Biological Forum – An International Journal **(SI-AAEBSSD-2021) 13(3b): 31-35(2021)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Identification of sustainable and profitable maize based cropping systems in Godavari Zone

Phani Kumar, K.[1], Dakshinamurty, K.[2], Sravanthi, S.[3], Mohan Vishnu Vardhan K.[4], Chamundeswari, N.[1] and Mohan Rao, K.[1]*

[1]*Maize Research Station, ARS, Vijayarai, West Godavari District, (A.P.), India.*
[2]*College of Agriculture, Rajamahendravaram, East Godavari District, (A.P.), India.*
[3]*KVK, Rastakuntubai, Vizianagaram District, (A.P.), India.*
[4]*Regional Agricultural Research Station , Nandyal-518502, Kurnool District, (A.P.), India.*

(Corresponding author: Dakshinamurty, K.)*
(Received 01 July 2021, Accepted 25 September, 2021)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: In Godavari Zone of Andhra Pradesh, maize is becoming an important cereal crop. However even though farmers are reporting maize yields up to 10 tons per hectare, due to increased cost of cultivation and high input requirements, profitability of this maize based systems are not very remunerative to farmers. In Godavari zone, mostly farmers following Fallow- maize system and there is a possibility to include either millets or pulses in the system to improve overall productivity and profitability. This experiment was conducted at Maize Research Centre, ARS, Vijayarai to identify the sustainable and profitable maize based cropping system. It consists of 7 treatments viz., T1-Fallow- maize, T2- Maize-Maize system, T3- Millets (korra) –Maize, T4- Pulses (black/green gram) – Maize, T5- Fallow- Maize+ High value vegetable crops (water melons/vegetables)-paired row, T6- Maize- Maize+ High value vegetable crops (water melons/vegetables)-paired row and T7- Maize- Maize+ pulses (black/green gram/cowpea)-paired row in simple RBD design. Highest system yields were obtained in treatment T6 i.e Maize- Maize+ High value vegetable crops (water melons/vegetables)-paired row followed by T7 (Maize- Maize+ pulses (black/green gram/cowpea)-paired row). Highest returns and B:C ratio was obtained in Maize-Korra cropping system.

Keywords: Cropping systems, Intercropping, Maize-pulses, Economics and System yield.

INTRODUCTION

Maize (*Zea mays* L.), also termed as 'corn' and 'queen of cereals', is the third most important cereal of the world, ranks at third position amongst the cereals after rice and wheat and it is a member of Poaceae family.In India, maize contributes nearly 9 % in national food basket after rice and wheat. In addition to staple food for human beings, quality feed for poultry and animals, it serves as a basic raw material for the industry for production of starch for textile, pharmaceutical, cosmetic industries, high quality corn oil, protein, alcoholic beverages, food sweeteners etc. It is used as an ingredient in more than 3000 products. In recent decades, maize yield has been greatly improved by increased mineral fertilization and mechanization and changes in planting density. In Godavari zone, Majority of farmers adopting fallow-maize system due to high cost of cultivation. Hence there is a need for identification of sustainable and profitable maize based sequence and inter cropping systems to improve overall profitability. Adjusting the crop geometry in maize by adopting paired row system, we can include high value vegetable and pulse crops to enhance over all productivity and income of maize based systems. Various studies states that the basic requirement for improving the crop productivity lies in the betterment of soil fertility and is highly related with soil organic matter. Intensive cropping and tillage systems resulted in substantial decrease in soil organic matter levels. Rotating cereals with legumes is a cheaper means of improving soil fertility and system productivity. Intercropping is an ancient multiple-cropping system that is popular with smallholder farmers in developing countries today, due to its higher land and nutrient use efficiency (Agegnehu *et al*. 2006; Li *et al*. 2007), better economic returns (Mucheru-Muna *et al.* 2010; Asten *et al.* 2011), and lower pest and disease incidence (Trenbath 1993) as compared to sole crops (Rusinamhodzi *et al*., 2012 and Huang *et al.*, 2015).

