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EFFECT OF FARMING SYSTEMS ON DIVERSITY AND SEASONAL ABUNDANCE OF INSECT PESTS AND THEIR NATURAL ENEMIES IN CAULIFLOWER

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ABSTRACT

A study was conducted on effect of two farming systems namely zero budget natural farming (ZBNF) and conventional farming (CF) on diversity and seasonal abundance of insect pests of cauliflower and their natural enemies during 2018-19 and 2019-20. Studies revealed that ZBNF system harboured less pest diversity and attracted more natural enemies as compared to the CF system. Natural enemy activity and % parasitisation were maximum in ZBNF system as compared to CF system. The results indicate that indigenous ZBNF formulations and intercropping have a positive effect on the population of natural enemies and repelled the insect pests much better as compared to CF system.

Key words: Zero budget natural farming, conventional farming, insect pests, natural enemies, cauliflower, repellency, parasitisation, natural enemy activity

Cauliflower *Brassica oleracae* var. *botrytis* L., is one of the common vegetables, and introduced in India in 1822 from England (Chatterjee et al., 1986). It is currently grown throughout the country. Cauliflower is attacked by various insect pests (Gaikwad et al., 2018; Raja et al., 2014). A large number of insecticides have been recommended and used to control these. These insecticides have their own harmful effects, including their negative impacts on natural enemies. Agroecosystem is not self-regulated as compared to others due to monocropping, and extra efforts are required to control the pests. Natural enemies play an effective role in IPM (Mandal and Patnaik, 2008). Intercropping, organic amendments generally harbour more natural enemies. Farming systems have great impact on insect pests and natural enemies, and organic practices increase the natural enemies (Gallo and Pekar, 1999). Such comparisons are necessary, as agroecosystems are with increased pest diversity and reduced natural enemies (Yadav 1989; Meena et al., 2002). The effect of organic farming system on natural enemies is required to be brought out and there are many studies. Recently a new system of farming called as zero budget natural farming (ZBNF) has been practiced. However, the studies on the impact of this system on the diversity and abundance of insect pests and their natural enemies are lacking. Natural enemies play key role in insect pest control (Liu et al., 2000). Hence, the current study to study the effects of ZBNF in comparison to conventional farming (CF) in cauliflower.

MATERIALS AND METHODS

The study was carried out at the experimental farms of Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh (1300 masl). Cauliflower (PSBK-1) was raised following standard package of practices for ZBNF and CF separately. In ZBNF, the main crop was intercropped with pea (P89), coriander (local selection) and mustard (trap crop). In CF cauliflower was raised as a sole crop, with plot size of 9x 4.5 m. For fertilization and pest management, indigenous plant and cow dung-urine based formulations were used. Jeevamrit, Ghanjeevamrit and Beejamrit were used as fertilizers, while Darekastra @ 500 l ha^{-1}, Bramhastra @ 3% and Agniastra @ 3% were used for pest management in ZBNF (Palekar, 2016). In CF system crop was raised following all the standard package of practices recommended by the University. The fertilizers used were urea @ 300 kg, SSP @ 675 kg and MOP @ 85kg/ha. The pests and diseases were controlled by need based applications of Captan (75%WP), malathion (50%EC) and imidacloprid (17.8%SL).

The diversity and seasonal abundance of insect pests were monitored at weekly intervals from nursery stage to final harvest. The data on the number of species

of pests and their natural enemies and the density of each species were observed. The population density of aphids, whitefly, caterpillars and beetles were counted on plant basis from 50 randomly selected plants in each case. The natural enemies viz. coccinellids and syrphid flies' density were observed by directly counting the beetles and maggots/ plant; in case of parasitized aphids, the parasitized ones were collected from 50 randomly selected plants and kept in the laboratory for emergence of adult parasitoids. The parasitized larvae of diamond back moth and cabbage butterfly were collected from sampling plants and kept in the laboratory for the emergence of parasitoids. The diversity of insect pests and natural enemies were analysed through Simpson Index (Simpson, 1949) and Shannon- Wiener Index (Shannon, 1948). For evaluating the seasonal abundance, weekly data collected were statistically analysed using t-Test by OP-STAT software (Sheoran et al., 1998).

