Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2020; 8(1): 387-391

Received: 10-11-2019
Accepted: 12-12-2019

Effect of diversified cropping system on insect and weed pest diversity

RS Pan, Pradip Kumar Sarkar, Reshma Shinde, Moanaro, Rakesh Kumar, JS Mishra, AK Singh and BP Bhatt

RS Pan
ICAR- Research Complex for Eastern Region, FSRCHPR, Ranchi, Jharkhand, India

Pradip Kumar Sarkar
ICAR- Research Complex for Eastern Region, FSRCHPR, Ranchi, Jharkhand, India

Reshma Shinde
ICAR- Research Complex for Eastern Region, FSRCHPR, Ranchi, Jharkhand,India

Moanaro
ICAR- Research Complex for Eastern Region, FSRCHPR, Ranchi, Jharkhand, India

Rakesh Kumar
ICAR- Research Complex for Eastern Region, Patna, Bihar, India

JS Mishra
ICAR- Research Complex for Eastern Region, Patna, Bihar, India

AK Singh
ICAR- Research Complex for Eastern Region, FSRCHPR, Ranchi, Jharkhand, India

BP Bhatt
ICAR- Research Complex for Eastern Region, Patna, Bihar, India

Corresponding Author:
RS Pan
ICAR- Research Complex for Eastern Region, FSRCHPR, Ranchi, Jharkhand, India

Abstract
An experiment was conducted to study the effect of diversified cropping system on insect and weed pest diversity without compromising the yield of target crop. The result revealed that, there was significantly higher grain yield in case of Finger millet (3.72 t ha^{-1}) followed by Finger millet+Black gram (3.11 t ha^{-1}) and Finger millet+Horse gram (3.11 t ha^{-1}. It also clearly showed that there was relatively higher Shannon's diversity Index value of insect pest in the diversified cropping system of Rice+blackgram (0.62) when compared to monocropping system, but the Shannon's index value of weeds was found to be comparatively and significantly higher in sole crops (*i.e.*, having highest value of 0.99 in Horse gram cropping system), compared to diversified systems *viz.*, Finger millet+Horse gram (0.73) and Finger millet+Black gram (0.74). In crop diversification systems, infestation of leaf folder, *Anticarsia irrorata* was observed in black gram and horse gram in all the sole and integrated plots. Whereas, the species *Cnaphalocrocis medinalis* was recorded maximum in the case of rice, black gram and Finger millet+black gram cropping systems. The insect pest, *Maruca testulalis* infestation was observed only in black gram cropping system with maximum damage of pods during its development stage that resulted in reduction of crop yield. Hence, it was cleared that the diversified cropping systems like Finger millet+Black gram and Finger millet+Horse gram were found to be the best cropping systems for controlling insect and weed pest diversity, naturally without compromising the yield of target crop. Among the sole crops, Finger millet cropping systems was found to be the best compared to others in achieving maximum crop yield with low insect pest and weed infestation.

Keywords: Diversified, cropping system, insect, weed, pest and diversity

Introduction

Climate change has increased the crop losses and yield variability [1, 2, 3] which has led to an increase in price volatility threatening food security and nutrition [3, 4]. Insect pests and plant diseases are one of the major factors contributing to reduction in crop yields, farmers' incomes and also threatening food security. In this context, crop diversification which is the practice of cultivating more than one variety of crops belonging to the same or different species in a given area in the form of rotations and or intercropping, appears as a potential solution to maintain crop productivity, soil fertility, environmental sustainability and reducing the pest and diseases incidence. Moreover, crop diversification can also provide habitats for beneficial insects, and this can help reduce the number of pests by rendering host crops less apparent for colonization by parasites.

Diversified cropping system tends to be more resilient and agronomically stable due to reduced insect and weed pressure, reduced soil erosion due to use of cover crops, reduced use of fertilizers in mixed cropping which include leguminous crops that add nitrogen in soil and also helps in increasing soil fertility which leads to increase in crop yield per unit area [5]. Diversification of crops can be effective strategy for achieving the objectives of food and nutrition security, judicious use of land and water resources, sustainable agricultural development and environmental improvement, employment generation, source of income growth and poverty alleviation [6].

