Effect of Summer Maize-Legume Intercropping System on Growth, Productivity and Competitive Ability of Crops

Pilli Manasa
Post-graduate Student, Department of Agronomy
M. S. Swaminathan School of Agriculture, Centurion University of Technology and Management, Paralakhemundi-761 211, India
p.manasa@cutm.ac.in
SagarMaitra
Associate Professor, Department of Agronomy
M. S. Swaminathan School of Agriculture, Centurion University of Technology and Management, Paralakhemundi-761 211, India
sagar.maitra@cutm.ac.in
M. Devender Reddy
Professor and Dean, Department of Agronomy, M. S. Swaminathan School of Agriculture, Centurion University of Technology and Management, Paralakhemundi-761 211, India
devender.reddy@cutm.ac.in

Abstract- Maize (Zea mays L.), the queen of cereals, is planted with wide spacing and so it offers the scope of intercropping. Considering the benefits of cereal-legume association, an experiment on maize-legume intercropping system was conducted during summer season of 2018 at Bagusala Farm of M. S. Swaminathan School of Agriculture, Centurion University of Technology and Management, Gajapati district, Odisha under typical sub-humid and sub-tropical climatic conditions. The treatments were comprised of ten cropping systems namely, T1: sole maize (Zea mays L.), T2: sole greengram (Vignaradiata L.), T3: sole groundnut (Arachishypogeae L.), T4: sole blackgram (Vignamungo L.), T5: Maize with greengram (2:1), T6: Maize with groundnut (2:1), T7: Maize with blackgram (2:1), T8: Maize with greengram (2:2), T9: Maize with groundnut (2:2) and maize with blackgram (2:2). Paired row sowing of hybrid maize was done with a spacing of 30 cm × 25 cm / 80 cm in sole maize. Pure stand of legume i.e. green gram, groundnut and black gram were sown with 30 cm × 10 cm spacing. As per the treatments, single and double row of intercrops were taken in between two pairs of maize. The observations recorded from the experiment clearly showed that the growth and productivity of maize was influenced by the treatments. However, in additive series of intercropping treatments, legumes produced considerable yield. The competition functions like land equivalent ratio (LER), relative crowding co-efficient (RCC), aggressivity (A) and competitive ration (CR) prominently indicated the benefits of maize-legume intercropping system under south Odisha conditions.

Keywords: Maize, legume, intercropping, growth, productivity, competitive ability

1. INTRODUCTION

Maize (*Zea mays* L.) is one of the important crops occupying third position next to wheat and rice in cereal production in the world. It is a source of carbohydrate and used for both human consumption and animal feed worldwide due to its high feeding value (Undie et al. 2012[1]). In India, the crop occupies 9.19 m ha with a production of 24.17mt and average productivity is 2632 kg/ha (2014-15). Maize is also one of the important cereals cultivated in Odisha. The area under the crop in the state is 2.8 lakh ha and production is 7.79 lakh t with a productivity of 2785 $kgha^{-1}$ which is higher than the national average. Besides, the government of Odisha is keen on promoting private sector investment in maize value chain. The crop offers enough scope of intercropping as it has widely spaced rows. Maize has been recognized as a common component in most intercropping system and it seems to lead as the cereal constituent of intercrop and is regularly combined with dissimilar legumes. Intercropping is growing of two or more generally dissimilar crops simultaneously on the same piece of land with distinct row arrangement. The main reason to adopt intercropping is to increase in productivity per unit area per unit time by efficiently utilizing the resources (Willey, 1979[2]).Biological efficiency of intercropping gets improved due to exploration of large soil mass compared to mono-cropping (Sarkar*et al.*, 2000[3]). Moreover, by adoption of

intercropping risks in crop cultivation can be minimized and the natural resources are fully utilized. This practice is an attractive strategy to smallholder farmers for increasing productivity, utilization of land and labour though intensification of land uses (Seran and Brintha, 2010[4]). Furthermore, intercropping cereals with legumes have huge capacity to replenish soil mineral nitrogen through its ability to biologically fix atmospheric nitrogen (Mandal*et al*., 1991[5]; Maitra*et al*., 2000[6]; Giller, 2001[7]). Intercropping of maize and legume is advantageous in many aspects including higher productivity in additive series, N benefit by maize crop in association and higher monetary gain. The choice of legume species, seeding ratio or row proportion and competition ability within mixtures mayaffect the growth of the species used in intercropping systems (Kariaga, 2004[8]).The impact of maize based cropping system was not much studied under south Odisha conditions; hence the study has been conducted to evaluate the efficiency of summer maize-legume intercropping system.