In searching for alternatives for mono-cropping, diversification of cropping systems with short duration legume crops should be emphasized. Growing several species of crops together or sequentially also utilize nutrients more efficiently than monoculture (Monika shukla *et al*., 2020). Further the land available for cultivation is limited due to ever increasing population, the need, therefore is to intensify agricultural production through increasing the cropping intensity. This can be achieved only through double/intercropping and multiple cropping (Bhat *et al*., 2013). Under Godavari zone conditions, diversification of maize based cropping systems with short duration legume crops could increase the overall systems productivity, while decreasing the environmental impact.

Cultivation of grain legumes such as beans (*Phaseolus vulgaris* L.) as the companion crop can provide a different ecological niche for the insects while also emitting some chemicals that may deter larvras and oviposition (Ndakidemi *et al.,* 2016). Legume intercropping is widely encouraged as a viable integrated soil fertility management strategy (Proctor *et al.,* 2007 and Vanlauwe, *et al.,*2010) as legumes can also serve as a push factor against insect pests (Midega *et al*., 2018 and Khan *et al.,* 2010). Some plant bioactive materials have also demonstrated efficacy as botanical insecticides for the control of various insect pests of economic importance (Tanyi *et al*., 2017). Besides direct effects on pests, companion crops and botanicals can enhance the population of natural enemies of field pests. Maize can provide shade to associated legumes and the legume species should be to some extent tolerant to shade. Legume species like black gram (*Vigna mungo*), cowpea (*Vigna unguiculata*), groundnut (*Arachis* *hypogea*) and green gram (*Vigna radiata*) have much less effect on maize and these are tolerant to maize shade (Mandal *et al.,* 2014 and Manasa *et al.,* 2018). Cereal-legume intercropping is very common in the continents of Asia, Africa and South America (Layek *et al.,* 2018).

Hence based on the discussions with various stakeholders across value chain, it was observed that there is a need to develop sustainable and profitable maize based cropping systems and also identification of intensive maize based intercropping systems under micro irrigation for increasing overall system productivity and profitability. Keep in view these requirements the current trial was planned with an objective to identity sustainable and profitable maize based cropping systems.

MATERIAL AND METHODS

The experiment was conducted at Maize Research Centre,Vijayarai, West Godavari during both *kharif* and *rabi* for the years2019-20 and 2020-21. The field experiment was conducted in Randomized Block Design (RBD) with seven treatments and replicated thrice. The treatments include, T1-Fallow- maize, T2- Maize-Maize system, T3- Millets (korra) –Maize, T4- Pulses (black/green gram) – Maize, T5- Fallow- Maize+ High value vegetable crops (water melons)-paired row, T6- Maize- Maize+ High value vegetable crops (Cauliflower)-paired row, T7- Maize- Maize+ pulses (black/green gram/cowpea)-paired row. Maize was sown at a spacing of 75 X 20 cm, for paired row it was 50-50-100-50-50cm X 20 cm. Blackgram and Korra was sown at a spacing of 30 cm x 10 cm. Fertilizers, nitrogen, phosphorus and potash were applied at the rate of 200 -60 P_2O_5-50 K_2O kg/ha. Rabi maize was fertilized with 240 N -80 P_2O_5-80 K_2O/ha as per the university recommendations. The other recommended practices were followed during crop growth period. Yield was calculated in terms of equivalent yield and economics including net returns and B:C ratio were calculated.

RESULTS AND DISCUSSION

The results on total system yields indicate that during rabi season of the first year of study, total maize equivalent yields (MEY)were the highest in the treatment where Fallow-Maize intercropped with Cauliflower(10279 kg/ha) followed by Maize-Maize inter cropped with cauliflower (10149 kg/ha).However, the total system equivalent yields for both the seasons were highest with Maize- Maize+ cauliflower (16086 kg/ha) followed by Maize- Maize+ black gram (15671 kg/ha).

During second year of study, rabi season total MEY were the highest in Maize-Maize intercropped with Blackgram (10338kg/ha) followed by Fallow- Maize inter cropped with cauliflower (10200 kg/ha).The total system yields were the highest with Maize-Maize+ cauliflower (16283 kg/ha) followed by Maize- Maize+ black gram (16217 kg/ha).

