International Journal of Agriculture, Environment and Biotechnology
Citation: IJAEB: 13(1): 33-38, March 2020
DOI: 10.30954/0974-1712.1.2020.16

ASSOCIATION OF AGRICULTURE, ENVIRONMENT AND BIOTECHNOLOGY

AGRONOMY

Yield Attributes, Yield, Competitive Ability and Economics of Summer Maize-Legume Intercropping System

Pilli Manasa[1], Sagar Maitra[2] and Saurav Barman[3]

[1&2]Department of Agronomy, M.S. Swaminathan School of Agriculture, Centurion University of Technology and Management, Paralakhemundi-761 211, India
[3]Department of Agricultural Chemistry and Soil Science, M.S. Swaminathan School of Agriculture, Centurion University of Technology and Management, Paralakhemundi-761 211, India

*Corresponding author: p.manasa@cutm.ac.in (**ORCID ID:** 0000-0001-7727-4972)

Paper No. 814 **Received:** 12-11-2019 **Revised:** 04-01-2020 **Accepted:** 27-02-2020

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. The experiment was laid out in randomized complete block design and the treatments were comprised of ten cropping systems, namely, T_1: sole maize, T_2: sole green gram (*Vigna radiata* L.), T_3: sole groundnut (*Arachis hypogaea* L.), T_4: sole black gram (*Vigna mungo* L.), T_5: maize + greengram (2:1), T_6: maize + groundnut (2:1), T_7: maize + blackgram (2:1), T_8: maize + greengram (2:2), T_9: maize + groundnut (2:2) and T_{10} maize +black gram (2:2). Paired row sowing of hybrid maize was done with a spacing of 80 cm/30 cm × 25 cm in sole maize. Pure stand of legumes 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 result indicated that intercropped legumes improved the yield components of maize and offered some bonus yield. The maximum maize grain yield (5669 kgha^{-1}) was noted with sole maize, however, maize equivalent yield of 7609kg ha^{-1} was recorded with maize + groundnut (2:2) and it was followed by maize + black gram with 2:2 ratio (6902 kg ha^{-1}). In expression of the competition functions, maize + groundnut (2:2) recorded the highest values of area time equivalent ratio (1.70), relative yield total (1.47) and monetary advantage (₹ 42002 kg ha^{-1}). The intercropping combination of maize + groundnut (2:2) recorded the highest net return (₹ 47954 ha^{-1}), with a benefit-cost ratio of 1.00, but by the treatment maize + black gram with 2:2 ratio registered greater B:C ratio (1.11) with net return of ₹ 45499 ha^{-1}.

Highlights

- Intercropping either of maize + groundnut (2:2) or maize + black gram (2:2) can be chosen to obtain higher maize equivalent yield in south Odisha.
- Maize + groundnut (2:2) intercropping system recorded the highest ATER, RYT, MA and net return.

Keywords: Maize, legume, intercropping, yield, competitive ability, economics

Maize (*Zea mays* L.) is an important cereal in many developed and developing countries of the world and provides maximum share of human food. Since, it is a versatile crop grown across a wide range of agro ecological zones, there is no cereal crop on the earth that has so much yield potential and hence it is popularly called 'queen of cereals'. India produces 21.81 million tonnes of maize from 8.69 m ha of area with a productivity of 2509 kg/ha (Anonymous, 2016). The wider row spacing in maize can be used to grow legumes as intercrop give additional yield. The main concept of intercropping is to get increased total productivity per unit area and time, besides equitable and judicious utilization of land

resource and farming inputs including labour, with the insurance against crop failure. One of the main reasons for higher yield in intercropping is that the component crops are ableto use growth resources differently, so that when grown together, they complement each other and make better overall use of growth resources than grown, separately (Willey 1979; Maitra *et al.* 2001). 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 return. Legume as an intercrop can increase crop yields and economic benefits of intercropping systems (Mucheru *et al.* 2010). Maize in association with legumes gave higher total yield and net return (Patra *et al.* 2000). The impact of maize based intercropping system was not much studied under south Odisha conditions; hence the experimentwas conducted to evaluate the efficiency of summer maize-legume intercropping system.

