 75 kg P_2O_5, 75 kg K_2O and 40 kg N, 80 kg P_2O_5, 80kg K_2O ha^{-1}, respectively. The other management operations were done as per recommended package of practices for both main and intercrops. Maize, groundnut and soybean crop were harvest 97, 120 and 116 days after sowing. Growth and yield parameters were recorded as per standard procedures. The data was analyzed statistically by the analysis of variance method Cochran and Cox (1963) and analysis of two years pooled values were given.

The measurement on light interception was taken at 60 DAS. The light incident radiation was recorded at top of the plant canopy, middle of the plant canopy and at ground surface with the help of luxmeter. Light intensity was measured in five randomly selected plants in each plot. Light incidence at the middle of plant canopy and at the ground surface expressed as % of total incident radiation at the top of the canopy was obtained by the following formula:

$$\text{\% Light incidence at middle of canopy or at ground surface} = \frac{\text{Light intensity at the middle of canopy or at ground surface}}{\text{Light intensity above the canopy}} \times 100$$

Estimation of chlorophyll was done by using Dimethyl Sulfoxide (DMSO) method of extraction Hiscox and Israeclstam (1979). The 0.05 g of sample pieces of top most maize leaves at knee height stage, groundnut and soybean leaves at 40 DAS were kept in 10 ml of DMSO for 12 hours at a temperature of 60^0C for chlorophyll extraction. The sample was cooled to room temperature and it was diluted to five times. The absorbance of chlorophyll extract was recorded at 645 and 663 nm wavelength with the help of spectrophotometer.

$$\text{i) Chlorophyll a (mg/g fresh weight)} = \frac{(12.3\,A_{633} - 0.86\,A_{645})}{a\ 1000 \times w} \times V$$

$$\text{ii) Chlorophyll b (mg/g fresh weight)} = \frac{(19.3\,A_{645} - 3.6\,A_{633})}{a\ 1000 \times w} \times V$$

Where, a = path length of cubette (cm); W = fresh weight of leaf tissues (g);V = volume depending on dilution (ml).

RESULTS AND DISCUSSION

Growth parameter

An increasing trend of plant height and dry matter accumulation were observed in each treatment with the increase in age of the crop (Table 1). At harvest the plant height, length of leaves and total dry matter production of maize varied significantly due to intercrops. The highest plant height, dry matter of maize and intercrops (groundnut/soybean) were observed under sole cropping as compared to maize + legumes intercrop. Similar results were reported by Alam et al. (2005). At harvest, the highest average length of leaves /plant was recorded in sole maize which was statistically at par with paired row systems with both groundnut and soybean and significantly greater than the other treatments. The highest root weight / plant in legume was recorded in maize + groundnut (1:2) followed by maize + groundnut (2:4). Crop growth rate (CGR) and leaf area duration (LAD) of maize was influenced significantly by different treatment combinations under study. During 60-75 DAS, the higher CGR of maize was obtained in sole cropping which was statistically at par with maize + groundnut (1:2) and maize + soybean (2:4) intercropping system and significantly superior to other treatments expect leaf area duration. But for legumes, CGR and LAD were significantly higher in sole cropping than maize + legume intercropping system. Similarly at 60-75 DAS, the highest NAR value of maize was observed in maize + soybean (2:4) system which was statistically at par with all other systems except maize + soybean (1:2) system of cropping. In case of legume crop, higher NAR was observed in groundnut than soybean under both sole and intercropping situations.

Yield and Yield attributes

Cob weight / plant was significantly higher in case of maize +soybean (1:2) treatments which was statistically at par in sole maize and maize +groundnut (2:4) ratio. This might be due to less nutrient uptake, more inter-row competition among the plants in the paired row system of maize and soybean. It is suggested that groundnut can better adjust with maize even in the paired row system as compared to soybean. Jana and Saren (1998) reported similar results. Pod weight/plant was not significantly affected by intercropping treatments. The highest length of cob (22.82 cm), number of rows/cob (13) and number of grains/cob (282) were recorded at harvest on sole maize. Bharati et al. (2007) reported that the different intercropping systems did not have much effect on the length of maize cob and number of grains/cob.

