The Andhra Agric. J 61(3):501-505, 2014

Performance of Maize and Soybean Intercropping Systems in Relation to Zinc Application Under Rainfed Condition

Malve Sachin Himmatrao, R Raghavaiah and P Spandana Bhatt
Department of Agronomy, College of Agriculture, Rajendranagar, ANGRAU, Hyderabad 500030

ABSTRACT

A field experiment was carried out during the rainy (*kharif*) season of 2009-10 at Rajendranagar, Hyderabad, to find out effect of row ratio (1:1 and 1:2) and zinc levels on growth, yield, productivity, economics of maize + soybean intercropping systems under rainfed condition. The result revealed that growth and yield components of maize and soybean were less in intercropping systems compared to sole cropping. Intercropping of 1:1 and 1:2 ratio declined the seed yield by 14.75 and 11 per cent in maize and 52.19 per cent and 38.34 per cent in soybean as compared to sole crop. However, the total productivity of systems in terms of maize grain equivalent and LER (6182 kg ha^{-1} and 1.47) was found to be higher with maize + soybean 1:2 ratio. Irrespective of the cropping system, application of 50 kg $ZnSO_4$ ha^{-1} recorded significantly higher grain yield of maize and soybean (5301 and 936 kg ha^{-1}), maize-equivalent yield (6850 kg ha^{-1}) and LER. Highest net return (Rs. 43594) and B:C ratio (2.26) were found in maize + soybean 1:2 ratio with 50 kg $ZnSO_4$ ha^{-1} application.

Key words : Economics, Intercropping, Maize, Soybean, Yield.

Maize is one of the important crops of Asia, next to rice and wheat because of higher yield per unit area. The practice of growing two or more crops together, without any definite spatial arrangement, is being followed in rainfed condition. Intercropping has been recognized as a kind of biological insurance against risk under aberrant rainfall behavior in dry land environment. When crops of different growth habits are put together in an intercropping system, it provides greater opportunity to secure higher yield from the same piece of land. The benefit of intercropping system depends on suitable row arrangement with population adjustment for better utilization of growth resources like space, water, nutrient etc. In view of such situation, there is an ample scope to utilize the vacant wider inter-row space of maize during the initial slow growth period of the crop by introducing some compatible crop to get more productivity as well as net return from a unit of land. Soybean is considered as an ideal crop for intercropping with maize owing to its comparative tolerance for shade and drought and less competitiveness for soil moisture. For successful and profitable intercropping system, there must be proper row ratio of component crop in order to avoid the limitation of reduced plant population of base crop under traditional intercropping systems (Beets, 1977).

Maize crop is an exhaustive crop which requires high amount of macronutrients like NPK and micronutrients like zinc. Similarly, soybean has also shown response to zinc application (Nilam Kanase *et al*., 2008). In maize, zinc acts as a catalyst and stimulant in most of the physiological and metabolic processes. It plays a vital role in synthesis of protein and IAA (Indole Acetic Acid), chlorophyll formation and carbohydrate metabolism and acts as a metal activator of enzyme, resulting in increased growth and development of plants which ultimately gave higher grain yield (Patel *et al.,* 2008). Hence the present investigation was planned to study the performance of maize and soybean intercropping systems in relation to zinc application under rainfed condition.

MATERIAL AND METHODS

A field experiment was conducted during the rainy (*kharif*) season of 2009-10 at Students' farm, ANGRAU, Rajendranagar Hyderabad. The soil was sandy clay loam type, low in organic carbon (0.43 %) and nitrogen (194 kg N ha^{-1}), medium in phosphorous (31.2 kg P ha^{-1}), high in potassium (199 kg K ha^{-1}) and low in zinc (0.5 ppm_ha^{-1}). There were 16 treatment combinations compromising 4 cropping systems, viz., sole maize (C_1), sole soybean (C_2), maize + soybean 1:1 (C_3) and 1:2 ratio (C_4) and 4 zinc levels, 0, 25, 50 and 75 kg $ZnSO_4$ ha^{-1}.

Sixteen treatments were laid out in randomized block design (factorial) with three replications. The additive rows of maize and soybean were adjusted according to row ratio of treatments. The fertilizer dose of maize was 180:60:40 and soybean was 30:60:40 NPK kg ha^{-1}. 'Decalb Super 900' (Cargil) maize, JS 335 soybean were sown on 14 August-09, respectively. In sole crop, Maize was sown at a spacing of 60 cm between rows and soybean at 30 cm distance. In 1:1 intercropping system, each row of soybean was planted between two rows of maize, however, in 1:2 ratio, 2 rows of soybean were planted between 2 rows of maize with row spacing of maize at 90 cm and plant-to-plant spacing at 17.5 cm. Economics was worked out on the basis of existing market price. The Land Equivalent Ratio (LER) was computed as suggested by Willy (1979). Maize grain equivalent yield was calculated by converting the seed of soybean into maize on the basis of existing sale price in market was worked out as per the procedure outlined by Palaniappan (1985).