2. MATERIALS AND METHODS

The field experiment was conducted during summerseason of 2018 at Bagusala Farm (23°39' N latitude, 87°42' E longitude) of M. S. Swaminathan School of Agriculture, Centurion University of Technology and Management, Paralakhemundi, Gajapati district, Odisha under typical sub-humid and sub-tropical climatic conditions. During the period of experimentation the maximum and minimum temperature ranged from 36 to 49°C and 19 to 30°C respectively. Crops received negligible amount of rainfall distributed during the growing period. The soil of the experimental plot was clay loam in texture, acidic in reaction (pH 6.2), with low level of organic carbon (0.45%), with available of N 78.4 kg/ha. The experiment was laid in Randomized Block Design and replicated thrice. Treatments were comprised of ten cropping systems namely, T1: sole maize (*Zea mays*L.), T2: sole green gram (*Vignaradiata*L.), T3: sole groundnut (*Arachishypogeae*L.),T4: sole blackgram (*Vignamungo*L.), T5: Maize with greengram(2:1), T6: Maize with groundnut (2:1), T7: Maizewith blackgram (2:1), T8: Maize with greengram (2:2), T9: Maize with groundnut (2:2) and maize with blackgram (2:2) . Under this experiment the main cropwas maize hybrid 'Kaveri 50' and the intercrops wereGreengram var. 'IPM 02-03', groundnut var. 'K-6' and blackgram var. 'PU 31'.Paired row sowing of hybrid maize was done with a spacing of 30 cm × 25 cm / 80 cm in sole maize. Pure stand of legume i.e. green gram, groundnut andblackgramwere sown with 30 cm × 10 cm spacing. As per the treatments, single and double row of intercrops were taken in between two pairs of maize.The fertilizerdoses for hybrid maize and grain legumes were 120 kg N, 60 kg $P_2O_5$and 60 kg K_2O/ha and 20 kg N, 40 kg P_2O_5 and 20 kg K_2O /harespectively. The sources of N, P_2O_5 and K_2O were urea, single super phosphate and muriate of potash respectively.In case of sole cropping of legumes, the entire fertilizers were applied as basal, however, in maize half of N and full dose of P_2O_5 and K_2O were applied as basal and remaining 50 per cent of N fertilizer was applied in maize at knee height stage. Inmaize and legume intercropped plots, the fertilizer dose applied as per recommendation for maize.The duration of the crops, namely, maize, green gram, groundnut and black gram was 119, 73, 127 and 87 days respectively. The other management operations were done asper recommended package of practices for both of the main andintercrops. Growth and yield parameters were recorded asper standard procedures and analyzed statistically. Competition functions were calculated as per the formulae provided earlier by researchers (McGilchrist(1965)[9]; Willey and Osiru, 1972[10]; Hall, 1974[11]; Willey and Rao, 1980[12]).

3. RESULTS AND DISCUSSION

The results obtained from the above study in terms of growth, yield and competition functions were presented in tables and necessary statistical analysis was done (Table 3.1, 3.2 and 3.3).

3.1 Effect on growth parameters of crops

The growth parameters like the height of the plant (cm) and dry matter accumulation (g $plant^{-1}$) were presented in table (3.1), which clearly indicated that there was significant difference among the treatments in expression of said characters of maize and legumes. Sole maize produced the maximum height of the plant and it was significantly more than the treatments maize + greengram and maize + blackgramcombinations irrespective of the row proportion of legumes. However, the values of the height of the plant were statistically at par with sole crop of maize when it is intercropped with groundnut either with single or double rows of the legume oilseed crop. There was also significant difference among the treatments in maximization of the height of the plant of legumes. The maximum height of the plant was noted with sole groundnut which was statistically at par with intercropped groundnut with single and double row proportions. Groundnut both as sole and intercropped with maize significantly produced more height of

the plant than other legumes. Moreover, it was also noted that each legume species when intercropped with maize did not show any difference with in the same species.

The dry matter accumulation (g plant^{-1}) of maize and legumes was influenced by intercropping system.Sole maize was statistically at par with maize intercropped with groundnut (2:2) and it registered significantly more dry matter accumulation (176.12 g plant^{-1}) than any other combinations. Among different legume species, groundnut alone or in combination with maize recorded the maximum dry matter accumulation. For other legumes also, it was noted that there was no significant difference with in the legume species between pure stand and in association with maize irrespective of row ratio.Earlier Mandal*et al.* (2014)[13] noted variation in growth parameters of maize and legumesinintercropping system.