Therefore, it is imperative to identify the mechanisms of crop diversification in agricultural systems which helps in both pest and disease management with increased crop yield [7, 8, 9]. On the other hand, weeds also act as a good shelter to many detrimental pests and diseases of the crops. Therefore, weed control is must to reduce cumulative negative impacts on yields of target crops. Hence, weed control during first four weeks is very critical in many vegetable crops [10]. Marana *et al.* [11] had reported the critical period of weed competition to be as 30-40 days after sowing, otherwise their presence during that period or ahead may lead to reduced fruit yield by 70% depending on stage and duration of competition [12]. Increasing crop diversity may offer advantages in reducing disease, weed and pest population densities and severity over sole crops [7, 9]. Keeping these in view, an experiment was carried out to study the impact of crop diversification on insect pest infestation, weed diversity and yield of crops in Eastern Plateau and Hill Region.

Materials and Methods

The experiment was conducted in the research farm of ICAR-Research Complex for Eastern Region, FSRCHPR, *Ranchi*, located in Jharkhand (23.35º N and 85.33º E at 629 m altitude having average rainfall of 1000 mm) during *kharif* season from July to October in 2016-17 and 2017-18. The experimental soil was acidic in nature, low in organic carbon, available nitrogen and potassium. The experiment was laid in a randomized block design with three replication and eight crop diversification levels *viz.*, Rice, Finger millet (Ragi), Black gram and Horse gram were grown as sole crops and as mixed crops in all four paired combinations in 1:1 ratio (*i.e.*, Rice+Black gram, Rice+Horse gram, Finger millet+Black gram and Finger millet+Horse gram).

Monitoring of insect pests

The incidence of various insect pests on the crops was recorded at weekly intervals. The pest population was observed/ recorded based on the numerical count method as described by Lal [13] from randomly 10 selected plants (10 numbers of each leaves and pods) from different locations in the plots. The insect diversity index was calculated per plot as per the procedure given by Shannon and Wiener [14] for measuring the diversity and Margalef [15] for measuring the species richness.

a. Shannon-Wiener diversity index (1949)

Diversity index = $H = -\sum Pi \ln Pi$

Where, $Pi = n / N$

n = number of individuals of one species
N = total number of all individuals in the sample
In = natural logarithm

b. Margalef's richness index (1958)

$d = (S - 1)/\ln N$

Where, d = Margalef's richness index

S = number of species
N = total number of individuals

c. Measurement of evenness

For calculating the evenness of species, the Pielou's Evenness Index (e) was used [16].
$e = H / \ln S$

Where, H = Shannon - Wiener diversity index
S = total number of species in the sample

Observations on weed diversity

The weed diversity (at different stages of development of crop) considering a fixed time interval was recorded at 30 days after sowing [12] from centre of the plot by using quadrat method (size of quadrats 1 m X 1 m were laid out to study the weed diversity parameters) [17]. A wooden scale was used to measure the length or height of the weeds and a vernier calliper was used to measure the basal diameter of the weeds.

Statistical analysis

Data collected including crop yield, insect and weed *viz.*, frequency, density and diversity indices were analyzed following the standard methodology as described above and also by using Systat-12 software [18] for computation of ANOVA to test the significant difference.

Results and Discussion

The average crop yield under different land-use systems were enumerated and mentioned in Table 1. Significantly higher grain yield of crop was recorded in case of Finger millet (3.72 t ha^{-1}) followed by Finger millet+Black gram (3.11 t ha^{-1}) and Finger millet+Horse gram (3.11 t ha^{-1}), Horse gram (2.37 t ha^{-1}), Rice+Horse gram (2.13 t ha^{-1}), Black gram (1.93 t ha^{-1}), Rice+Black gram (1.72 t ha^{-1}) and the lowest grain yield was recorded in Rice (1.30 t ha^{-1}). The results were also in accordance with the results of Smith *et al.* [19] who reported that yields of winter wheat did not get affected by weeds under diversified cropping systems included in the rotation but the yields of the same crop got reduced in monocultures. The reduction in yield of sole crop compared to mixed crop could be attributed to differences in light penetration through crop canopy [20] and level of insect, pest and diseases incidences [7, 8, 9].