In groundnut based intercropping systems, the highest pod as well as nut yield was recorded in sole cropping which differed significantly from all other system of cropping (Table 2). This difference of groundnut pod and seed yield was also reported by Dutta and Bandyopadhyay (2006). Pod yield of groundnut was significantly affected by maize + groundnut intercropping systems in both the years. The pod yield differed mainly due to the highest number of plants/m^2 and number of pods / plant. Razzaque et al. (2007) also reported higher pod yield of groundnut in monoculture. The pod yield of groundnut in intercropping situation was considerably reduced. This corroborates with the findings of Ghosh (2002), Sarkar and Pal (2004) and Razzaque et al. (2007). The reduction of pod yield might be due to shading effect of maize on the groundnut. Similar trend was also obtained in case of soybean based intercropping systems. The result thus indicated that, the pod and grain yields of both groundnut and soybean were considerably reduced in intercropping situation and the effect was much more pronounced in the paired row system. Maize crop produced highest grain yield in sole cropping which was statistically at par with intercropping situations like maize + soybean (1:2) and maize + groundnut (2:4). The lowest grain yield was observed in maize +soybean (2:4) which may be due to higher competition faced by the crop in 2: 4 row ratio due to presence of more number of plants per unit area. The presence of groundnut in the paired row system probably had more synergistic effect as compared to antagonistic effect and therefore the maize crop in association with groundnut in the paired row system reported comparable yield. This might be due to more competition among plants due to higher plant population which might have caused reduction in availability of growth factors for the legume component and finally there was yield reduction. On the other hand, the sole crop received higher availability of nutrient, moisture, light, space etc and produced more number of pods/plant, seeds/pod and finally gave higher grain yield. This corroborates with the findings of Pandey et al. (2003). The highest stover yield of maize was recorded in sole cropping which was significantly greater than all intercropping situations while lowest stover yield was recorded in maize + groundnut (2:4) system. The highest stover yield may be the result of more vegetative growth per plant due to presence of less plant population where the individual plant faced less inter-row competition and had avail better nutrient uptake, moisture, space and light. Similar results were also reported by Alom et al. (2010). In groundnut based systems, the higher biomass yield of groundnut was observed in sole cropping which was significantly greater than other system of cropping. Reduced biomass yield of groundnut under different intercropping situations was due to lower plant population compared with sole crop of groundnut and also shading effect of maize. The trend was similar in case of soybean based systems. Among all the treatments under study, in terms of maize equivalent yield, maize + groundnut (2:4) gave the highest maize equivalent yield (7.06 t ha^{-1}) and recorded significantly more maize equivalent yields compared to sole maize. These results were confirmed with the findings of Adhikari et al. (2005). Further, sole groundnut and soybean crop gave higher maize equivalent yield than sole maize but lower than the intercropping systems. The highest benefit cost ratio maize + groundnut (1:2) followed by maize + soybean (1:2), maize + groundnut (2:4) and maize + soybean (2:4) treatments.

Concentration and uptake of nitrogen

Concentrations of N in grains and straw of maize were significantly increased due to maize + groundnut (1:2) and sole maize (Table 3), which was statistically higher than all other treatments. Similar trend was recorded in the protein content in grains and N content in straw. The highest N concentrations in grain and straw, and protein content in grains were obtained in maize + soybean (1:2) and maize + groundnut (2:4) treatment. The total N uptake by sole maize was significantly higher than all other systems of intercropping. This may be accorded to the fact that more nitrogen became available to the maize having more spacing, less plant population and ultimately reflected in higher grain N content (%), higher grain yield and finally higher N uptake. The lowest nitrogen uptake under Maize + groundnut (2:4) system may be due to higher plant population which might have resulted in less accessibility of available N. But among intercrops, the highest N uptake was observed in sole soybean. The results thus indicated that the sole treatments proved superior over other intercropping systems with respect to the N uptake in grains. The protein content in grain showed similar in sole maize and maize + groundnut intercrops but soybean in sole and intercrops situation reveals higher protein content.