From the pooled data of two years, the trend was similar as fallowed in first year. The highest total system equivalent yields were obtained with Maize- Maize+ cauliflower (16185 kg/ha followed by Maize- Maize + black gram (15944 kg/ha) (Table 1 & Fig. 1). The greater yields in intercropping systems were observed mainly due to the fact that the component crops in the intercropping systems showing complementary effects amongst themselves and utilizing the natural resources efficiently than raised as sole crops (Sagar Maitra *et al.,* 2020). It was observed in several other studies that intercropping of maize with mungbean found to increase water use efficiency, light use efficiency as well as nutrient use efficiency which positively affected not only the final yield but also other agronomic parameters such as plant height, number of grain rows per cob, cobs length, cob girth, thousand grain weight, total dry matter (Shahid Raza, 2017 and Khan *et al.,* 2017).

Regarding economics (Table 2), Korra in *kharif*, followed by Maize in *rabi* recorded the highest net returns and BC ratio during both the years and in pooled data. Inclusion of vegetables in maize based cropping systems resulted in higher system productivity with increased water productivity as observed in a study with maize-potato-onion in comparison to rice-wheat cropping system (Gill and Sharma, 2005). For *peri* urban areas, inclusion of high value vegetables such as peas, onion, radish *etc.* with maize based sequences proved more remunerative than rice-wheat system and maize (cobs)-radish-onion is the most productive and profitable cropping system (Singh, 2006). Hence it is highly remunerative and sustainable to accommodate sequence and intercropping systems in maize instead of sole maize.

Intercropping is a common practice of small and marginal farmers in developing countries of Asia and Africa and in risky and fragile ecological conditions which is known as a suitable practice to provide natural insurance and thus provides a profitable shape to farm economy. Under moisture stress conditions, more of ground area is covered under maize-legume intercropping than sole cropping of maize which Maize - Production and Use 8 leads to less evaporation loss of soil moisture. Under extreme conditions, may be due to either biotic or abiotic factors, a crop may fail, but there will be less chance of failure of more crops grown in intercropping, which are morphologically dissimilar and if so happened some yield and return will be earned to save small holders' economic interest. Thus stability in yield and return are achieved due to creation of crop diversity in the intercropping systems. In economic point of view, it may be stated that small farmers may face problem of seasonal price variability of commodities which often can destabilize net realization, but diversification in the form of intercropping can stabilize farm income to a great extent. Experimental results indicated superiority of intercropping maize-beans in soil fertility restoration and income enhancement than monocropping of the component crops (Onduru *et al.*, 2007). Yield enhancement of crops is another basis to strengthen the economy of small and marginal farmers adopting intercropping system (Lulie, 2017) Though intercropping of maize grain legumes is labour and cost intensive, small holders of central Mozambique prefer it because of reduced risk of crop failure and enhanced productivity (Rusinamhodzia *et al*., 2017).

Table 1: System yields of maize based cropping system during 2019-20, 2020-21 and in pooled data.

Treatment	First Year						Second Year						Pooled Data					
	Kharif (kg/ha)		Rabi (kg/ha)			System yields	Kharif (kg/ha)		Rabi (kg/ha)			System yields	Kharif (kg/ha)		Rabi (kg/ha)			System yields
	Yield	MEY	Main crop	Inter Crop	Total (MEY)		Yield	MEY	Main crop	Inter crop	Total (MEY)		Yield	MEY	Main crop	Inter crop	Total (MEY)	
Fallow-Maize	0	0	9200	0	9200	9200	0	0	8648	0	8648	8648	0	0	8924	0	8924	8924
Maize-Maize	5880	5880	8917	0	8917	14797	6040	6040	8523	0	8523	14563	5960	5960	8720	0	8720	14680
Korra-Maize	1917	3727	8920	0	8920	12647	2358	4585	9120	0	9120	13705	2137.5	4156	9020	0	9020	13176
Black gram-Maize	867	2648	9430	0	9430	12078	723	2812	9524	0	9524	12336	795	2730	9477	0	9477	12207
Fallow-Maize + cauliflower	0	0	8560	4269	10279	10279	0	0	8418	4582	10200	10200	0	0	8489	4425.5	10240	10240
Maize- Maize+ cauliflower	5937	5937	8610	3822	10149	16086	6218	6218	8527	3956	10065	16283	6077.5	6077.5	8568.5	3889	10107	16185
Maize- Maize+ black gram	6050	6050	8933	225	9621	15671	5879	5879	8782	400	10338	16217	5964.5	5964.5	8857.5	312.5	9980	15944

