RESEARCH ARTICLE Legume Research- An International Journal, Volume 47 Issue 9: 1583-1587 (September 2024)

Legume based Profitable Intercropping System for Management of Fall Armyworm in Maize

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10.18805/LR-5179

ABSTRACT

Background: Incidence of fall armyworm in maize has been reported at a severe level since 2018 resulting in low yield and in extreme cases complete failure of the crop. In view of undesirable effects of unilateral reliance on chemicals, greener avenues like intercropping needs to be explored, which promise to subside pests, as well as, provide higher income to cultivators.

Methods: Field experiment was conducted during 2019-2021, consecutively for three years to investigate the consequences of intercropping with legumes *viz*., red gram (*Cajanus cajan* L.), black gram (*Vigna mungo* L.), green gram (*Vigna radiata* L.), cowpea (*Vigna unguiuculata* L.), groundnut (*Arachis hypogaea* L.) and soybean (*Glycine max* L.) on incidence of fall armyworm in maize and the cost economics involved.

Result: Among the different intercrops studied, maize+cowpea recorded significantly lowest mean per cent infested plants (45.0 per cent) at 75 days after sowing which was statistically on par with maize+green gram (45.5 per cent). The next effective intercropping system was maize+black gram (55.7 per cent) followed by maize+red gram (58.2 per cent). Maize as a sole crop recorded the highest mean per cent infested plants (76.3 per cent) at 75 days after sowing. The system equivalent yield (SEY) of the intercropping systems under study ascertained that the maize+cowpea achieved highest SEY of 5230 kg per ha followed by maize+green gram (5160 kg per ha) followed by maize+black gram (4900 kg per ha). Upon comparison of the benefit cost ratio (BC ratio), the maize+cowpea proved to be highly profitable with BC ratio of 4.11 followed by maize+green gram (4.05) followed by maize+black gram (3.85), whereas, sole maize recorded minimum BC ratio of 2.87.

Key words: B:C ratio, Fall armyworm, Intercropping, Legumes, Maize.

INTRODUCTION

Maize (*Zea mays* L.) is the most important cereal crop cultivated in an area of 180.63 million hectares in 165 countries across the world recording a production of 1134 million tonnes growing at an average annual rate of 3.46 per cent (Anonymous, 2020a). It is widely valued for its extensive use as feed, fodder and as raw material for various industrial applications. In India, maize ranks third among cereals after rice and wheat, both in terms of area and production, registering maximum growth rate among food crops (Rakshit and Chikappa, 2018). Maize is attacked by nearly 130 species of insect pests in India among which borers cause upto 20-30 per cent yield losses (Atwal and Dhaliwal, 2002). In recent times, Fall armyworm [FAW; *Spodoptera frugiperda* (J.E. Smith)] is emerging as the most destructive pest of maize in India since its report in May 2018. Its rapid spread to more than 90 per cent of maize growing areas of diverse agro-ecologies of India within a short span presents a major challenge to small holder maize farmers, maize-based industry, as well as food and nutritional security (Suby *et al*., 2020). The value of crop loss is estimated at between US$2,481 million and US$6,187 million (Shylesha *et al*., 2018). In 2018, this notorious, pestiferous and havoc able pest has entered India. In India, 33-36 per cent loss in yields have been attributed to this pest as per the preliminary reports (Jagdish *et al*., 2019; Aruna *et al*., 2019). During 2019, Fall armyworm was reported in nearly 3 lakh hectares in various states of India (Karnataka, Madhya Pradesh, Rajasthan, Maharashtra, Mizoram, Tamil Nadu, Telangana and Andhra Pradesh) and was estimated to affect over 7-8 lakh hectares in 2020-21 (Anonymous, 2019; Aizawl, 2019).