RESULTS AND DISCUSSION

Growth parameters

Plant height of maize as well as soybean crop were increased progressively with crop ontogeny, irrespective of cropping systems and zinc levels in maize and soybean crop (Table 1). Among all cropping systems, maize + soybean 1:1 ratio recorded significantly higher plant height in both maize and soybean crop due to competition for light in intra-inter row spacing. However, there was no significant influence of zinc on plant height of maize and soybean crop. The decrease in LAI (Leaf Area Index) and dry mater production of intercropped maize might be due to the competition by intercrop for space and other resources (Shivakumar and Virmani, 1980 and Bharti *et al.,* 2007). Higher values of LAI and dry matter production were recorded in sole maize with the application of 50 kg $ZnSO_4$ ha^{-1}.

Yield attributes

Sole crop of both maize and soybean recorded maximum yield attributing characters like cob length, cob girth, number of seeds cob^{-1} and 100-seed weight in maize and number of pods $plant^{-1}$, seeds pod^{-1} and 100-seed weight in soybean (Table 1). The reduction in yield attributes of both the crops might be due to crowding effect of soybean on maize as a result of higher plant density per unit area that resulted in inter row competition for space, nutrients and light. Among zinc levels, significantly maximum yield attributes were recorded at 75 kg $ZnSO_4$ ha^{-1} which was at par with 50 kg $ZnSO_4$ ha^{-1} and both were comparatively higher than that of 0 and 25 kg $ZnSO_4$ ha^{-1}. The increase in yield attributes of maize and soybean were due to the efficient translocation of photosynthates to the developing seeds (Lingle and Holberg, 1957).

Maize grain yield

Higher grain yield of maize was recorded in sole crop of maize (5484 kg ha^{-1}), followed by maize + soybean 1:2 (4877 kg ha^{-1}) and 1:1 ratio (4675 kg ha^{-1}), respectively (Table 1). The reduction in grain yield of maize in 1:1 and 1:2 ratios was 14.75 and 11.0 per cent as compared to sole crop of maize. The reduction due to decrease in yield attributing characters of maize was because of competition by intercropped soybean for resources. These results are in accordance with the finding of Padhi (2001) and Parvender Sheoran *et al.,* (2009).

Zinc sulphate @ 50 kg ha^{-1} resulted in considerable increase in grain yield of maize by 22.2 % and 8.9 % over 0 and 25 kg $ZnSO_4$ ha^{-1}, respectively (Table 1). The increased grain yield due to overall improvement of growth parameters as well as yield attributes and also a good response of zinc on zinc deficient soil (Lingle and Holberg, 1957).

Soybean seed yield

Seed yield of soybean was found significantly higher with sole soybean (1278 kg ha^{-1}), compared to 1:1 (611 kg ha^{-1}) and 1:2 ratio (788 kg ha^{-1}) intercropping systems (Table 1). The

Table 1. Growth, yield components, grain yield of maize and soybean, LER and maize equivalent yield as influenced by different cropping systems and zinc levels.