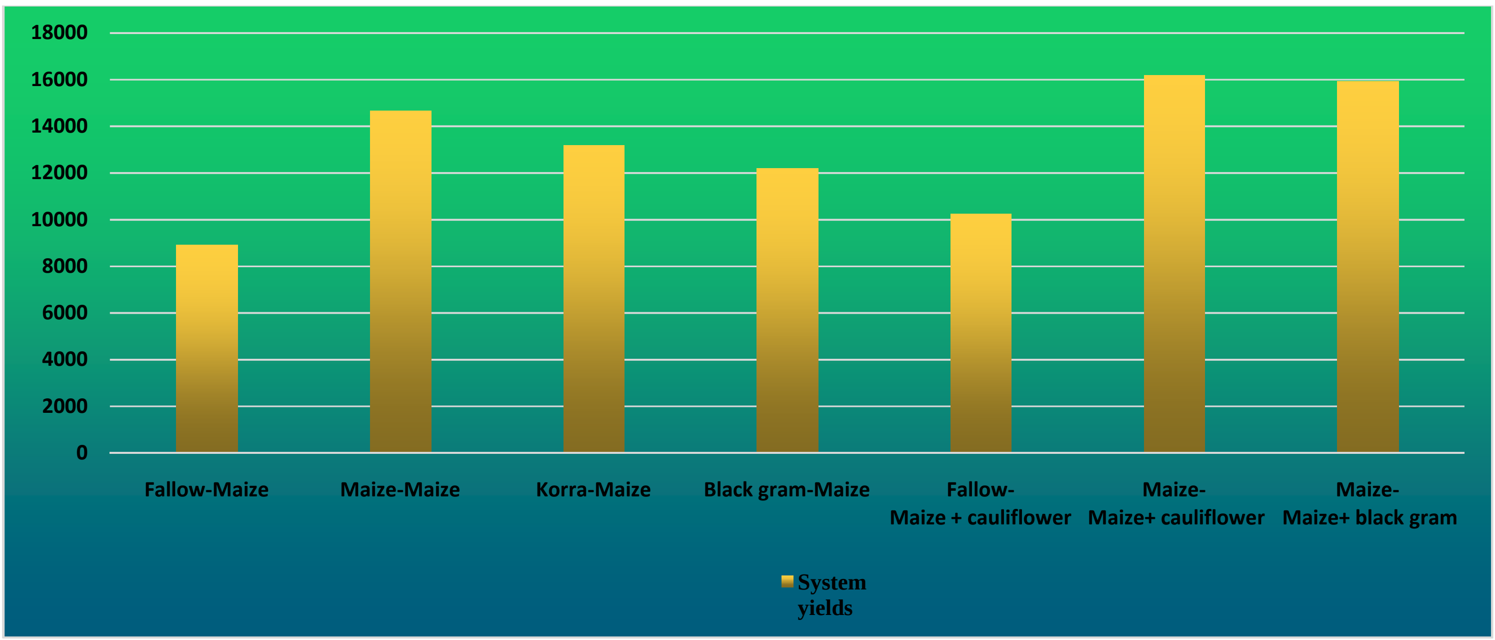

Fig. 1. System yields of maize based cropping systems (Pooled data).

Table 2: Gross returns, Net returns and BCR of maize based cropping system during 2019-20, 2020-21 and in pooled data.