Chemical control is regarded as an emergency control measure for the outbreak of unprecedented invasive pest, FAW in the region. ICAR-Indian Institute of Maize Research has recommended group of pesticides like emamectin benzoate, spinosad and chlorantraniliprole against FAW Anonymous (2020b). However, FAW is known to develop resistance against synthetic pesticides if chemical control is exclusively employed for its management (Burtet *et al*., 2017). It is not pragmatic to control FAW population by depending only on a single management practice but rather on an integrated pest control strategy (Chimweta *et al*., 2020 and Kumela *et al*., 2019). It is therefore crucial to identify

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How to cite this article: Saritha, R. and Visalakshi, M. (2024). Legume based Profitable Intercropping System for Management of Fall Armyworm in Maize. Legume Research. 47(9): 1583-1587. doi: 10.18805/LR-5179.

Submitted: 28-05-2023 **Accepted:** 05-09-2023 **Online:** 15-09-2023

environmentally friendly and cost-effective strategy for the management of this pest. Under these situations intercropping can play a significant role to enhance the productivity and profitability per unit area and time through more coherent use of land, water and solar energy, besides assuring indemnity against crop failure. Intercropping cereal with legume is recognized as the most popular agricultural practice in many developing countries of the world (Songa *et al*., 2007 and Kiwia *et al*., 2019). Maize, sorghum and pearl millet are the most familiar cereal species, whereas bean, soybean, cowpea, pigeonpea, groundnut are legume species. The cereal species is grown for primary importance and the legume species that helps in fixation of atmospheric nitrogen into the soil is added for secondary importance of increased crop production and reduced pest and weed incidence (Khan *et al*., 2014). Intercropping of legumes with main crop to reduce the pest pressure is one of the promising integrated pest management strategies and study of such a technique will be useful for formulating an effective and remunerative integrated pest management module to combat fall army worm in maize.

MATERIALS AND METHODS

The experiments were executed in a 0.14 ha area at Regional Agricultural Research Station (Acharya NG ranga Agricultural University), Anakapalle, Andhra Pradesh during *kharif* (August to October) of 2019, 2020 and 2021 to explore the consequences of intercropping on incidence of fall armyworm in maize and the cost economics invloved.

Cultivation of maize with intercrops

The experiment was performed in a randomized block design, having three replications for each treatment. Maize crop was sown at a spacing of 60 cm × 15 cm, sesame seeds in the experimental field. The standard recommended crop practices were followed and the crops were raised as purely rainfed. Manual weeding was taken up twice and no plant protection measures were taken up during the entire crop growth period. Six intercropping systems were evaluated in comparison to sole maize crop. The intercrops were raised with main crop in replacement series. Maize (*Zea mays* L.; Variety: CP-333) was grown as the main crop along with red gram (*Cajanus cajan* L.; Variety: LRG-52), black gram (*Vigna mungo* L.; Variety: PU-31), green gram (*Vigna radiata* L.; Variety: WGG 42), cowpea (*Vigna unguiuculata* L.; Variety: local), groundnut (*Arachis hypogaea* L; Variety K-9) and soybean (*Glycine max* L.; Variety JS-335) were grown as intercrops.

Damage of fall armyworm and beneficial insects

Data had been recorded using standard sampling methods from ten plants selected randomly per plot. The data pertaining to per cent plant damage and per cent leaf damage by fall armyworm were recorded and the naturally occurring predators were also recorded as number of spiders/coccinellids per plant. Data was recorded in various intercropping systems and sole maize from initial appearance till crop maturity at fifteen days interval and the seasonal means were computed. All the coccinellids were reported together as one entity, regardless of the family to which they belonged. Similarly, all species of spiders were reported together.

Evaluation of yield and cost economics

Plot wise and replication wise yield was recorded separately for sesame (main crop) and intercrops and the total per hectare yield was calculated according to the following formula (Bondre *et al*., 2017).

$$\text{Yield, kg/ha} = \text{Factor} \times \text{Seed yield (per plot)}$$

Where,

$$\text{Where, Factor} = \frac{10000}{\text{Net plot size'}}\ m^2$$

System equivalent yields

The yields of the various intercrops are transformed into the equivalent yield of main crop on the basis of the price of the crop produce. The system equivalent yield (SEY) is calculated as follows (Chetty and Reddy, 1987):

$$SEY^{n}_{i=1} = \sum (Y_i \times e_i)$$

Where,

Y_i = Yield of ith component.

e_i = Equivalent factor of ith component or price of ith crop.

