Mysore J. Agric. Sci., 51 (2) : 425-429, 2017

Effect of Crop Geometry in Maize Based Intercropping System

S. S. Shree Harsha Kumar and B. C. Shankaralingappa
Department of Agronomy, College of Agriculture, UAS, GKVK, Bengaluru-560 065
E-mail : harshakumar931@gmail.com

Abstract

A field experiment was carried out during *kharif* season of 2014 at Zonal Agricultural Research Station, GKVK, Bengaluru to study the effect of crop geometry in maize based intercropping system. The results revealed that significantly higher kernel yield of maize (5802 kg ha^{-1}) was obtained in maize (paired row system-30 / 90 cm) + frenchbean + horsegram (as second intercrop after frenchbean) than maize (60 x 30 cm) + guar / frenchbean additive intercropping and it was on par with the sole maize with 30 / 90 cm paired row system. LER, maize equivalent yield, net returns and B:C ratio were also higher in maize (paired row system-30 / 90cm) + frenchbean + horsegram additive intercroppong (1.56, ₹ 13931 kg ha^{-1}, ₹ 112592 ha^{-1} and 2.95, respectively) and maize (paired row system-30 / 90cm) + frenchbean intercropping (1.47, 13738 kg ha^{-1}, 113561 ha^{-1} and 3.09, respectively) than in maize (60 x 30 cm) + guar/frenchbean additive intercropping. Maize (paired row system-30 / 90 cm) + frenchbean additive intercropping was superior to sole crop of maize (either in 60x30 cm or paired row system-30 / 90 cm) as indicated by higher net returns (113561 ha^{-1}) with B:C ratio (3.09).

Keywords: Maize, crop geometry, intercropping, paired row system

Maize (*Zea mays* L.) is one of the important cereals next to wheat and rice in the world. In India, it is consumed as food, fodder and also has industrial uses. About 35 per cent of the maize produced in India is used for human consumption, 25 per cent each in poultry and cattle feed and 15 per cent in food processing industries. In India it is cultivated over an area of 9.19 m ha with a production of 24.17 m.t and productivity of 2632 kg ha^{-1} (Anon., 2015). In Karnataka, it occupies an area of 13.31 lakh ha with a production of 40.85 lakh t and productivity of 3018 kg ha^{-1} which is greater than the national average.

The extent of cultivable land is gradually decreasing, mainly because of rapid urbanization and industrialization due to the global population explosion resulting in ever increasing pressure on cultivated land for food and commercial crops. Food supply is one of the most important problems the world is enduring nowadays; intercropping is used in many parts of the world for the production of food and feed crops (Carruthers *et al.,* 2000). The main objective of intercropping is to augment total productivity per unit area and time, besides judicious and equitable utilization of land resources and farming inputs without reducing base crop yield (Marer *et al.,* 2007 and Zhang *et al.,* 2007).

Maize provides an opportunity for inclusion of intercrops because of its wider row spacing and plasticity of the crop to row spacing. Maize and legume intercropping was found to be more productive and remunerative compared to sole cropping (Kumar *et al.,* 2008 and Kamanga *et al.,* 2010). Guar is a hardy legume containing gelling agent (guar gum) in seeds. Demand is rising rapidly due to industrial use of guar gum. The guar is being introduced into new areas because of higher commercial value and greater demand. It is an imperative to introduce guar crop in new areas, one way of introducing this crop is intercropping with cereals like maize.

The research information available on paired row agro-techniques of maize based intercropping system is meager. Hence, the present investigation was carried out to study the effect of crop geometry in maize based intercropping system.