Table 3.1 Growth parameters of crops in summer maize-legume cropping system

Treatments	Height of the plant at harvest (cm)		Dry matter accumulation at harvest (g plant^{-1})	
	Maize	Legume	Maize	Legume
Sole maize	230.4		176.12	
Sole greengram		27.2		6.07
Sole groundnut		58.1		11.46
Sole blackgram		38.6		6.93
Maize + greengram (2:1)	210.6	28.1	141.94	6.12
Maize + groundnut (2:1)	225.2	56.8	164.16	11.73
Maize + blackgram (2:1)	213.6	35.8	158.14	6.84
Maize + greengram (2:2)	215.4	27.9	152.23	6.14
Maize + groundnut (2:2)	226.2	56.1	171.92	11.58
Maize + blackgram (2:2)	216.1	37.6	160.12	6.76
SEm±	4.16	0.87	3.39	0.38
CD (P=0.05)	12.52	2.62	10.42	1.14
CV (%)	6.7	6.4	6.3	13.9

3.2 Effect on yield of maize and legumes

The yields of maize and legume were influenced by cropping system. Sole maize produced the maximum grain yield and the treatment was statistically at par with the intercrop combinations with groundnut. Sole maize resulted in significantly more grain yield than the intercropped maize with greengram or blackgram irrespective of row proportion. It was noted that all intercrop combinations produced less grain yield than sole maize. Sole maize also produced maximum stover yield and the treatment was statistically at par with the stover produced in maize + groundnut (2:1) intercrop combination. Moreover, sole maize recorded more stover yield than remaining treatments. In case of biological yield, sole maize being statistically at par with maize + groundnut (2:2) registered significantly higher values than other intercrop combinations.Earlier researchers also noted similar type of observations in productivity of maize (Bhatnagar*et al.*(2012)[14]; Kheroar and Patra(2014)[15]; Mandal*et al.*(2014)[13]. There was also variation in grain/ pod yield of legumes. Pure stands of legumes produced more grain yield than when these intercropped with maize and this variation is due to the difference of population. When the legumes were intercropped in maize with single row after a pair of maize rows, the legume got only a forth of population than pure stand of their respective species. Similarly when the legumes were taken in combination with maize with 2:2 ratio, these got half of the population than the sole legumes. The yield difference in legumes due to variation in population in maize-legume intercropping was also noted earlier by scientists (Kheroar and Patra(2014)[15]; Mandal*et al.*, 2014)[13].

Table 3.2 Yield of crops in summer maize-legume intercropping system

Treatments	Grain/pod yield (kg ha^{-1})		Stover yield (kg ha^{-1})		Biological yield (kg ha^{-1})	
	Maize	Legume	Maize	Legume	Maize	Legume
Sole maize	5668.5		8164.2		13832.7	

Sole greengram		618.5		1196.5		2717.0
Sole groundnut		1231.4		2218.4		3449.8
Sole blackgram		955.9		1294.5		2250.4
Maize + greengram (2:1)	4953.6	125.8	6275.3	241.6	11228.9	367.4
Maize + groundnut (2:1)	5447.4	278.4	7456.2	501.6	12903.6	780.0
Maize + blackgram (2:1)	5241.8	223.5	7093.6	280.7	12335.4	518.2
Maize + greengram (2:2)	4976.5	243.6	6869.9	482.1	11846.4	725.7
Maize + groundnut (2:2)	5609.6	521.6	7812.6	948.8	13422.2	1467.4
Maize + blackgram (2:2)	5204.5	433.5	7116.4	618.3	12320.9	1051.8
SEm±	95.21	8.62	124.44	16.4	229.61	28.71
CD (P=0.05)	239.36	25.86	383.46	49.17	707.49	86.06
CV (%)	5.4	5.7	5.1	5.7	5.7	5.8

3.3 Effect on competitive ability of crops

Different competition-functions like land equivalent ratio (LER), relative crowding co-efficient (RCC), aggressivity (A) and competitive ration (CR) were calculated and presented in table 3.3. LER is the relative land area required for sole crops to produce the yield achieved in intercropping system. LER of maize and legumes were calculated and they were added to get combined LER. Maize + groundnut (2:1) registered the highest combined LER among all intercrop combinations. In case of some other combinations LER value was close to the highest value. Maize is a wide spaced crop with slower growth during early stage. Besides, paired row planting of maize provided enough scope to the legumes to grow. These ultimately helped the crops to express the higher LER and advantage of maize-legume intercropping system.The results showed that the combined RCC was more than 1, indicating a clear yield advantage in the study. This might be due to complementarity. The results are in agreement with the findings of Willey and Osiru (1972)[10]. The highest combined RCC was obtained with maize + groundnut (2:2) indicated greater yield advantage. Aggressivity with negative value indicated that the species is dominated and where the value is positive indicates the species as dominant. In the present study, maize showed positive value except when intercropped with blackgram (2:1). The competitive ratio (CR) of legumes were greater than unity indicating legumes were more competitive than maize. Such results might be due to variation in growth of component species and/or abilities to overcome bad effects of competition from either of component species grown in association. Among the legumes the lower values were noted with maize when intercropped with legumes with 2:2 ratio and it clearly indicated that 2:2 proportions created a balanced competition in maize-legume intercropping system. In the additive series of intercropping, maize got its desired population; thus produced yield close to its pure stand and paired row geometry of planting provided enough scope to the legumes to express satisfactory growth and productivity probably due to temporal and spatial complementary effect.