The insect and weed pest community was analyzed for species diversity by applying Shannon-Weiner index which combines the effect of richness and evenness of the species occurring in a community. During the analyses, Shannon-Weiner index decreased with decrease in total number of species. The diversity indices of the insect and weed pest in the monocropping and diversified cropping systems are presented in Table 1. The data clearly showed relatively higher diversity of insect pest in the diversified crop system compared to the sole cropped except in black gram sole crop. In the present study, the highest diversity index for insects was found to be in Rice+black gram (0.62) followed by black gram (0.58) and Finger millet+black gram (0.42) cropping systems. The diversity index value of weeds was found to be comparatively and significantly higher in sole crops compared to diversified system. The highest diversity index of weed was found in sole crop of Horse gram (0.99) and lowest in case of Finger millet+Horse gram (0.73) and Finger millet+Black gram (0.74) cropping system. Margalef's richness index is a measure of species richness with a positive correlation towards diversity in an ecosystem. Under diversified cropping systems, the richness index of insect pest was found to be more compared to the sole cropped except in black gram sole crop (Table 1). The highest Margalef's richness index for insect pests was found in sole cropped black gram (7.95) followed by Rice+black gram cropping system (7.52) and Finger millet+black gram cropping system (6.64). While the Margalef's richness index of weed was more in sole cropped compared to diversified cropping systems. The highest Margalef's richness index for weeds was found in sole cropped Rice (1.07), followed by black gram (1.03), finger millet (0.93) and horse gram (0.93). Many researchers have studied the diversity of insects and their association and interactions with the plant community. Panzer and Schwartz [21] investigated that 49% of variance in insect species is due to plant species richness among the studied areas.

Evenness index is a measure of distribution of a species in an ecosystem. In our results, the diversified cropping system recorded evenness of insect indicating uniform distribution of species compared to the sole cropped ecosystems (Table 1). The highest evenness of insect pest was observed in Rice+black gram system (0.097) and lowest in sole cropped finger millet (0.005). The results were in line with the observations made by Anbalagan *et al.* [22] who reported maximum diversity, richness, and evenness of insect pest in the vegetables intercropping compared to those in the sole cropped. While Evenness index for weeds was more in sole cropped compared to diversified cropping systems. The highest evenness of weeds was observed in sole cropped horse gram (0.69).

Table 1: Effect of crop diversity on insect and weed pest diversity

Treatments	Crop components		Total grain yield (t ha^{-1})	Insect pest diversity indices			Weed diversity indices		
	Description	Symbol		Shannon's Index	Margalef's richness index	Evenness index	Shannon's Index	Margalef's richness index	Evenness index
T-1	Rice	R	1.30^{f}	0.29^{c}	2.08^{e}	0.050^{d}	0.96^{ab}	1.07^{a}	0.066^{ab}
T-2	Finger millet (Ragi)	FM	3.72^{a}	0.04^{f}	1.13^{f}	0.007^{g}	0.87^{abc}	0.93^{b}	0.061^{c}
T-3	Black gram	BG	1.93^{de}	0.58^{a}	7.95^{a}	0.088^{b}	0.95^{ab}	1.03^{a}	0.065^{b}
T-4	Horse gram	HG	2.37^{c}	0.16^{d}	4.52^{c}	0.025^{e}	0.99^{a}	0.93^{b}	0.069^{a}
T-5	Rice+Black gram	R + BG	1.72^{e}	0.62^{a}	7.52^{a}	0.097^{a}	0.85^{bcd}	0.58^{cd}	0.059^{d}
T-6	Rice+Horse gram	R+ HG	2.13^{cd}	0.11^{e}	3.66^{d}	0.017^{f}	0.86^{abc}	0.63^{c}	0.060^{cd}
T-7	Finger millet+Black gram	FM + BG	3.11^{b}	0.42^{b}	6.64^{b}	0.067^{c}	0.74^{cd}	0.51^{d}	0.054^{e}
T-8	Finger millet+Horse gram	FM + HG	3.11^{b}	0.03^{f}	1.29^{f}	0.005^{g}	0.73^{d}	0.64^{c}	0.054^{e}

Data represent the mean ± standard deviation. Means within a column that did not differ significantly at 5% level of significance when compared with Fisher's Least Significant Difference are followed by the same superscript letters.