Chlorophyll content and light interception

Data on chlorophyll content in maize leaf (Figure 1) indicated that the maximum chlorophyll content was recorded in maize + soybean (1:2) system, but not much difference was observed in case of intercropping situation. In legume based intercropping systems, the highest chlorophyll a was recorded under maize + soybean (1:2) which was statistically at par with maize + soybean (2:4) system. In case of groundnut, the maximum value of chlorophyll a was observed on sole groundnut treatment which was statistically at par with all other groundnut based systems (Figure 2). The estimation of chlorophyll b in maize revealed that the higher chlorophyll b was recorded in pure stand and maize + soybean (2:4) system whereas lowest chlorophyll b was observed in case of maize + soybean (1:2) system. This result was just reverse to that of chlorophyll a content. In case of maize + soybean intercropping system, the chlorophyll b content of soybean was also maximum in maize + soybean (1:2) followed by maize + soybean (2:4) and sole cropping. Among groundnut based system, the maximum value of chlorophyll b content of groundnut was recorded under maize + groundnut (1:2) which was statistically at par with other groundnut based systems. The maximum estimated value of total chlorophyll (chlorophyll a + chlorophyll b) was observed on sole maize, which was statistically at par with all other system of cropping. The highest amount of total chlorophyll content in maize under sole cropping might be due to better availability soil moisture, higher nutrient uptake etc. For soybean highest value of total chlorophyll was recorded in maize + soybean (1:2) system which was statistically at par with maize + soybean (2:4) system. In groundnut based systems, the maximum value was recorded in sole cropping which was statistically at par with other maize + groundnut based system.

In the middle canopy, highest % of light interception was observed in maize + groundnut (2:4) (Figure 1). Jiao et al. (2008) also found maize + groundnut intercropping enhanced the efficient utilization of strong light by maize and weak light by groundnut resulting in yield advantages. But in the lower canopy, highest light interception was noticed in maize + groundnut (1:2). The results indicated that due to better canopy development and more number of leaves per unit area, the light interception was higher in the maize based intercropping systems. The percentage of light interception in soybean and groundnut in the middle canopy was highest in maize + legume (2:4) intercropping system (Figure 2). This may be probably due to better canopy development and more plant population in the paired row system. However, in the lower canopy, the percentage light interception in legume crops was highest in maize + legume (1:2) intercropping system. Keating and Carberry (1993) also opined that soybean and maize intercropping make better use of solar radiation.

CONCLUSION

Sole cropping performed better than the intercropping system, but intercropping of maize with legume is much more beneficial in terms of equivalent yield. The intercropping of maize with soybean was more remunerative than groundnut intercropping as well as sole crop of maize and soyabean in the kharif season under red and lateritic soil condition of West Bengal.

ACKNOWLEDGEMENT

We gratefully acknowledge Dr. Mahua Banerjee, Institute of Agriculture, Visva-Bharati, Sriniketan, for his assistance and guidance.

REFERENCES

Adhikari, S., Chakarborty, T. and Bagchi, D. K. 2005. Bio- economic evaluation of maize (*Zea mays*) and groundnut (*Arachis hypogaea*) intercropping in drought prone area of Chotonagpur plateau region of Jharkhand. *Indian Journal of Agronomy,* 50 (2): 113- 115

Alam, M. Z., Haider, S. A. and Paul, N. K. 2005. Effects of sowing time and nitrogen fertilizer on barley (Hordeumvulgare L.). *Bangladesh Journal of Botany*, 34(1): 27-30

Alom, M. S., Paul, N. K. and Quayyum, M. A. 2010. Production potential of different varieties of hybried maize (*Zea mays* L.) with groundnut (*Arachis hypogaea* L.) under intercropping system, Bangladesh

Bharati, V., Nandan, R., Kumar, V. and Panday, I. B. 2007. Effect of irrigation levels on yield, water-use-efficiency and economics of winter maize (*Zea mays*)-based intercropping systems, *Indian Journal of Agronomy*, 52(1): 27-30