Table 3.3. Competition functions of summer maize-legume intercropping system

Intercropping systems	Land equivalent ratio (LER)			Relative crowding co-efficient (RCC)			Aggressivity (A)		Competitive ratio (CR)	
	Maize	Legume	Combined	Maize	Legume	Combined	Maize	Legume	Maize	Legume
Maize + greengram(2:1)	0.874	0.824	1.698	6.921	1.276	8.197	0.06	-0.06	0.27	3.77
Maize + groundnut (2:1)	0.961	0.904	1.865	24.636	1.168	25.804	0.06	-0.06	0.27	3.76
Maize + blackgram (2:1)	0.925	0.931	1.856	12.264	1.214	13.478	-0.02	0.02	0.25	4.02
Maize + greengram	0.877	0.787	1.664	7.191	1.299	8.490	0.09	-0.09	0.56	1.72

(2:2)										
Maize + groundnut (2:2)	0.989	0.847	1.836	95.239	1.461	96.700	0.13	-0.13	0.58	1.71
Maize + blackgram (2:2)	0.925	0.907	1.832	11.261	1.658	12.874	0.02	-0.02	0.51	1.96

REFERENCES

[1] U. L. Undie, D. F. Uwah and E. E. Attoe,"Effect of intercropping and crop arrangement on yield and productivity of late season Maize/soybean mixtures in the humid environment of South Southern Nigeria", Journal of Agricultural Science, vol. 4, no.4, **(2012)**, pp. 37-50.

[2] R. W. Willey, "Intercropping its importance and research needs.I. Competition and yield advantages", Field Crop Abstract, vol. 32, **(1979),** pp.1-10.

[3] R. K.Sarkar, D. Shit and S. Maitra, "Competition functions, productivity and economics of chickpea (*Cicerarietinum*)-based intercropping system". Indian Journal of Agronomy, vol. 45 no. 4, **(2000),** 681-686.

[4] T. H. Seran and I. Brintha, "Review on maize based intercropping, Journal of Agronomy, vol. 9, no.3, **(2010)**, pp. 135-145.

[5] B. K. Mandal, M. C.Dhara, B. B.Mandal, S. R.Bhunia and A. Dandapat,"Nodulation in some legumes grown as pure and intercrops", Indian Agriculturist,vol. 35, no. 1,**(1991)**, pp.15-19.

[6] S. Maitra, D. C.Ghosh, G.Sounda, P. K. Jana, and D.K. Roy, "Productivity, competition and economics of intercropping legumes in finger millet (*Eleusinecoracana*) at different fertility levels",Indian Journal of Agricultural Sciences, vol. 70, no.12,**(2000),** pp. 824-828.

[7] K. E. Giller, " Nitrogen Fixation in Tropical Cropping Systems", 2nd Ed., CABI, Wallingford, **(2000)**, pp. 423.

[8] B. M. Kariaga,"Intercropping maize with cowpeas and beansfor soil and water management in western Kenya.Proceedings of the13th international soil conservation organisation conference, July 2004.Conserving soil and water for society, Brisbane.**(2004),**pp. 1-5.

[9] C. A. McGilchrist, "Analysis of competition experiments", Biometrics, vol. 21, **(1965)**, pp.975-985.

[10] R. W. Willey and D.S.O. Osiru, "Studies on the mixture and beans (Phaseolus vulgaris) with particular reference to plant population, Journal of Agricultural Science, Cambrige, vol. 79, **(1972),** pp.519-529.

[11] R. L. Hall, "Analysis of the nature of the interference between plants of different species, II. Nutrient relations in a *Nandi setaria* and green leaf *Desmodium* association with particular reference to potassium. Australian Journal of Agricultural Research, vol. 25, **(1974)**, pp. 479-756.

[12] R. W. Willey and M.R. Rao, "A competitive ratio for quantifying competition between intercrops", Experimental Agriculture, vol.16, **(1980),** pp.105-111.

[13] M. K. Mandal, M. Banerjee, H. Banerjee, A. Alipatra and G. C. Malik, "Productivity of maize (Zea mays) based intercropping system during kharif season under red and lateritic tract of West Bengal, The Bioscan, vol.9, no.1, (2014), pp. 31-35.

[14] A.Bhatnagar, M. Singh Pal and V. Singh, " Productivity and Profitability of Maize Based Intercropping Systems", Madras Agric. J., vol. 99 no.7-9, (2012),pp. 530-532.

[15] S. Kheroar and B.C. Patra, "Productivity of maize-legume intercropping systems under rainfed situation", African J.Agric. Research.Vol. 9, no.20, **(2014),** pp.1610-1617.