Benefit cost ratio

Benefit cost ratio (B: C ratio) was calculated with respect to different intercropping systems versus sole sesame for managing sucking pests, according to following formula (Bondre *et al*., 2017):

$$\text{B: C ratio} = \frac{\text{Gross returns}}{\text{Cost of cultivation}}$$

Statistical analysis

The experiments have been replicated thrice during three subsequent years. The data from field experiments was screened by ANOVA (analysis of variance) after getting transformed into $\sqrt{x+0.5}$ using AGRES as per Gomez (1984). Pooled RBD ANOVA was done using Microsoft excel. Critical difference was calculated at 5% probability level and treatments mean values were compared using Duncan's multiple range test (DMRT) as per Gomez and Gomez, (1984).

RESULTS AND DISCUSSION

Field experiments to study the effect of intercropping on fall armyworm incidence and beneficiary insects (coccinellids and spiders) in maize were conducted in three subsequent *kharif* (August to October) seasons for three consecutive years (2019, 2020 and 2021) and the pooled data was statistically analyzed. The results and discussion are presented hereunder.

Effect of intercropping on incidence of fall armyworm in maize

Pooled mean data acquired from the field experiments of three consecutive years on effect of intercropping on incidence of fall armyworm in maize are presented in Table 1. Among six intercropping systems studied, maize+cowpea recorded significantly lowest mean per cent infested plants (45.0 per cent) at 75 days after sowing which equated statistically with maize+green gram (45.5 per cent). The next effective intercropping system was maize+black gram (55.7 per cent) followed by maize+red gram (58.2 per cent) followed by maize+groundnut (58.8 per cent) followed by maize+soybean (59.6 per cent), all of which were statistically on par with each other. Maize as a sole crop registered the highest mean per cent infested plants (76.3 per cent) at 75 days after sowing.

The present investigation indicated the significantly least per cent of mean damaged leaves due to fall armyworm at 75 days after sowing was manifested in maize+cowpea (33.8 per cent) and maize+green gram (34.6 per cent). The next effective intercropping systems were maize+black gram (46.8 per cent) followed by maize+groundnut (49.1 per cent) followed by maize+red gram (50.5 per cent) followed by maize+soybean (51.0 per cent), all of which were statistically on par with each other. Sole maize at 75 days after sowing exhibited the highest mean per cent damaged leaves (58.3 per cent).

The current study concurs with the stated findings of Degri *et al*. (2014); Girma *et al*. (2018) and Clovis *et al*. (2020), where intercropped maize with leguminous crops resulted in a significantly lower FAW infestation, compared with mono-cropped maize as certain crops and their arrangements will help disrupt host location by pests and act as repellents or deterrents reducing oviposition due to presence of allelochemicals.

Effect of intercropping on predators population in maize

As depicted in Table 1, the mean population of predatory coccinellids was significantly more in maize+cowpea (1.19 per plant) along with maize+green gram (1.11 per plant). The next better performing intercropping system with regard to coocinellid population was maize+black gram (0.90 per plant). All the other intercropping systems *viz*., maize+red gram (0.21 per plant), maize+groundnut (0.13 per plant), maize+soybean (0.10 per plant) were statistically on par with sole maize (0.12 per plant). Statistically higher number of spiders (1.01-1.03 per plant) was recorded in maize+cowpea (1.14 per plant) and maize+green gram (1.13 per plant), the spider population per plant was 1.01 in maize+black gram. The spider population was low in maize+red gram (0.13 per plant), maize+soybean(0.12) and maize+groundnut(0.11 per plant) which were on par with spiders recorded in sole sesame (0.14 per plant).

Comparable findings have been reported by Seran and Brintha (2010); Girma *et.al.* (2018) and Uday kumar *et.al.* (2021). Habitat manipulation as a method of conservation biological control which employs intercrops in the main crop field to conserve the beneficial insect fauna like natural enemies. Crop diversification with various temporal and spatial arrangements reduces pest incidence while increasing the population of beneficial arthropods.