MATERIALS AND METHODS

The experiment was conducted 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, Odisha which is situated under typical tropical climatic conditions during the summer season of 2018. The weekly mean maximum and mean minimum temperatures during the crop period ranged from 28.4° to 45.8°C and 14.4° to 26.5°C respectively with an average maximum of 39.8°C and minimum of 20.6°C. The weekly mean relative humidity during crop period ranged from 88.36 percent to 56.9 percent. A rainfall of 69.2 mm was received the during crop growth the period. The soil was clay loamy in texture, slightly acidic in reaction (pH 6.2), low in organic carbon (0.45%), available nitrogen, phosphorus and potassium were 78.4, 20.6 and 128.4 kg ha^{-1}respectively. The recommended doses of fertilizers @ 120:60:60 kg N: P_2O_5:$K_2O$$ha^{-1}$ and 20:50:20 kg N: P_2O_5:$K_2O$$ha^{-1}$for sole maize and legumes respectively were applied separately in monoculture. In intercropping situations, the recommended dose of fertilizer for maize (120:60:60 kg N: P_2O_5:$K_2O$$ha^{-1}$) was applied. In case of sole maize and maize + legume treatments half dose of nitrogen, entire quality of phosphate and potash were applied as basal dose in each plot, however, all fertilizers were applied as basal to sole legumes. The remaining half of nitrogen was top-dressed to maize and maize + legume plots at knee height stage. The experiment was laid out in a Randomized Complete Block Design (RCBD) comprising ten treatments with 3 replications. Therefore, in each replication there were ten plots of 5.0 m × 4.0 m size. The treatments were T_1: sole maize, T_2: sole greengram, T3: sole groundnut, T4: sole blackgram, T5: maize + greengram (2:1), T6: maize + groundnut (2:1), T7: maize + blackgram (2:1), T8: maize + greengram (2:2), T9: maize + groundnut (2:2) and T10 maize + blackgram (2:2). Maize hybrid 'Kaveri' 50 was chosen (120 days) in the experiment and for **g**reen gram 'IPM 02-03' (70 days), groundnut 'K6' (125 days) and black gram,'PU 31' (85 days) varieties were selected. Spacing adopted for paired row hybrid maize (under both of sole and intercropping) was 30 cm/ 80 cm × 25 cm, however, pure stand of legume i.e. green gram, groundnut and blackgram were sown with 30 cm × 10 cm spacing. In intercropped treatments legumes were sown 1 or 2 rows in between two pairs of maize as per the treatment.

RESULTS AND DISCUSSION

Yield attributes of maize

The data on yield attributes recorded, viz., number of cobs $plant^{-1}$, number of rows cob^{-1}, number of grains row^{-1}, number of grains cob^{-1}, hundred grain weight, grain weight cob^{-1}, and grain weight $plant^{-1}$were analyzed statistically and presented in Table 1. The data on Number of cobs $plant^{-1}$showed that there was no significant difference among the treatments, however, T_1: sole maize) and T_9: maize + groundnut (2:2) showed maximum value (1.30). The results are in conformity with the findings of Kheroar and Patra (2013) and Khan *et al*. (2018). All treatments under study remained statistically at par in registering number of rows per cob^{-1}, but the maximum value (12.8) was noted with T_1 (sole maize). Earlier Mandal *et al.* (2014) noted similar observation. The treatment T_1 (sole maize) recorded maximum of number of grains row^{-1} of maize cob (15.9) and it was closely followed by the treatments T_6: maize + groundnut (2:1) and T_9: maize + groundnut (2:2). Earlier Saleem *et al.* (2011) obtained similar type of results. Maximum number

Table 1: Effect of intercropping system on yield attributes of maize

Treatments	Yield attributes of Maize						
	Number of cobs plant^{-1}	Number of rows cob^{-1}	Number of grains row^{-1}	Number of grains cob^{-1}	100 grain Weight (g)	Grain weight (g) cob^{-1}	Grain weight (g) plant^{-1}
T_1 Sole Maize	1.30	12.8	15.9	203.5	27.62	56.2	73.07
T_5 Maize + green gram (2:1)	1.26	12.2	14.7	179.3	27.41	49.2	61.92
T_6 Maize + groundnut (2:1)	1.29	12.7	15.6	198.1	27.58	54.6	70.49
T_7 Maize + black gram (2:1)	1.27	12.3	15.4	189.4	27.54	52.2	66.26
T_8 Maize + green gram (2:2)	1.26	12.2	14.9	181.8	27.52	50.0	63.04
T_9 Maize + groundnut (2:2)	1.30	12.6	15.6	196.6	27.61	70.3	70.27
T_{10} Maize + black gram (2:2)	1.28	12.4	15.1	187.2	27.56	51.6	67.08
SEm ±	0.03	0.49	0.65	3.41	0.68	0.91	1.62
CD (P=0.05)	NS	NS	NS	NS	NS	2.81	4.99
CV (%)	9.1	11.8	12.7	12.0	7.4	5.2	7.2