Treatments	Maize							Soybean				Maize grain yield (kg ha^{-1})	Soybean seed yield (kg ha^{-1})	LER	Maize equivalent yield (kg ha^{-1})
	Plant height (cm)	Dry matter (kg ha^{-1})	LAI	Cob length (cm)	Cob girth (cm)	Number of seeds per cob	100-seed weight (g)	Plant height (cm)	Pods plant^{-1}	Seeds pod^{-1}	100-seed weight (g)				
Cropping systems															
Sole maize	197	12496	3.65	17.0	14.9	435	28.7	-	-	-	-	5484	-	1.0	5484
Sole soybean	-	-	-	-	-	-	-	37.1	38.0	2.81	14.35	-	1278	1.0	2115
Maize + soybean (1:1)	209	11509	3.31	15.3	14.0	406	26.5	41.0	26.0	2.40	12.20	4675	611	1.31	5687
Maize + soybean (1:2)	201	11788	3.50	15.8	14.3	417	27.1	39.0	33.1	2.62	13.51	4877	788	1.47	6182
S.Em ±	2.44	150	0.04	0.09	0.09	5.50	0.24	0.30	0.78	0.05	0.19	115.1	19.35	0.04	119.7
C.D (P=0.05)	6.85	441	0.11	0.27	0.26	16.1	0.69	0.83	2.24	0.12	0.48	337.7	56.76	0.14	345.8
Zinc levels															
0 kg $ZnSO_4$ ha^{-1}	198	11168	3.19	15.4	13.8	380	25.6	38.7	28.8	2.40	12.50	4338	795	1.39	5654
25 kg $ZnSO_4$ ha^{-1}	202	11723	3.43	16.0	14.3	411	27.3	39.8	31.0	2.53	13.01	4868	869	1.40	6306
50 kg $ZnSO_4$ ha^{-1}	204	12234	3.63	16.4	14.7	436	28.6	39.9	33.9	2.70	13.60	5301	936	1.41	6850
75 kg $ZnSO_4$ ha^{-1}	206	12589	3.70	16.6	14.9	450	29.3	39.7	34.7	2.75	13.92	5543	973	1.40	7153
S.Em ±	2.74	173	0.05	0.11	1.08	6.30	0.27	0.32	0.90	0.05	0.20	132.9	22.34	0.06	135.0
C.D (P=0.05)	N.S	505	0.13	0.30	0.31	18.6	0.80	N.S	2.59	0.13	0.56	389.9	65.00	N.S	381.2
Interaction (C X Zn)	N.S	N.S	N.S	N.S	N.S	N S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

Table 2. Economics of cropping systems as influenced by different treatment combination.

Treatments	Gross return (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	Benefit:Cost ratio
Sole maize + 0 kg $ZnSO_4$ ha^{-1}	43234	26302	1.55
Sole maize + 25 kg $ZnSO_4$ ha^{-1}	47880	30073	1.68
Sole maize + 50 kg $ZnSO_4$ ha^{-1}	53986	35304	1.88
Sole maize + 75 kg $ZnSO_4$ ha^{-1}	58397	38840	1.98
Sole soybean + 0 kg $ZnSO_4$ ha^{-1}	16611	2138	0.14
Sole soybean + 25 kg $ZnSO_4$ ha^{-1}	18321	2973	0.19
Sole soybean + 50 kg $ZnSO_4$ ha^{-1}	19696	3473	0.21
Sole soybean + 75 kg $ZnSO_4$ ha^{-1}	20791	3693	0.21
Maize + soybean (1:1) + 0 kg $ZnSO_4$ ha^{-1}	46047	28887	1.68
Maize + soybean (1:1) + 25 kg $ZnSO_4$ ha^{-1}	52758	34723	1.92
Maize + soybean (1:1) + 50 kg $ZnSO_4$ ha^{-1}	54884	35974	1.90
Maize + soybean (1:1) + 75 kg $ZnSO_4$ ha^{-1}	58799	39314	2.01
Maize + soybean (1:2) + 0 kg $ZnSO_4$ ha^{-1}	50356	32836	1.87
Maize + soybean (1:2) + 25 kg $ZnSO_4$ ha^{-1}	55671	37276	2.02
Maize + soybean (1:2) + 50 kg $ZnSO_4$ ha^{-1}	62864	43594	2.26
Maize + soybean (1:2) + 75 kg $ZnSO_4$ ha^{-1}	62986	42841	2.12

magnitude of decrease in seed yield of soybean in 1:1 and 1:2 was 52.19 % and 38.34 %, compared to sole crop. Reduction in seed yield of soybean in intercropping systems due to less plant population of soybean, more intra and inter plant competition, more shading effect of maize on soybean. These results are in conformity with the findings of Singh (2000) and Dutta and Bandopadhay (2006). As regard to zinc doses, 50 kg $ZnSO_4$ ha^{-1} showing more seed yield of soybean as compared to 0 and 25 kg $ZnSO_4$ ha^{-1}. This is because of enhancement of enzymatic activity of soybean by zinc application which in turn might have stimulated the translocation of assimilates efficiently toward sink that resulted into increase in yield (Nilam Kanse *et al*., 2008).