In crop diversification systems, infestation of leaf folder, *Anticarsia irrorata* was observed (Fig. 1) in black gram and horse gram in all the sole and integrated plots and the highest mean number 0.113 per leaf was recorded in black gram integrated with Finger millet (*i.e.,* Finger millet+Black gram) and horse gram integrated with rice (*i.e.,* Rice+Black gram) at 7th week after sowing. Whereas, rice leaf folder, the insect *Cnaphalocrocis medinalis* attack was recorded maximum in the case of rice, black gram and Finger millet+black gram crops (*i.e.,* 2.0 % leaf damage (0.020 infestation per leaf) during the 9th and 10th week after sowing (Fig. 2). The insect pest, *Maruca testulalis* infestation was observed (Fig. 3) in black gram crops and the maximum damage of pods was recorded as 0.0064 per pod (*i.e.,* 0.64%). The population of *M. testulalis* was highest during the pod development stage (*i.e.,* at 11 weeks after sowing) which resulted in reduction of crop yield. There was also an attack of insect pest of *Crocidolomia binotalis* in the cropping systems of Rice, black gram and Rice+black gram, having number of infestations per leaf recorded as 0.013, 0.007 and 0.007, respectively. Pan *et al.* [23] reported that in crop diversification under rainfed condition, the cropping systems *viz.,* Finger millet+Black gram and Finger millet+Horse gram were found to be the best conventionally practiced for controlling weed biomass and diversity naturally without compromising the yield of interest. According to Langer *et al.* [24], crop diversification compared with a monoculture, affects the pest population in two ways by altering the neighboring plants and microclimatic conditions as well as by altering quality of host plant. The diversification of crops have reduced incidence of pest as there is increase in botanical diversity [25], which makes difficult for the pest to find host plants. Thus crop diversification suffers significantly less damage from insects compared to monoculture which lead to high crop yield [26].