of grains per cob was noticed with the T_1: sole maize (203.52) and it was closely followed by T_6: maize + groundnut (2:1) and T_9: maize + groundnut (2:2). The results are in conformity with the findings of Rajeshkumar *et al*. (2018). There was no significant difference among the intercropping systems in enhancement of 100 grain weight of maize cob however, the treatment T_1 (sole maize) noted the highest (27.62g) weight of 100 grains. Earlier Jan *et al.* (2016) also noted non-significant difference in test weight of maize by intercropping system. The treatments differed significantly among themselves in enhancement of grain weight of maize. Highest grain weight cob^{-1} (56.21g) was noticed with T_1: sole maize and the treatment was significantly superior to T_5: maize + green gram (2:1), T_7: maize + black gram (2:1), T_8: maize + green gram (2:2) and T_{10}: maize + black gram (2:2). However, sole maize (T_1) was statistically at par with the treatments T_6: maize + groundnut (2:1) and T_9: maize + groundnut (2:2) in increasing of grain weight of maize cobs. Grain weight plant^{-1} was significantly influenced by sole maize and other intercropping system .Sole maize (T_1) produced maximum grain weight plant^{-1} (73.07g) which was statistically at par with T_6: maize + groundnut (2:1) and T_9: maize + groundnut (2:2). But the treatment T_1: sole maize recorded significantly more grain weight per plant of maize the some other treatments like T_5: maize + green gram (2:1), T_7: maize + black gram (2:1), T_8: maize + green gram (2:2) and T_{10}: maize + black gram (2:2). Mandal *et al*. (2014) also recorded higher values of grain weight plant^{-1} with sole maize in maize-legume intercropping system.

Yield

Grain yield of maize was significantly influenced by maize + legume intercropping system (Table 2).

Table 2: Yield of crops in summer maize-legume intercropping system

Treatments	Grain yield kg ha^{-1}		Stover yield kg ha^{-1}	
	Maize	Legume	Maize	Legume
T_1 Sole Maize	5669		8164	
T_2 Sole Green gram		618		1196
T_3 Sole Groundnut		1231		2218
T_4 Sole Black gram		956		1294
T_5 Maize + green gram (2:1)	4954	126	6275	242
T_6 Maize + groundnut (2:1)	5447	278	7456	502
T_7 Maize + black gram (2:1)	5242	223	7094	281
T_8 Maize + green gram (2:2)	4977	244	6870	482
T_9 Maize + groundnut (2:2)	5610	522	7813	949
T_{10} Maize + black gram (2:2)	5205	433	7116	618
SEm±	95	8.6	124	16.4
CD (P=0.05)	293	25.9	383	49.2
CV (%)	5.4	5.7	5.1	5.7

Highest grain yield was observed with T_1: sole maize (5668.5 kg ha^{-1}) and it was significantly superior to T_5: maize + green gram (2:1), T_7: maize + black gram (2:1), T_8: maize + green gram (2:2), T_{10}: maize + black gram (2:2). However maize yield

obtained in the treatment sole maize (T_1) was on par with T_6: maize + groundnut (2:1) and T_9: maize + groundnut (2:2). Earlier Pandey *et al.* (1999) observed similar results as sole maize produced more yield than intercropped maize and this result was probably due to inter species competition in intercropping. Stover yield of maize was influenced by maize + legume intercropping system. Maximum Stover yield of maize was recorded with T_1: sole maize (8164.2 kg ha^{-1}), however, it being statistically at par with T_9: maize + groundnut (2:2) produced significantly more straw yield than T_5: maize + green gram (2:1), T_6: maize + groundnut (2:1), T_7: maize + black gram (2:1), T_8: maize + green gram (2:2) and T_{10}: maize + black gram (2:2). The results corroborate with the findings of Rajeshkumar *et al.* (2018).