	2019-20							2020-21							Pooled Data						
	Cost of cultivation							Cost of Cultivation							Cost of Cultivation						
	Kharif	**Rabi**	**Intercrop**	**Total cost**	**Total income**	**Net returns**	**BCR**	**Kharif**	**Rabi**	**Intercrop**	**Total cost**	**Total income**	**Net returns**	**BCR**	**Kharif**	**Rabi**	**Intercrop**	**Total cost**	**Total income**	**Net returns**	**BCR**
Fallow-Maize	0	70284	0	70284	165600	95316	2.36	0	68174	0	71174	155664	84490	2.19	0.0	69229.0	0.0	70729.0	160632.0	89903.0	2.3
Maize-Maize	67284	70284	0	137568	266340	128772	1.94	60846	68174	0	129020	262134	133114	2.03	64065.0	69229.0	0.0	133294.0	264237.0	130943.0	2.0
Korra-Maize	15235	70284	0	85519	227655	142136	2.66	17340	68174	0	85514	246690	161176	2.88	16287.5	69229.0	0.0	85516.5	237172.5	151656.0	2.8
Black gram-Maize	28002	70284	0	98286	217425	119139	2.21	25480	68174	0	93654	222048	128394	2.37	26741.0	69229.0	0.0	95970.0	219736.5	123766.5	2.3
Fallow-Maize + cauliflower	0	70284	26000	96284	185030	88746	1.92	0	68174	23358	91532	183600	92068	2.01	0.0	69229.0	24679.0	93908.0	184315.0	90407.0	2.0
Maize-Maize+ cauliflower	67284	70284	26000	163568	289555	125988	1.77	60846	68174	23358	152378	293094	140716	1.92	64065.0	69229.0	24679.0	157973.0	291324.5	133352.0	1.8
Maize-Maize+ black gram	67284	70284	8000	145568	274684	129116	1.89	60846	68174	6540	135560	291906	156346	2.15	64065.0	69229.0	7270.0	140564.0	283295.0	142731.0	2.0

Maize | Blackgram | Korra | Maize + Cauliflower (Paired row method) | Maize + Blackgram (Paired row method

Fig. 2. Maize, Blackgram and Korra during *kharif* season; Maize intercropped Cauliflower and blackgram in Paired row method during *Rabi*.

FUTURE SCOPE

There is a necessity to widen the research on the effect of intercropping on insect and pathogen dynamics in maize and also its impact on weeds.

Conflict of interest. No conflict of interest exists.

Acknowledgements. Authors are grateful to Acharya N.G. Ranga Agricultural University for providing necessary inputs and support to fulfill this research work.

REFERENCES

Agegnehu, G., Ghizaw, A and Sinebo, W. (2006). Yield performance and land-use efficiency ofbarley and faba bean mixed cropping in Ethiopian highlands. *European Journal of Agronomy*, *25*: 202–207.

Asten, P. J. A., Wairegi, L. W. I., Mukasa, D and Uringi, N. O. (2011). Agronomic and economic benefits of coffee–banana intercropping in Uganda's smallholder farming systems. *Agricultural Systems*.*104*: 326–334.

Bhat, R.A.., Ahmad, L and Wani, G.A.(2013). Growth, yield and economics of maize as affected by cropping sequences, rates and frequency of farm yard manure (FYM). *African Journal of Agricultural Research*. *8*(27): 3632-3638.

Gill, M.S. and Sharma, G.C. (2005). Cropping systems diversification opportunities and conservation agriculture. *Journal of Farming Systems Research and Development*. *11*(2): 127-134.

Huang, C., Liu, Q., Heeink, N., Stomph , T. J.Li.B., Liu, R., Zhang, H., Wang, C., Li, X., Zhang, C., vander werf, and Zhang, F. (2015). Economic performance and sustainability of a novel intercropping system on the North China. *Plain. PLoS ONE*. *10*: 135518.

Khan, Z. R., Midega,C. A. O., Bruce, T. J. A., Hooper, A. M and Pickett, J. A. (2010). Exploiting phytochemicals for developing a "push-pull" crop protection strategy for cereal farmers in Africa. *Journal of Experimental Botany*, *61*(15): 4185–4196.