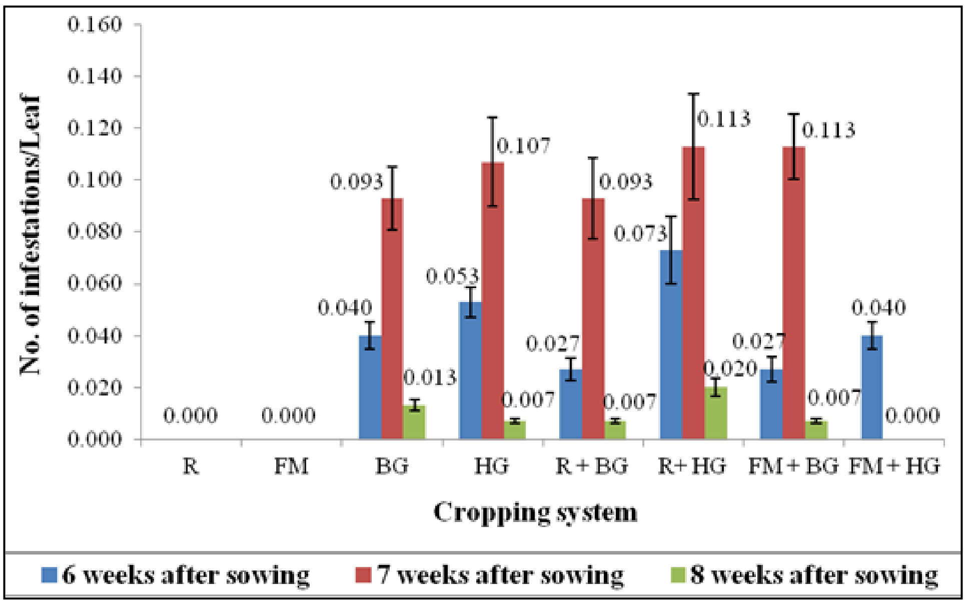

Fig 1: Population of *Anticarsia irrorata* at 6, 7 and 8 weeks after sowing

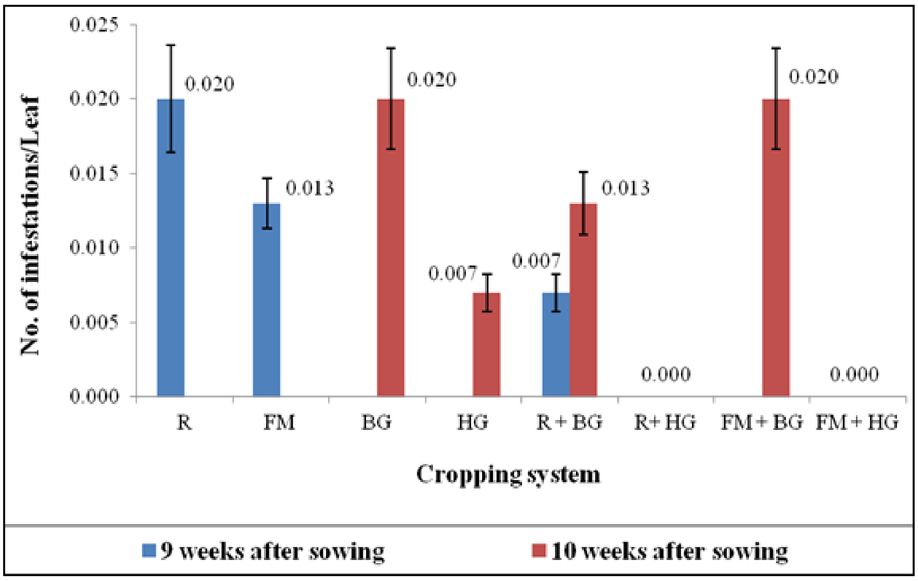

Fig 2: Population of *Cnaphalocrocis medinalis* at 9 and 10 weeks after sowing

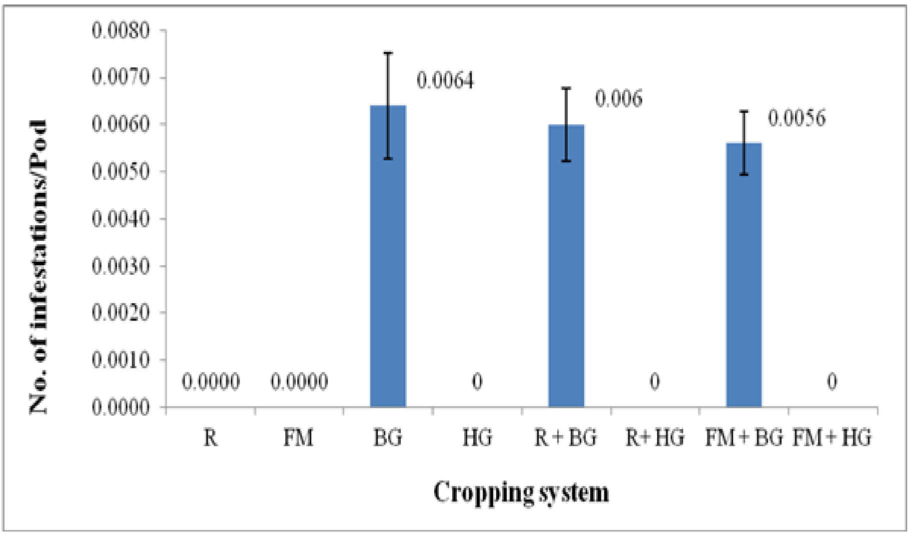

Fig 3: Population of *Maruca testulalis* at 11 weeks after sowing

Conclusion

The cropping systems, Finger millet+Black gram and Finger millet+Horse gram were found to be the best cropping systems or land-use systems for controlling insect and weed pest diversity naturally without compromising the yield of interest. While considering the sole crops, the treatment Finger millet was found to be the best cropping systems compared to others in achieving maximum crop yield with low insect pest and weed infestation.