RESULTS AND DISCUSSION

Diversity of insect pests and natural enemies: During 2018-19, six species of insect pests (under 6 genera and families each) were observed on cauliflower crop under ZBNF and CF systems. The pests include: the cabbage aphid *Brevicoryne brassicae* (L.); flea beetle *Phyllotreta* sp; greenhouse whitefly *Trialeurodes vaporariorum* (Westsood); diamond back moth *Plutella xylostella* (L.); cabbage head borer *Hellula undalis* (F.) and cabbage butterfly *Pieris brassicae* (L.). During 2019-20, in ZBNF system the diversity and species composition remained the same as that of previous year. In CF system, in addition to the above insect pests cabbage semilooper *Thysanoplusia orichalcea* (F.) was observed. As regards natural enemies, seven species were found associated with insect pests under ZBNF system. Out of these, five were predators and two parasitoids. Among predators, two coccinellids i.e. *Coccinella septempunctata* (L.) and *Hippodamia variegata* (Goeze); and three syrphids i.e. *Episyrphus balteatus* (De Geer), *Eupeodes frequens* (Matsumura) and *Metasyrphus confrator* (Wiedemann) were observed. The parasitoids observed were *Diaeretiella rapae* (Mc'Intosh) parasitizing the cabbage aphid, and *Diadegma semiclausam* (Hellen) parasitizing the larvae of *P. xylostella*.

During 2019-20 in ZBNF system, eight species of natural enemies were observed, all the species observed in the previous year were found along with the parasitoid *Cotesia glomerata* (L.) parasitizing the larvae of butterfly. In cauliflower grown under the conventional farming system, six species of natural enemies were observed during both the years of study. Five of them were predators and one was parasitoid. Among the five predators, two coccinellids i.e. *C. septempunctata* and *H. variegata*; and three syrphids i.e. *E. balteatus*, *E. frequens* and *M. confrator* were observed. The parasitoid observed was *D. rapae* parasitizing the cabbage aphid. The insect pest diversity indices revealed that CF based cauliflower ecosystem was more diverse than ZBNF system, while, the natural enemies' diversity indices revealed that ZBNF based system was more diverse (Table 1). This is possibly because of higher crop diversity and non-application of insecticides in the ZBNF system.

Seasonal abundance: The cabbage aphid appeared during the last week of October, 2018 (44th standard week (SW)- 2.74± 0.30 and 4.18± 0.40 aphids plant^{-1} in ZBNF and CF systems, respectively during 2018-19; and reached peak incidence of 23.40± 4.00 and 27.74± 5.09 aphids plant^{-1}) during 6th and 5th SW in ZBNF and CF systems, respectively. In 2019-20, the aphids appeared @2.04± 0.38 and 4.04± 0.66 aphids plant^{-1} in ZBNF and CF systems, during the last week of October, 2019 (44th SW), and peaked to 18.88± 3.94 and 28.38± 4.94 aphids plant^{-1} during 6th and 5th SW in ZBNF and CF systems, respectively (Fig.1A). The

Table 1. Diversity indices of insect pests and their natural enemies in cauliflower under ZBNF and CF systems (2018-19, 2019-20)

Diversity indices	Insect-pests				Natural enemies			
	2018-19		2019-20		2018-19		2019-20	
	Farming systems		Farming systems		Farming systems		Farming systems	
	ZBNF	CF	ZBNF	CF	ZBNF	CF	ZBNF	CF
Simpson index	0.78	0.68	0.74	0.64	0.51	0.54	0.47	0.50
Shannon index (H)	0.73	0.99	0.82	1.06	1.23	0.78	1.38	0.83
H_{max}	1.79	1.79	1.79	1.94	1.38	1.10	1.60	1.10
Evenness (J)	0.41	0.55	0.46	0.55	0.89	0.71	0.86	0.75
Dominance (D)	0.59	0.45	0.54	0.45	0.11	0.29	0.14	0.25

flea beetle appeared during the last week of October, 2018 (44th standard week) @0.14± 0.05 and 0.30± 0.07 beetles plant^{-1} in ZBNF and CF systems, and reached peak of 0.28± 0.08 and 0.60± 0.12 beetle plant^{-1} during the 50th SW in ZBNF and CF systems, respectively; during the second year, the incidence appeared during the last week of October, 2019 (44th SW) @ 0.10± 0.04 and 0.26± 0.06 beetle plant^{-1} in ZBNF and CF systems respectively; these reached the peak in the second week of December, 2019 (50th SW) @ 0.24± 0.07 and 0.58± 0.13 beetles plant^{-1} in ZBNF and CF systems, respectively (Fig.1B).