Cochran, W.G. and Cox, G. M.1963. Experimental Designs.1st India Ed. Asia publishing House, Bombay, Calcutta, New Delhi and Madras

Dutta, D. and Bandyopadhyay, P. 2006. Production potential of intercropping of groundnut (*Arachis hypogaea*) with pigeonpea (*Cajanus cajan*) and maize (*Zea mays*) under various row proportion in rainfed Alfisols of West Bengal, *Indian Journal of Agronomy*, 51(2): 103-106

Ghosh, P. K. 2002. Agronomic and economic evaluation of groundnut (*Arachis hypogaea*)-cereal fodder intercropping during the post-rainy season. *Indian Journal of Agronomy*, 47(4): 509-513

Giller, K. E. and Wilson, K. J. 1991. Nitrogen Fixation and Tropical Cropping Systems, pp: 10–120. CAB International, Wallingford

Hiscox, J.D. and Israelstam, G. F. 1979. A method for the extraction of chlorophyll from leaf tissue without maceration. *Canadian Journal of Botany*, 57: 1332-1334

Jana, .P K. and Saren, B. K. 1998. Dry-matter accumulation, yield attributes and yield of summer maize (*Zea mays*) and groundnut (*Arachis hypogaea*) intercropping systems as influenced by irrigation, *Indian Journal of Agronomy*, 43(1): 18-22

Jeyabal, A. and Kuppuswamy, G. 2001. Recycling of organic wastes for the production of vermicompost and its response in rice-legume cropping systems and soil fertility. *Haryana Journal of Agronomy*, 15: 153–170

Jiao, N.Y., Zhao, C. Ning, T.Y., Hou, L.T., Fu, G.Z., Li Z.J. and Chen, M.C. 2008. Effects of maize-peanut intercropping on economic yield and light response of photosynthesis. *Chinese Journal of Applied Ecology*, 19: 981-985

Keating, B. A. and Carberry, P. S. 1993. Resource capture and use in intercropping: Solar radiation. *Field Crop Research*, 34: 273-301

Pandey, I. B., Bharati, V. and Mishra, S. S. 2003. Effect of maize (*Zea mays* L.) -based intercropping systems on maize yield and associated weeds under rainfed condition. *Indian Journal of Agronomy*, 48(1): 30-33

Rao, 2004. Planting Pattern, vegetable inter crops and fertilizer management. M.Sc. (Ag.). Thesis submitted to Acharya N.G. Ranga Agricultural University, Hyderabad

Razzaque, M. A., Rafiquzzaman, S., Bazzaz, M. M., Ali, M. A. and Talukdar, M. M. R. 2007. Study on the intercropping groundnut with chilli at different plant populations. *Bangladesh Journal of Agriculture Research*, 32(1): 37-43

Sarker, R. K. and Pal, P. *K. 2004. Effect of intercropping rice (Oryza sativa) with groundnut (Arachis* hypogaea) and pigeonpea (*Cajanus cajan*) under different row orientations on rainfed uplands. *Indian Journal of Agronomy*, 49(3): 147-150