Layek, J., Das, A., Mitran, T., Nath, C., Meena, R.S., Yadav, G.S. (2018). Cereal+legume intercropping: An option for improving productivity and sustaining soil health. In: Meena RS et al., editors. Legumes for Soil Health and Sustainable Management. Singapore: Springer Nature. 347-386.

Li, L., Li, S. M., Sun, J. H,, Zhou, L. L., Bao, X. G., Zhang, H. G. and Zhang, F. S. (2007). Diversity enhances agricultural productivity via rhizosphere phosphorus facilitation on phosphorus-deficient soils. *Proceedings of the National Academy of Sciences of the United States of America*. *104*(1): 1092–1119.

Lulie B. (2017). Intercropping practice as an alternative pathway for sustainable agriculture: A review. *Academic Research Journal of Agricultural Science and Research*, *5*(6): 440-452.

Manasa, P., Maitra, S., Reddy, M.D. (2018). Effect of summer maize-legume intercropping system on growth, productivity and competitive ability of crops. *International Journal of Management, Technology and Engineering*. *8*(12): 2871-2875.

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.

Midega, C. A. O., Pittchar, J. O., Pickett, J. A., Hailu, G. W and. Khan, Z. R.(2018). A climate-adapted push-pull system effectively controls fall armyworm, Spodoptera frugiperda (J. E. Smith), in maize in East Africa. *Crop Protection*.*105*: 10–15.

Monika, S., Sadhu, A.C and Pinal, Patel. (2020). Diversification of maize based cropping system under middle Gujarat conditions. International web-conference – "Resource Management and Biodiversity Conservation to Achieve Sustainable Development Goals", 11-12 September, 2020.Academy of Natural Resource Conservation and Management, Lucknow U.P., India.

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

Ndakidemi, B., Mtei, K and. Ndakidemi, P. A. (2016). Impacts of synthetic and botanical pesticides on beneficial insects. *Agricultural Sciences*, *7*(6): 364–372.

Onduru, D.D and Du Preez, C.C. (2007). Ecological and agro-economic study Maize - Production and Use 14 of small farms in sub-Saharan Africa. *Agronomy for Sustainable Development*, *27*: 197-208.

Proctor, J., Edwards, I. D., Payton, R. W and Nagy, L. (2007). Zonation of forest vegetation and soils of mount Cameroon, West Africa. *Plant Ecology*. *192*(2): 251–269.

Rusinamhodzi, L., Corbeels, M., Nyamangara, J., Giller, K.E. (2012). Maize-grain legume intercropping is an attractive option for ecological intensification that reduces climatic risk for smallholder farmers in central Mozambique. *Field Crops Research*.*136*: 12–22.

Sagar maitra., Tanmoy Shankar and Pradipta Banerjee. (2020). Potential and Advantages of Maize-Legume Intercropping System. Maize - Production and Use. http://dx.doi.org/10.5772/intechopen.91722.

ShahidRaza Khan., Muhammad Asghar Ali., Amjed Ali., Raja Shafqat Ali., Jamshaid Qamar and Muhammad Tariq Saleem. (2017). Effect of Intercropping on Yield of Maize Hybrids With Mungbean. *Journal of Advance in Agriculture*. *7*(1): 973-975.

Singh, P. (2006). Alternate cropping systems in periurban areas. In: PDCSR Annual Report, 2005-06, page: 11.

Tanyi, C. B., Ngosong, C and Ntonifor, N. N.(2017).Comparative effects of Piper guineense emulsion and cabbage-tomato intercropping for controlling cabbage pests and improving performance. *Journal of Agriculture and Ecology Research International*, *13*: 1–12.

Trenbath B.R. (1993). Intercropping for the management of pests and diseases. *Field Crops Research*. *34*: 381–405.

Vanlauwe, B., Bationo, A and Chianu, J. (2010). Integrated soil fertility management, *Outlook on Agriculture*, *39*(1): 17–24.