Material and Methods

A field experiment was carried out during *kharif,* 2014 in Zonal Agricultural Research Station, GKVK, Benagluru, Karnataka which is situated in the Eastern Dry Zone (Zone–5) at 12° 58' N latitude, 77° 35' E longitude and an altitude of 930 m above mean sea level. The soil of experimental site was red sandy clay

loam, neutral in soil reaction (pH 6.78), low in organic carbon content (0.32 %), medium in available nitrogen (286.15 kg ha^{-1}), low in available P_2O_5 (21.69 kg ha^{-1}) and medium in available K_2O (243.48 kg ha^{-1}). The experiment was laid out in a randomized complete block design with three replications. The treatments comprised of T_1: Sole maize (60 x 30 cm); T_2: Sole maize (Paired row system - 30 / 90 cm); T_3: Sole guar; T_4: Sole frenchbean; T_5: Sole horsegram; T_6: Maize (60 x 30 cm) + guar additive intercropping; T_7: Maize (60 x 30 cm) + frenchbean additive interropping; T_8: Maize (Paired row system - 30 / 90 cm) + guar additive intercropping; T_9: Maize Paired row system - 30 / 90 cm) + frenchbean additive interropping; T_{10}: Maize Paired row system - 30 / 90 cm) + frenchbean + horsegram additive interropping. Horsegram was sown as second intercrop after the harvest of french bean in maize (paired row system of 30 / 90 cm) + french bean intercropping. Farm yard manure was applied uniformly to all the plots at the rate of 7.5 t ha^{-1} two weeks before sowing. The recommended dose of fertilizer for maize (100 kg N, 50 kg P_2O_5 and 25 kg K_2O ha^{-1}), guar (25 kg N, 75 kg P_2O_5 and 60 kg K_2O ha^{-1}) and french bean (62.5 kg N, 100 kg P_2O_5 and 75 kg K_2O ha^{-1}) was applied in the form of urea, single super phosphate and muriate of potash. In case of maize, 50 per cent N was applied as basal and remaining dose of nitrogen (50 kg ha^{-1}) was applied in two equal splits as top dressing at 30 and 45 DAS. In intercropping treatments, recommended dose of fertilizer for maize plus fertilizer for intercrops based on their population was applied. The other management operations were done as per recommended package of practices for both main and intercrops. Growth and yield parameters were recorded as per standard procedures. B:C ratio was calculated by dividing the gross returns from the cost of cultivation and maize equivalent yield (MEY) was calculated on the basis of prevailing market prices of both maize and intercrops.

Results and Discussion

The kernel yield of maize in sole cropping was not significantly influenced by crop geometry (60 x 30 cm and paired row system of 30 / 90 cm). There was also no significant differences in yield parameters such as cob length, rows cob^{-1}, kernel weight $plant^{-1}$ and 100-kernel weight (Table I) and growth parameters like plant height, leaf area and dry matter $plant^{-1}$ (Table II) between 60 x 30 cm spacing and paired row system (30 / 90 cm) of sole maize crop. These results are in conformity with the findings of Ashoka (2011). For intercropping systems, paired row system of 30/90 cm was better for maize crop. In intercropping

TABLE I

Yield and yield components of maize as influenced by crop geometry in additive intercropping system

Treatments	Cob length (cm)	Rows cob^{-1}	Kernel weight $plant^{-1}$ (g)	100 Kernel weight (g)	Kernel yield (kg ha^{-1})	Stover yield (kg ha^{-1})
T_1	18.2	15.2	104.0	31.6	5682	6954
T_2	18.4	17.7	115.8	33.7	5794	7307
T_6	17.3	14.5	99.6	31.2	5605	6937
T_7	17.5	14.8	100.6	31.0	5642	7018
T_8	17.6	16.9	122.2	30.7	5738	7406
T_9	17.5	17.3	117.8	33.1	5796	7288
T_{10}	17.6	16.6	123.9	31.7	5802	7219
S.Em±	0.9	1.0	9.2	2.0	43.1	193.9
C.D. (P=0.05)	NS	NS	NS	NS	132.7	NS