Impact of intercropping in maize on economics of yield

The data on impact of intercropping in maize with legumes on yield economics are depicted in Table 2. The system equivalent yield (SEY) of the intercropping systems under study ascertained that the maize+cowpea achieved highest SEY of 5230 kg per ha followed by maize+green gram (5160 kg per ha) followed by maize+black gram (4900 kg per ha) and then by maize+red gram (4760 kg per ha) followed by maize+groundnut (4700 kg pe ha) and maize+soybean (4600 kg per ha. The yield realized by sole maize was 4560 kg ha^{-1}. Highest returns were generated from maize + cowpea (Rs.115060.00 per ha) followed by maize+green gram (Rs.113520.00 per ha) followed by maize+black gram (Rs.107800.00 per ha) followed by maize+red gram (Rs.104720.00 per ha) followed by maize+groundnut (Rs.103400.00 per ha) followed by maize+soybean (Rs.101200.00 per ha) and lastly sole maize (Rs.100320.00 per ha). The calculated costs of cultivation of various intercropping systems are shown in Table 2. Upon

Table 1: Effect of intercropping in maize on incidence of fall armyworm and beneficial insects.

Treatment	*Mean per cent infested plants (up to 75 days after sowing)	*Mean per cent damaged leaves (up to 75 days after sowing)	*Mean beneficial insects population per plant	
			Coccinellids	Spiders
Maize+Redgram	58.2	50.5	0.21	0.13
Maize+Black gram	55.7	46.8	0.90	1.01
Maize+Green gram	45.5	34.6	1.11	1.13
Maize+Cowpea	45.0	33.8	1.19	1.14
Maize+Groundnut	58.8	49.1	0.13	0.11
Maize+Soybean	59.6	51.0	0.10	0.12
Sole maize	76.3	58.3	0.12	0.14
CD (P=0.05)	6.2	8.9	0.11	0.09
CV	12.2	10.0	10.5	12.3

*Pooled mean for three consecutive seasons (2019, 2020 and 2021).

Table 2: Impact of maize intercropping on yield economics.

	Maize yield (kg ha^{-1})	Intercrop yield (kg ha^{-1})	Maize equivalent yield of the system (kg ha^{-1})	Returns from maize (Rs.ha^{-1})	Returns from intercrop (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Cost of cultivation (Rs. ha^{-1})	B:C ratio
Maize+Redgram	4398.3	159.2	4760	96762	7958	104720	30000	3.49
Maize+Black gram	4706.0	56.9	4900	103533	4267	107800	28000	3.85
Maize+Green gram	4840.1	88.0	5160	106483	7037	113520	28000	4.05
Maize+Cowpea	5072.5	57.7	5230	111595	3465	115060	28000	4.11
Maize+Groundnut	4337.5	122.7	4700	95424	7976	103400	35000	2.95
Maize+Soybean	4515.8	46.3	4600	99348	1852	101200	35000	2.89
Sole Maize	4560.0	-	4560	100320	-	100320	35000	2.87

Maize: Rs. 22 per kg; Red gram: Rs. 50 per kg; Black gram: Rs. 75 per kg; Green gram: Rs. 80 per kg; Cowpea: Rs. 60 per kg; Groundnut: Rs. 65 per kg; Soybean: Rs. 40 per kg.

comparing the benefit cost ratio (B:C ratio), the maize + cowpea proved to be the most profitable with B:C ratio of 4.11 followed by maize+ green gram (4.05) followed by maize+black gram (3.85) followed by maize+red gram (3.49) as presented in Table 2. The B:C ratio of maize + groundnut (2.95), maize + soybean (2.89) and sole maize (2.87) were nearly the same. There are umpteen findings elucidating the higher income generated due to intercropping when compared to sole crop. Monetary benefits owing to intercropping in maize has been recorded by Nirmal *et al*. (2020), Assefa and Dereje (2019) and Maitra *et al*. (2019). Kiwia *et al*. (2019) and Khan *et al*. (2014) have also expressed the positive consequences of cereal legume intercropping by registering low pest, disease and weed incidence and also being more remunerative.