References

1. Tubiello FN, Soussana JF, Howden SM. Crop and pasture response to climate change. Proceedings of National Academic Sciences. 2007; 104:19686-19690.
2. Hawkins E, Fricker TE, Challinor AJ, Ferro CAT, Ho CK, Osborne TM *et al*. Increasing influence of heat stress on French maize yields from the 1960s to the 2030s. Global Change Biology, 2013; 19:937-947.
3. FAO. Climate Change and Food Security: Risks and Responses, 2016. http://www.fao. org/3/a-i5188e.pdf
4. Lobell DB, Schlenker W, Costa-Roberts J. Climate trends and global crop production since 1980. Science. 2011; 333:616-620. https://doi.org/10.1126/science. 1204531.
5. Lin BB. Resilience in agriculture through crop diversification: adaptive management for environmental change. Bioscience. 2011; 61:183-193. doi: 10.1525/bio.2011.61.3.4.
6. Hedge DM, Tiwari PS, Rai M. Crop diversification in Indian Agriculture. Agricultural Situation in India, 2003, 351-354.
7. Li CY, He XH, Zhu SS, Zhou HP, Wang YY, Li Y *et al*. Crop diversity for yield increase. PLoS ONE**.** 2009; 4:e8049.
8. Yang M, Zhang Y, Qi L, Mei X, Liao J, Ding XP *et al*. Plant-plant-microbe mechanisms involved in soil-borne disease suppression on a maize and pepper intercropping system. PLoS ONE, 2014; 9, e115052.
9. Ding XP, Yang M, Huang H, Chuan YR, He XH, Li CY *et al*. Priming maize resistance by its neighbors: Activating 1,4-benzoxazine-3-ones synthesis and defense gene expression to alleviate leaf disease. Frontiers in Plant Science, 2015; 6:830.
10. Holm L. Some quantitative aspects of weed competition in vegetable crops. Weeds. 1956; 4:111-123.
11. Marana J, Gongola R, Paredes E, Labrada R. Critical period for competition from weeds and direct-sown tomato. Cienciay Tecnica en la Agricoltura, Hortizalas, Papa, Granosy Fibra. 1983; 2:73-83.

12. Govindra S, Bhan VM, Tripathi SS. Effect of herbicde alone and combination with weeding on tomato and association with weeds. Indian Journal of Weed Science. 1986; 16:262-266.
13. Lal OP. Notes summer school on Advance technologies in improvement of vegetable crops, including cole crops, I.A.R.I., May 4-24, New Delhi, 1998, 63-66.
14. Shannon CE, Wiener W. The mathematical theory of communication. Urbana, University of Illinois Press, 1949, 177.
15. Margalef R. Temporal succession and spatial heterogeneity in phytoplankton. In: Perspectives in Marine biology, Buzzati-Traverso (ed.), Univ. Calif. Press, Berkeley, 1958, 323-347.
16. Pielou EC. The measurement of diversity in different types of biological collections. Journal of Theoretical Biology, 1966; 13:131-144.
17. Sinha MK, Banerjee A. Studies on weed diversity and its associated phytosociology under direct dry seeded rice systems. Communications in Plant Sciences. 2016; 6(3-4):47-54.
18. Wilkinson L, Coward M. SYSTAT: Statistics-II. (Version 12) Systat software Inc, Sanjose, CA-95110, 2007.
19. Smith RG, Gross KL, Robertson GP. Effects of crop diversity on agroecosystem function: Crop yield response. Ecosystems. 2008; 11:355-366.
20. Sharaiha R, Haddad N. Potential of intercropping of cabbage, broadbean and corn under Jordan Valley conditions. Dirasat Agricultural Science. 1985; 12(4):45-56.
21. Panzer R, Schwartz MW. Effectiveness of a vegetation-based approach to insect conservation. Conservation Biology. 1998; 12(3):693-702. https://doi.org/10.1046/j.1523-1739.1998.97051.x
22. Anbalagan V, Paulraja MG, Ignacimuthua S, Baskar K, Gunasekaran J. Natural enemies (Arthropoda-Insecta) biodiversity in vegetable crops in Northeastern Tamil Nadu, India. International Letters of Natural Sciences. 2016; 53:28-33.
23. Pan RS, Sarkar PK, Shinde R, Kumar R, Mishra JS, Singh AK *et al*. Effect of diversified cropping system on weed phytosociology. International Journal of Chemical Studies. 2019; SP6: 677-683
24. Langer V, Kinane J, Lyngkjær M. Intercropping for pest management: The ecological concept. In Koul O, Cupreus GW. (Eds.), Ecologically Based Integrated Pest Management (Wallingford, UK: Cabi Publishing, 2007, 462.
25. Risch SJ. Intercropping as cultural pest control: Prospects and limitations. Environmental Management. 1983; 7(1): 9-14.
26. Altieri MA, Letourneau DL. Environmental management to enhance biological control in agroecosystems. In Bellows TS, Fisher TW. (Eds), Handbook of biological control San Diego, CA: Academic Press, 1999, 319-354.