T_1: Sole maize (60 X 30 cm)
T_2: Sole maize (Paired row system - 30/90 cm)
T_3: Sole guar
T_4: Sole frenchbean
T_5: Sole horsegram
T_6: Maize (60 X 30 cm) + guar
T_7: Maize (60 X 30 cm) + frenchbean
T_8: Maize (Paired row system - 30/90 cm) + guar
T_9: Maize Paired row system - 30/90 cm) + frenchbean
T_{10}: Maize (Paired row system - 30/90 cm) + frenchbean + horsegram

TABLE II

Growth components of maize as influenced by crop geometry in additive intercropping system

Treatments	Plant height (cm)	Leaf area plant^{-1} (cm)	Dry matter plant^{-1} (g)
T_1	168.7	5929	242.2
T_2	174.5	6369	261.3
T_6	153.4	5834	246.4
T_7	161.3	5998	254.2
T_8	169.7	6225	267.5
T_9	173.9	6330	266.6
T_{10}	171.2	6305	270.9
S.Em±	2.68	144.6	10.4
C.D. (P=0.05)	8.26	445.7	NS

T_1: Sole maize (60 X 30 cm)
T_2: Sole maize (Paired row system - 30/90 cm)
T_3: Sole guar
T_4: Sole frenchbean
T_5: Sole horsegram;
T_6: Maize (60 X 30 cm) + guar
T_7: Maize (60 X 30 cm) + frenchbean
T_8: Maize (Paired row system - 30/90 cm) + guar
T_9: Maize (Paired row system - 30/90 cm) + frenchbean
T_{10}: Maize (Paired row system - 30/90 cm) + frenchbean + horsegram

systems, significantly higher kernel yield of maize (5802 kg ha^{-1}) was obtained in maize (paired row system of 30 / 90 cm) + frenchbean + horsegram additive intercropping than with maize (60 x 30 cm) + guar / frenchbean intercropping and it was on par with the sole maize in 30 / 90 cm paired row system. Higher kernel yield of maize in paired row maize + frenchbean / guar intercropping was due to marginally higher kernel weight plant^{-1} which was further due to significantly higher plant height and leaf area and marginally higher dry matter plant^{-1} (Table III). Similar results were also reported by Gollar and Patil (1997) and Asoka (2011). Stover yield of maize did not differ significantly due to crop geometry and intercropping with frenchbean or guar.

All intercropping treatments recorded more maize equivalent yield (MEY) and LER than sole maize crop (Table IV). Significantly higher MEY (13931 kg ha^{-1}) and higher LER (1.56) were observed in maize (paired row system of 30 / 90 cm) + frenchbean + horsegram additive intercropping and it was closely followed by maize (paired row system of 30/90 cm) + frenchbean intercropping (13738 kg ha^{-1} and 1.47 respectively). Similar results were also reported by Mandal *et al.*

TABLE III

Growth and yield parameters of intercrops as influenced by intercropping in maize at different crop geometry

Treatments	Plant height (cm)	Branches plant^{-1}	Dry matter plant^{-1} (g)	Pods plant^{-1}	Pod lenght(cm)	Pod / seed yield plant^{-1}	Pod / seed yield ha^{-1}	Haulm yield (kg ha^{-1})
T_3	42.76	3.37	9.28	21.42	3.62	2.92	414	1863
T_4	38.84	9.19	34.12	48.65	16.17	69.57	13628	2793
T_5	45.94	5.82	14.8	18.92	4.35	4.19	679	2914
T_6	31.49	1.44	3.99	9.11	3.05	1.45	100	584
T_7	27.72	4.79	19.21	32.62	12.93	37.21	3508	1932
T_8	37.36	2.19	5.33	15.63	3.29	1.82	125	729
T_9	35.14	7.85	28.05	39.33	15.42	60.43	6354	1786
T_{10}	34.66	8.02	29.28	41.94	14.19	62.92	6376	1891
	22.15 *	3.27 *	4.03 *	7.58 *	3.21 *	1.02 *	63 *	319 *