CONCLUSION

Intercropping in maize with legumes especially pulses like cowpea and green gram followed by black gram and red gram significantly reduced the fall armyworm incidence and has also shown positive influence in enhancement of natural enemies like coccinellids and spiders in the crop eco system. These systems were also proven to be sufficiently profitable in respect of higher yields and higher benefit cost ratio.

ACKNOWLEDGEMENT

The author is highly thankful for the resources provided by Acharya NG Ranga Agricultural University, Andhra Pradesh to conduct the present study.

STATEMENTS AND DECLARATIONS

Ethics approval and consent to participate

Not applicable.

Consent for publication

The authors agree that the submitted work has not been published previously (except in the form of an abstract, a published lecture or academic thesis), that the work is not under consideration for publication elsewhere and that all authors agree to the publication of this work.

Availability of data and material

Not applicable.

Funding

Not applicable.

Author's contributions

Dr. R. Saritha, Principal Scientist (Entomology): Conceptualization, formal analysis, investigation, methodology. Dr. M. Visalakshi, Principal Scientist (Entomology): Write-up assistance and supervision.

Conflict of interest

There is no conflict of interest on the manuscript. Competing interest in disclosure of the research work has been considered by the authors. The authors undertake full responsibility of the data / statements / opinions contained in the manuscript.

REFERENCES

Aizawl, P. (2019). Fall armyworm attack caused Rs 20 crore crop loss in Mizoram, The Hindu business line. Retrieved from https://www.thehindubusinessline.com/article27056315.ece.

Anonymous (2019). Management of fall Armyworm in maize (Minutes of the meeting on fall armyworm), Department of Agriculture, Cooperation and Farmer welfare, Ministry of Agriculture and Farmer Welfare, Government of India.

Anonymous (2020a). APEDA Agricultural and Processed Food Products Export Development Authority 2019-20, Ministry of Commerce and Industry,GOI;https://apeda.gov.in.

Anonymous (2020b). ICAR-Indian Institute of Maize Research. Identification and management of fall armyworm *Spodoptera frugiperda*. https://iimr.icar.gov.in/attachment /articles/37/FAW%20folder.

Aruna, B., Bhaskar, M., Bagade, P. and Rawal, N. (2019). Yield losses in maize (*Zea mays*) due to fall armyworm infestation and potential IoT-based interventions for its control. Journal of Entomology and Zoology Studies. 7(5): 920-927.

Atwal, A.S. and Dhaliwal, G.S. (2002). Agricultural Pests of South Asia and their management. Kalyani Publishers, New Delhi. pp. 189-192.

Borde, C.M., Pande, A.K. and Thomos, M. (2017). Study the effect of seed treatments and foliar spray against major insect pests of sesame. Ecology, Environment and Conservation. 23(3): 344-349.

Burtet, L.M., Bernardi, O., Melo, A.A., Pes, M.P., Strahl, T.T. and Guedes, J.V.C. (2017). Managing fall armyworm, *Spodoptera frugiperda* (Lepidoptera: Noctuidae), with Bt maize and insecticides in southern Brazil. Pest Management Science. 73(12): 2569-2577.

Chetty, C.K. and Reddy, M.N. (1987). A general proposal for ranking intercrop treatments. Indian Journal of Agricultural Science. 57: 64-65.

Chimweta, M., Nyakudya, I.W., Jimu, L. and Mashingaidze, A.B. (2020). Fall armyworm [*Spodoptera frugiperda* (J.E. Smith)] damage in maize: Management options for flood-recession cropping small holder farmers. International Journal of Pest Management. 66(2): 142-154.

Clovis, B.T., Raymond, N.N., Justin, N.O., Aaron, S.T. and Christopher, N. (2020). Effect of intercropping beans with maize and botanical extract on falls armyworm (*Spodoptera frugiperda*) infestation. International Journal of Agronomy. 60: 1-7.