COMPETITIVE ABILITY

Maize Equivalent Yield

Maize equivalent yield (MEY) was recorded to be higher in all of the cases of intercropping with respect to pure stand yield of maize. Maize yield + extra yield of legumes helped in increasing the maize equivalent yield in maize + legume intercropping system. Higher maize equivalent yield (7609 kg ha^{-1}) was noted with T_9: maize + groundnut (2:2 due to higher selling price of groundnut followed by T_{10}: maize + black gram (2:2). Moreover, sole maize produced grain yield of (5669 kg ha^{-1}), whereas T_9: maize + blackgram (2:2) recorded (7609 kg ha^{-1}) maize equivalent yield which is actually an increase of 34.2% enhancement of productivity. The results are in conformity with the findings of Pathak and singh (2008) and Nandan *et al*. (2013).

Relative yield total (RYT)

Relative yield total (RYT) is the sum of the relative yields (total biomass) of the species in the mixture and is expressed as the ratio of the yield of a species in the mixture to its yield in monoculture (Anders *et al.* 1996). Values greater than unity indicate partial complementarity among the species. In the study, among different intercrop combinations studied, T_9: maize + blackgram (2:2) recorded the maximum RYT (1.47) and it was followed by the treatment T_{10}: maize + black gram at 2:2 row proportion. The higher RYT value with above treatments was probably made possible by the contribution of the legume to the environment of the maize via nitrogen fixation (Baghdadi *et al.* 2016).

Monetary advantage (MA)

Monetary advantages were varied markedly by different intercropping systems. Intercropping paired row maize with two rows of groundnut (T_9) recorded the higher monetary advantage (₹ 42,002 ha^{-1}) and it was followed by intercropping of paired row maize with two rows of blackgram (T_{10}) in this study. All intercropping combinations of maize and legumes registered monetary advantage and this was probably due to adoption of additive series of intercropping in which was comprised of normal population of maize and additional legumes (Kheroar and Patra 2013).

Area Time Equivalent Ratio (ATER)

ATER was more than unity in all the treatments except T_5: maize + green gram (2:1) clearly indicated efficient use of area and time by the intercrops. The lowest ATER values as well as less than unity value was obtained with T_5: maize + green gram (2:1) and it clearly indicated inefficient biological efficiency of such crop mixture probably due to competitive factors. Intercropping maize and legumes with the treatments T_5, T_6, T_7, T_8, T_9, and T_{10} recorded

Table 3: Competition functions of summer maize-legume intercropping system

Intercrop combinations	Maize equivalent yield (kg ha^{-1})			Relative yield total (RYT)	Area time equivalent ratio(ATER)	Monetary advantage ₹ ha^{-1}
	Maize	Legume converted into maize	Total maize equivalent yield			
T_5 Maize + green gram (2:1)	4954	671	5625	1.07	0.93	27673
T_6 Maize + groundnut (2:1)	5448	1067	6515	1.19	1.13	35960
T_7 Maize + black gram (2:1)	5242	876	6118	1.15	1.03	33767
T_8 Maize + green gram (2:2)	4977	1299	6276	1.27	1.04	30123
T_9 Maize + groundnut (2:2)	5610	1999	7609	1.47	1.70	42002
T_{10} Maize + black gram (2:2)	5204	1697	6902	1.37	1.17	37273

ATER values slightly higher than unity indicating marginal yield advantages from these intercropping systems. The results corroborate the findings of Solanki *et al*. (2011) and Khan *et al.* (2018).

Table 4: Economics of summer maize-legume intercropping system

Treatments	Rupees ha^{-1}			B:C
	Cost of cultivation	Gross return	Net return	
T_1 Sole Maize	37200	70522	33322	0.90
T_2 Sole greengram	26200	41584	15384	0.59
T_3 Sole groundnut	39200	59644	20444	0.52
T_4 Sole blackgram	24100	46927	22827	0.95
T_5 Maize + green gram (2:1)	39866	70678	30812	0.77
T_6 Maize + groundnut (2:1)	42533	81652	39119	0.92
T_7 Maize + black gram (2:1)	39166	76551	37385	0.95
T_8 Maize + green gram (2:2)	42532	79160	36628	0.86
T_9 Maize + groundnut (2:2)	47866	95820	47954	1.00
T_{10} Maize + black gram (2:2)	41132	86631	45499	1.11

Economics

Maximum net returns of ₹ 47,954 ha^{-1} was obtained with treatment T_9: maize + groundnut (2:2) and it was followed by the treatment T10: maize + blackgram (2:2) which resulted in net returns of ₹ 45,499 ha^{-1}. But in case of benefit-cost ratio, T_{10}: maize + blackgram (2:2) and T_9: maize + groundnut (2:2) intercropping proportions yielded the value of 1.11 and 1.00 respectively. However, sole maize registered net returns of ₹ 33,322 ha^{-1} with a benefit-cost ratio of 0.90 and it clearly indicated advantage of former intercropping systems.