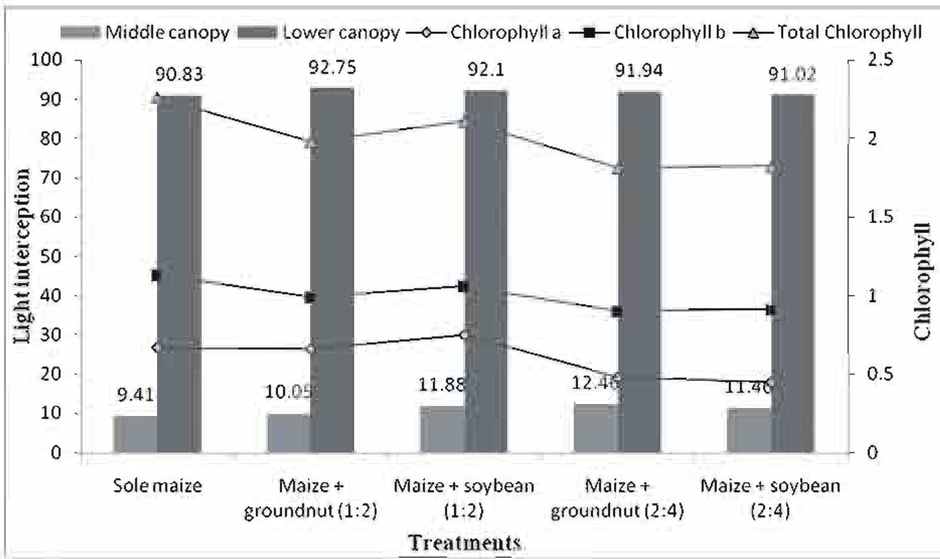

Figure 1. Chlorophyll estimation and % of light interception of maize crops (Pooled data of 2 years)

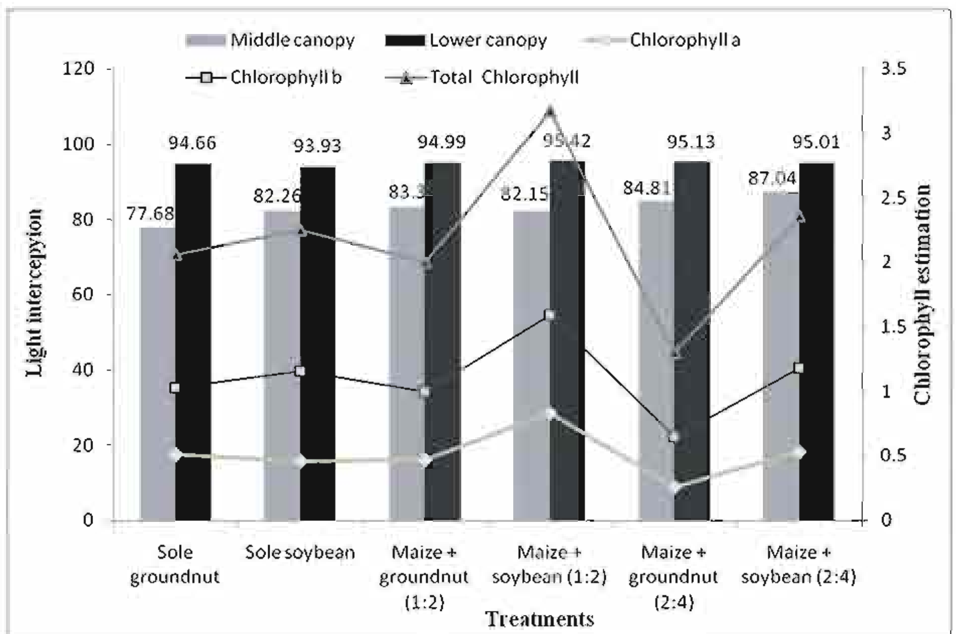

Figure 2. Chlorophyll estimation and % of light interception of legume crops (Pooled data of 2 years)

Table 1. Effect of intercropping system on growth parameters of maize and intercrops (groundnut, soybean) (Pooled data of 2 years)

Treatment	Plant height (cm) at harvest		DMA (g/m^2) at harvest		length of leaves (cm)/plant	Root weight(gm)/ plant at 60 DAS	CGR (g/m^2/day) at 60-75 DAS		NAR (g/m^2/day) at 60-75 DAS		LAD (day) at 60-75 DAS	
	Maize	Intercrop	Maize	Intercrop			Maize	Intercrop	Maize	Intercrop	Maize	Intercrop
Sole maize	162.48	-	447.2	-	67.33	-	16.76	-	11.64	-	21.59	-
Sole groundnut	-	56.88	-	960.40	-	15.33	-	22.47	-	2.60	-	130.18
Sole soybean	-	59.48	-	419.2	-	5.21	-	11.32	-	3.48	-	49.43
Maize + groundnut(1:2)	154.33	54.43	406.7	952.8	59.23	16.30	14.02	15.97	11.88	2.78	17.72	86.49
Maize + soybean(1:2)	151.85	56.75	313.8	360.4	61.10	5.98	8.19	4.62	7.78	0.95	15.90	73.58
Maize + groundnut(2:4)	154.65	54.83	334.1	826.4	64.68	13.80	11.19	9.52	11.24	1.81	16.07	78.32
Maize + soybean(2:4)	154.03	56.23	406.7	359.6	65.23	5.33	16.63	2.33	14.55	0.77	17.31	45.32
SEm ±	1.79	0.97	3.67	0.85	1.26	0.941	1.33	1.90	1.54	0.43	0.81	1.77
CD(P=0.05)	5.50	2.93	11.31	2.56	3.87	2.835	4.10	5.72	4.75	1.30	2.50	5.34