T_1: Sole maize (60 X 30 cm)
T_2: Sole maize (Paired row system - 30/90 cm)
T_3: Sole guar
T_4: Sole frenchbean
T_5: Sole horsegram
T_6: Maize (60 X 30 cm) + guar
T_7: Maize (60 X 30 cm) + frenchbean
T_8: Maize (Paired row system - 30/90 cm) + guar
T_9: Maize (Paired row system - 30/90 cm) + frenchbean
T_{10}: Maize (Paired row system - 30/90 cm) + frenchbean + horsegram
* Growth and yield parameters of horsegram

TABLE IV

Maize equivalent yield (MEY) and LER as influenced by crop geometry in additive intercropping system

Treatments	Yield (kg ha^{-1})		MEY (kg ha^{-1})	LER
	Maize	Intercrop		
T_1	5682	-	5682	1.00
T_2	5794	-	5794	1.00
T_3	-	414	1328	1.00
T_4	-	13628 *	17035	1.00
T_5	-	679	1698	1.00
T_6	5605	102	5932	1.23
T_7	5642	3508 *	10028	1.25
T_8	5738	125	6139	1.29
T_9	5796	6354	13738	1.47
T_{10}	5802	6376 *+64	13931	1.56
S.Em±	43.1	-	264.94	-
C.D. (P=0.05)	132.7	-	794.32	-

T_1: Sole maize (60 X 30 cm)
T_2: Sole maize (Paired row system - 30/90 cm)
T_3: Sole guar
T_4: Sole frenchbean
T_5: Sole horsegram
T_6: Maize (60 X 30 cm) + guar
T_7: Maize (60 X 30 cm) + frenchbean
T_8: Maize (Paired row system - 30/90 cm) + guar
T_9: Maize Paired row system - 30/90 cm) + frenchbean
T_{10}: Maize (Paired row system - 30/90 cm) + frenchbean + horsegram; LER: Land equivalent ratio
*Green bean yield of frenchbean

TABLE V

Cost of cultivation, gross returns, net returns and B:C ratio as influenced by crop geometry in maize based intercropping system

Treatments	Gross returns (₹ ha^{-1})	cost of cultivation (₹ ha^{-1})	Net returns (₹ ha^{-1})	B:C ratio
T_1	70018	34827	35191	2.01
T_2	72085	34827	37258	2.07
T_3	16402	14054	2348	1.17
T_4	205118	47405	157713	4.33
T_5	21105	14485	6620	1.46
T_6	73758	38829	34929	1.90
T_7	123275	54292	68983	2.27
T_8	76442	38829	37613	1.97
T_9	167853	54292	113561	3.09
T_{10}	170251	57659	112592	2.95

T_1: Sole maize (60 X 30 cm)
T_2: Sole maize (Paired row system - 30/90 cm)
T_3: Sole guar
T_4: Sole frenchbean
T_5: Sole horsegram;
T_6: Maize (60 X 30 cm) + guar
T_7: Maize (60 X 30 cm) + frenchbean
T_8: Maize (Paired row system - 30/90 cm) + guar
T_9: Maize (Paired row system - 30/90 cm) + frenchbean
T_{10}: Maize (Paired row system - 30/90 cm) + frenchbean + horsegram
Market price: Maize-₹ 12 kg^{-1}; guar-38.5 kg^{-1}; frenchbean-15 kg^{-1}; horsegram-30 kg^{-1}

(2014). Higher maize equivalent yield in maize (paired row system of 30 / 90 cm) + frenchbean intercropping system was attributed to higher green bean yield of frenchbean in paired row system of intercropping than in normal planting of maize + frenchbean and its higher market price. Performance of frenchbean was better in maize (paired row system-30 / 90 cm) + frenchbean additive intercropping system compare to that in maize (60 x 30 cm) + frenchbean additive intercrop. This was due to higher growth and yield parameters of frenchbean in paired row system (Table III). These results are in conformity with the findings of Ashoka (2011) and Ganajaxi (2008). Lesser growth and yield parameters of maize were observed in maize (60 x 30 cm) + frenchbean/guar intercropping as compared to paired row system. This might be attributed to availability of more space for maize at 30 / 90 cm paired row in intercropping than at 60 x 30 cm spacing, which might have helped maize plant in exploitation of natural resources more efficiently resulting in higher dry matter accumulation (Aravindkumar *et al.,* 2004).