LER and Maize equivalent yield

The intercropping treatment of maize + soybean at 1:2 ratio recorded significantly higher LER and maize grain equivalent yield values over other cropping systems (Table 1). The increase in maize equivalent yield and LER in intercropping systems of 1:1 and 1:2 were 3.7 %, 31 % and 12.72 %, 47 %, compared to sole cropping. This was due to the better utilization of land and natural resources in intercropping with additional advantage of soybean and highest market price of soybean, compared to sole cropping of maize and soybean (Meena *et al*., 2006). In respect of zinc levels, there was no significant effect of zinc on LER. However, a significant response was noticed in respect of maize grain equivalent yield upto 50 kg $ZnSO_4$ ha^{-1} which was at par with 75 kg $ZnSO_4$ ha^{-1}. Application of 50 kg $ZnSO_4$ ha^{-1} resulted in increased maize grain equivalent yield to an extent of 21.15 % and 8.6 % over 0 and 25 kg $ZnSO_4$ ha^{-1}, respectively.

ECONOMICS

Maize + soybean 1:2 ratio intercropping system fetched higher net return value and B:C ratio followed by 1:1 ratio system and sole stand of maize and soybean (Table 2). This might be due to the difference in grain yield and additional yield advantage of soybean, which resulted in higher net return and B:C ratio. Maximum net returns (Rs. 39125) was obtained in maize + soybean 1:2 ratio with 50 kg $ZnSO_4$ ha^{-1} which is followed by maize + soybean 1:2 ratio with 75 kg $ZnSO_4$ ha^{-1} (Rs. 42841), while lowest net return was obtained in sole soybean (Rs. 2138). Earlier, Singh (2000), Meena *et al.,* (2006) and Parvender Sheoran *et al.,* (2009) were also reported similar results.

Among different intercropping systems, highest B:C ratio (2.26) was recorded in maize + soybean 1:2 ratio together with 50 kg $ZnSO_4$ ha^{-1} application followed by maize + soybean 1:2 ratio together with 75 kg $ZnSO_4$ ha^{-1} (2.12). Overall, the application of higher levels of zinc to maize + soybean intercropping system was not found to be beneficial in terms of economic returns.

From the above results it can be concluded that growing of soybean in maize crop at 1:2 ratio was found remunerative under rainfed conditions along with the application of 50 kg $ZnSO_4$ ha^{-1} in zinc deficit soil of sandy clay loam.

LITERATURE CITED

Beets W E 1977 Multiple cropping of maize and soybean under a high level of crop management. *Netherlands Journal of Agricultural Sciences*, 25: 95-102.

Bharti V, Ravi Nandan, Vinod Kumar and Pandey I B 2007 Effect of irrigation levels on yield, water use efficiency and economics of winter maize. *Indian Journal of Agronomy,* 52(1): 27-30.

Dutta D and Bandyopadhaya P 2006 Production potential of intercropping of groundnut with pigeon pea and maize under various row proportions in rainfed alfisol of West Bengal. *Indian Journal of Agronomy,* 51(3): 103-106.

Lingle J C and Holberg D M 1957 The response of sweet corn to foliar and soil zinc application on a zinc deficient soil. *American society of soil science,* 70: 308-315.

Meena O P, Gaur B L and Singh P 2006 Effect of row ratio and fertility levels on productivity, economics and nutrient uptake in maize + soybean intercropping system. *Indian Journal of Agronomy,* 52(3):178-182.

Nilam Kanase K, Jadhao S M, Konde N M and Patil J D 2008 Response of soybean to application of zinc. *Agricultural Science Digest,* 28(1): 63-64

Padhi A K 2001 Effect of vegetable intercropping on productivity, economics and energetics of maize. *Indian Journal of Agronomy,* 46(2): 204-210.

Palaniappan S P 1985 Cropping systems in tropics; *Principals and management* pp, 25-28 Willy Eastern Limited.

Parvender Sheoran, Virender Sardana, Sukhvinder Singh and Sher Singh 2009 Productivity potential and economic feasibility of maize-greengram intercropping system under rainfed condition. *Indian Journal of Agricultural Sciences,* 79(7): 535-537.

Patel B T, Patel J J, Patel V B and Patel A M 2008 Zinc management in presence of and absence of FYM in *kharif* maize. *Crop Research,* 35 (3): 186-189.

Shivakumar M V K and Virmani S M 1980 Growth resources use of maize, pigeonpea and maize + pigeonpea intercrop in an operational research watershed. *Experimental Agriculture,* 16: 377-386.

Singh V P 2000 Planting geometry in maize and blackgram intercropping system under rainfed low hill valley of Kumaon. *Indian Journal of Agronomy,* 45(2): 274-278.

Willey R W 1979 Intercropping: its importance and research needs I. Competition and yield advantages. *Field Crop Abstract*, 32: 1-10.

(Received on 31.10.2012 and revised on 20.12.2012)