CONCLUSION

In the additive series of intercropping, maize got its desired population as compared to pure stand; thus intercropped maize produced yields close to its pure stand and paired row geometry of planting provided enough scope to the intercropped legumes to express satisfactory productivity probably due to temporal and spatial complementary effect. Intercropping maize + groundnut at 2:2 ratio and maize with blackgram at 2:2 ratio registered higher net return and these intercropping systems can be chosen in south Odisha conditions during summer.

REFERENCES

Baghdadi, A., Halim, R.A., Othman, R., Yusof, M.M. and Atashgahi, A.R.M. 2016. Productivity, relative yield and plant growth of forage corn intercropped with soybean under different crop combination ratio, *Legume Research*, **39**(4): 558-564.

Jan, R., Saxena, A., Jan, R., Khanday M. and Jan, R. 2016. Intercropping indices and yield attributes of maize and black cowpea under various planting patterns. *The International Quarterly Journal of Life Science,* **11**(2): 01-07.

Khan, M.A.H., Sultana, N., Akter, N., Zaman, M.S. and Islam, M.R. 2018. Intercropping gardenpea (*Pisium sativum*) with Maize (*Zea mays*) at farmers field Bangladesh. *Agril. Res*., **43**(4): 691-702.

Kheroar, S. and Patra, B.C. 2013. Advantages of Maize-Legume Intercropping Systems. *Journal of Agricultural Science and Technology* B 3: 733-744 earlier titles: *Journal of Agricultural Science and Technology*, ISSN 1939-1250.

Maitra, S., Samui, R.C., Roy, D.K. and Mondal, A.K. 2001. Effect of cotton based intercropping system under rainfed conditions in *Sundarban* region of West Bengal. *Indian Agriculturist*, 45(3-4): 157-162.

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 International Quarterly Journal of Life Science*, **9**(1): 31-35.

Mucheru, M.M., Pypers, P., Mugendi, D., Mugwe, J., Merckx, R. and Vanlauwe, B. 2010. A staggered maize-legume intercrop arrangement robustly increases crop yields and economic returns in the highlands of Central Kenya, *Field Crops Research*, **115**(2) 132-139.

Nandam, B., Shara, B.C., Kumar, A. and Nager, K.C. 2013. Production potential of maize and mustard under different intercropping system in moisture deficit sub-tropical areas of Jammu and Kashmir, India. *Legume Research,* **36**(5): 436-441.

Pandey, I.B., Bharati, V. and Mishra, S.S. 1999. Effect of maize (*Zea mays*)-based intercropping systems on maize yield and associated weeds under rainfed condition. *Ind. J. Agron*., **48**(1): 30-33.

Pathak, K. and Singh, N.P. 2006. Genotypic compatibility and planting pattern in urdbean and maize intercropping system. *Ind. J. Pulses Res*., **19**(1): 116-118.

Patra, B.C., Mandal, B.K. and Padhi, A.L. 2000. Production potential of winter maize (*Zea mays*) based intercropping systems, *Indian Journal of Agricultural Sciences,* **70**(4): 203-206.

Rajeshkumar, A., Venkataraman, N.S. and Ramadass, S. 2018. Integrated weed management in maize-based intercropping systems. *Indian Journal of Weed Science,* **50**(1): 79–81.

Saleem, R., Ahmed, Z.I., Ashraf, M., Arif, M., Malik, M.A., Munir, M. and Khan, M.A. 2011. Response of maize-legume intercropping system to different fertility sources under rainfed conditions, *Sarhad J. Agric.,* **27**(4).

Solanki, N.S., Dilip Singh. and Sumeriya, H.K. 2011. Resources utilization in maize (*Zea mays*) – based intercropping system under rainfed condition. *Indian Journal of Agricultural Sciences*, **81**(6): 511-515.

Willey, R.W. 1979. Intercropping-Its importance and research needs: Part 1, Competition and yield advantages, *Field Crop Abstract,* **32**(1): 1-10.