Among intercropping systems, maize (paired row system-30 / 90 cm) + frenchbean additive intercropping and maize (paired row system-30 / 90 cm) + frenchbean + horsegram additive intercropping had given more net returns (₹ 1,13,561 ha^{-1} and 112592

ha^{-1}, respectively) and B:C ratio (3.09 and 2.95) (Table V) than maize (60 x 30 cm) + frenchbean / guar intercropping and maize (paired row system-30 / 90 cm) + guar intercropping system and sole maize crop. This was due to higher frenchbean green pod yield and its higher market price. These results are in conformity with the findings of Ganajaxi (2008).

It can be concluded that paired row system of 30 / 90 cm is an ideal crop geometry for additive intercropping in maize. Maize (paired row system of 30 / 90cm) + frenchbean intercropping is highly productive and economical intercropping system as indicated by higher LER, net returns and B:C ratio under dryland condition.

References

Anonymous, 2015, Selected State / season-wise area, production and productivity of maize in India. *www.indiastat.com*

Aravindkumar, Singh, S. N. and Gajendra, G., 2004, Influence of planting ratio and fertilizer application on dry matter production, LAI and nutrient content and uptake by maize and groundnut intercropping. *Ann. Agric. Res. New Series,* **25** (2) : 283 - 288.

Ashoka, P., 2011, Agronomic investigations on maize (*Zea mays* L.) based cropping system. *Ph.D. Thesis,* Univ. Agric. Sci., Bengaluru.

Carruthers, K., Prithiviraj, B. F. Q., Cloutier, D., Martin, R. C. and Smith, D. L., 2000, Intercropping maize with soybean, lupin and forages: yield component responses. *Eur. J. Agro.,* **12** : 103 - 115.

Ganajaxi, 2008, Production potential of different cropping systems with frenchbean (*Phaseolus vulgaris* L.) in Northern Transition Zone of Karnataka. *Ph.D. Thesis,* Univ. Agric. Sci., Dharwad.

Gollar, R. G. and Patil, V. C., 1997, Studies on maize based cropping system under simultaneous and staggered planting of intercrops. *Karnataka J. Agri. Sci.,* **10** : 648 - 652.

Kamanga, B. C., Waddington, G. S. R., Robertson, M. J. and Giller, K. E., 2010, Risk analysis of maize-legume crop combinations with small holder farmers varying in resource endowment in central Malawi. *J. Exp. Agric.*, **46** : 1 - 21.

Kumar, R. B. P., Ravi, S. and Balyan, J. S., 2008, Effect of maize (*Zea mays*) + blackgram intercropping and integrated nitrogen management on productivity and economics of maize. *Int. J. Plant Sci.,* **3** (1) : 53 - 57.

Mandal, M. K., Banerjee, M., Banerjee, H., Alipatra, A. and Malik, G. C., 2014, Productivity of maize (*Zea mays*) based intercropping system during kharif season under red and lateritic tract of West Bengal. *The Bioscan.,* **9** (1) : 31 - 35.

Marer, S. B., Lingaraju, B. S. and Shashidhara, G. B., 2007, Productivity and economics of maize and pigeonpea intercropping under rainfed condition in northern transitional zone of Karnataka. *Karnataka J. Agric. Sci.*, **20** (1) : 1 - 3.

Zhang, L., Werf, W., Zhang, S., Li, B. and Spiertz, J. H. J., 2007, Growth, yield and quality of wheat and cotton in relay strip intercropping systems. *Field Crops Res.,* **103** : 178 - 188.

(*Received :* May, 2017 *Accepted :* June, 2017**)**