Degri, M.M., Mailafiya, D.M., Mshelia, J.S. (2014). Effect of intercropping pattern on stem borer infestation in pearlmillet (*Pennisetum glaucum* L.) grown in the Nigerian Sudan Savannah. Advances in Entomology. 2: 81-86

Girma, H., Niassy, S., Zeyaur, K.R., Ochatum, N., Subramanian, S. (2018). Maize-legume intercropping and push-pull for management of fall armyworm, stemborers and striga in Uganda. Agronomy Journal. 10: 2513-2522.

Gomez, K.A. and Gomez, A.A. (1984). Statistical Procedures for Agricultural Research. 2nd ed. John Wiley and Sons, New York. PP 657.

Jagdish, J., Mishra, S. and Maknwar, P. (2019). Strategies for sustainable management of fall armyworm, *Spodoptera frugiperda* (J.E. Smith) in sorghum. Paper presentation in XIX International Plant Protection Congress IPPC 2019, Hyderabad, Telangana, India. Retrieved from www.ippc2019. icrisat.org.

Khan, Z.R., Midega, C.A.O., Pittchar, J.O. (2014). Achieving food security for one million sub-Saharan African poor through push-pull innovation by 2020. Philosophical Transactions of the Royal Society B: Biological Sciences. 369(1639): 20120284. doi: 10.1098/rstb.2012.0284.

Kiwia, A., Kimani, D., Harawa, R., Jama, B., Sileshi, G. (2019). Sustainable intensification with cereal-legume intercropping in Eastern and Southern Africa. Sustainability. 11(10): 2891. https://doi.org/10.3390/su11102891.

Kumela, T., Simiyu, J., Birhanu, S., Likhayo, P., Mendesil, E., Gohole, L. and Tefera, T. (2019). Farmers' knowledge, perceptions and management practices of the new invasive pest, fall armyworm (Spodoptera frugiperda) in Ethiopia and Kenya. International Journal of Pest Management. 65(1): 1-9.

Maitra, S., Palai, J.B., Manasa, P. and Kumar, D.P. (2019). Potential of intercropping system in sustaining crop productivity. International Journal of Agriculture, Environment and Biotechnology. 12(1): 39-45.

Nirmal, O.A., Haldavanekar, P.C., Salvi, B.R., Sawardekar, S.V., Sanap, P.B., Haldankar, P.M., Mehendale, S.K., Parulekar, Y.R. and Bhuwad, A.V. (2020). Influence of spacing and intercropping on attack of falls armyworm infestation in sweet corn under konkan agro climatic conditions. International Journal of Current Microbiology and Applied Sciences. 11: 3550-3557.

Rakshit, S. and Chikkappa, G.K. (2018). Perspective of maize scenario in India: Way forward. Maize Journal. 7(2): 49-55.

Subyl, S.B., Soujanya, P.L., Yadava, P., Patil, J., Subaharan, K., Prasad, G.S., Babu, K.S., Jat, S.L., Yathish, K.R., Vadassery, J., Kalia, V.K., Bakthavatsalam, N., Shekharand, J.C. and Rakshit, S. (2020). Invasion of fall armyworm (*Spodoptera frugiperda*) in India: Nature, distribution, management and potential impact. Current Science. 119(1): 44-51.

Seran, T.H. and Brintha, I. (2010). Review on maize based intercropping. Journal of Agronomy. 9: 135-145.

Shylesha, A.N., Jalali, S.K., Gupta, A., Varshney, R., Venkatesan, T., Shetty, P., Ojha, R., Prabhu, C., Ganiger, C., Navik, O., Subaharan, K., Bakthavatsalam, N., Ballal, C.R. (2018). Studies on new invasive pest Spodoptera frugiperda (J.E. Smith) (Lepidoptera: Noctuidae) and its natural enemies. Journal of Biological Control. 32: 1-7.

Songa, J.M., Jiang, N., Schulthess, F., Omwega, C. (2007). The role of intercropping different cereal species in controlling lepidopteran stemborers on maize in Kenya. Journal of Applied Entomology. 131(1): 40-49.

Udayakumar, A., Shivalingaswamy, T.M. and Bakthavatsalam, N. (2021). Legume-based intercropping for the management of fall armyworm, *Spodoptera frugiperda* L. in maize. Journal of Plant Diseases and Protection. 128: 775-779.