Table 2. Effect of intercropping system on yield attributes and yield of maize and intercrops (groundnut, soybean) (Pooled data of 2 years)

Treatments	Cob and Pod weight /plant(gm)		Length of cob and pod (cm)		No of grains / maize cob	Grain yield (t ha^{-1})		Stover yield (t ha^{-1})		Maize Equivalent Yield (t ha^{-1})	B: C ratio
	Maize	Intercrop	Maize	Intercrop		Maize	Intercrop	Maize	Intercrop		
Sole maize	60.47	-	22.82	-	282	2.48	-	5.70	-	2.48	1.00
Sole groundnut	-	8.07	-	2.73	-	-	2.02	-	3.94	5.16	2.28
Sole soybean	-	5.21	-	3.48	-	-	2.08	-	2.97	3.24	1.01
Maize + groundnut(1:2)	55.44	6.88	21.39	2.58	235	2.06	1.93	4.72	2.82	6.99	3.24
Maize + soybean (1:2)	66.43	4.11	22.42	3.45	276	2.23	1.91	5.10	2.36	5.20	3.23
Maize + groundnut(2:4)	62.05	7.57	21.65	2.58	266	2.26	1.88	4.59	0.97	7.06	2.15
Maize + soybean (2:4)	46.47	3.46	21.26	3.48	240	1.87	0.95	4.91	1.09	3.35	1.01
S Em ±	2.52	0.47	0.61	0.04	10.12	0.09	0.10	0.13	0.17	-	-
CD(P=0.05)	7.78	NS	1.88	0.12	31.18	0.28	0.30	0.31	0.50	-	-

Maize grain- Rs. 900/q, Maize stove- Rs. 50/q, Groundnut grain- Rs. 2300/q, Soybean grain- Rs. 1400/q, Groundnut and Soybean stalk- Rs. 40/q

Table 3. Effect of intercropping system on protein, N content and uptake of maize and intercrops (groundnut, soybean) (Pooled data of 2 years)

Treatments	N concentration (%)				N uptake(kg ha^{-1})				Protein content in grains (%)	
	Grain		Stover		Grain		Stover			
	Maize	Intercrop	Maize	Intercrop	Maize	Intercrop	Maize	Intercrop	Maize	Intercrop
Sole maize	1.46	-	0.59	-	36.21	-	33.63	-	9.13	-
Sole groundnut	-	3.20	-	0.95	-	64.64	-	37.43	-	18.42
Sole soybean	-	6.49	-	0.77	-	134.99	-	22.87	-	37.31
Maize + groundnut (1:2)	1.46	3.19	0.51	0.84	30.08	61.76	24.07	23.69	9.13	18.34
Maize + soybean (1:2)	1.33	6.53	0.48	0.82	29.66	124.72	24.48	19.35	8.31	37.55
Maize + groundnut (2:4)	1.23	3.29	0.41	0.96	27.80	61.85	18.82	9.31	7.69	18.91
Maize + soybean (2:4)	1.32	6.42	0.46	0.59	24.68	60.99	22.59	6.43	8.25	35.88
SEm ±	0.02	0.02	0.02	0.01	1.40	3.64	1.50	1.09	0.12	0.013
CD (P=0.05)	0.06	0.06	0.07	0.05	4.31	10.97	4.63	3.30	0.36	0.39