Whitefly infestation started on 47th SW in ZBNF and CF systems, with the peak reaching in 52nd SW (0.58± 0.16 and 1.28± 0.28 whiteflies plant^{-1}) in ZBNF and CF systems, respectively in 2018-19; in 2019-20, the incidence appeared during the third week of November, 2019 (47th SW) and reached the peak in the last week of December, 2019 (52th SW) (Fig.1C). During 2018-19. Diamond back moth (DBM) started on 1st SW in ZBNF and CF systems, and reached peak in the third week of February, 2019 (8th SW) @0.96± 0.16 larvae plant^{-1} in ZBNF system, and 1.40± 0.18 larvae plant^{-1} in CF system; during 2nd year, the incidence started during

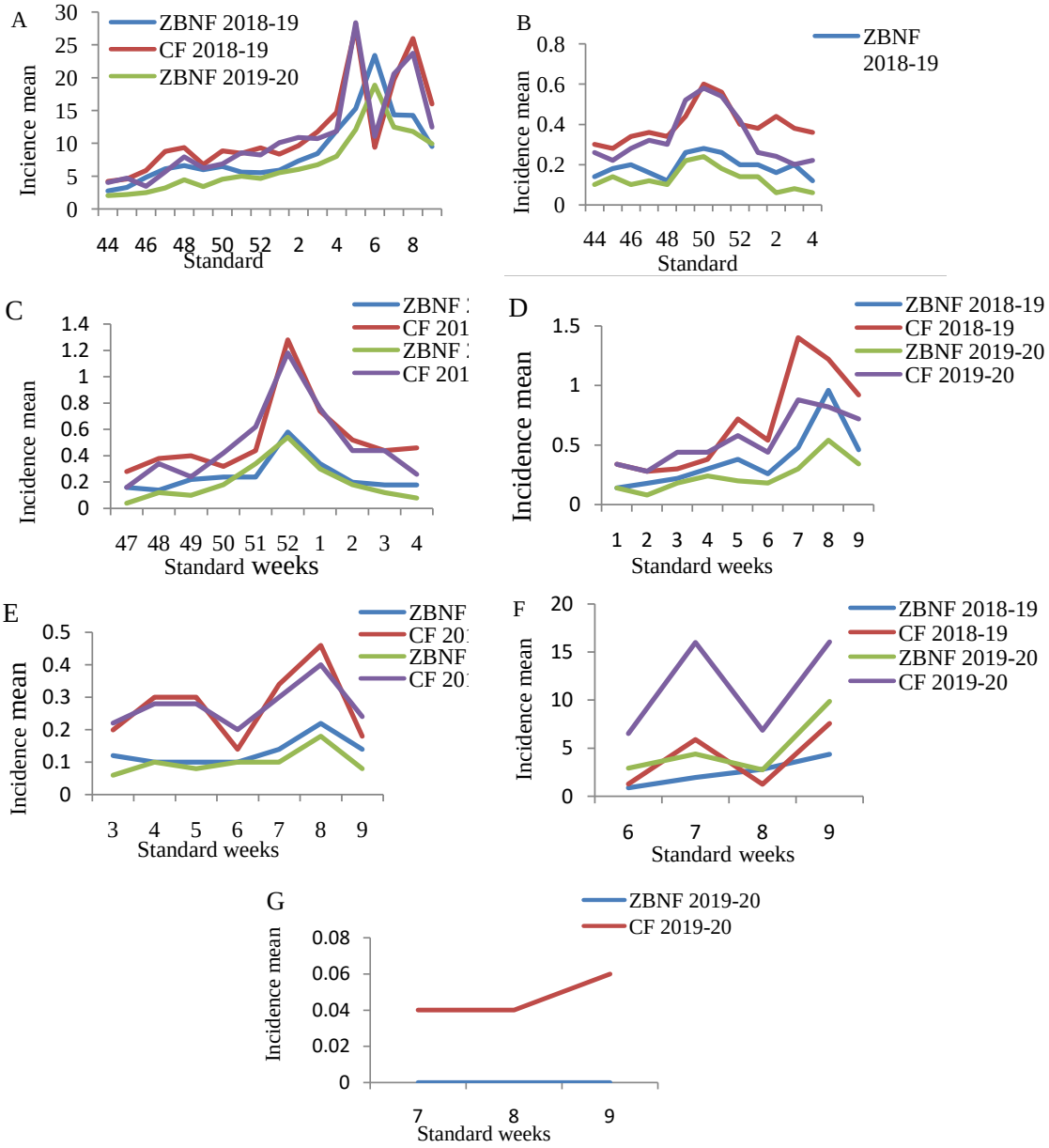

Fig. 1. Seasonal abundance of insect-pests of cauliflower under ZBNF and CF systems during 2018-19 and 2019-20

the first week of January, 2020 (1st SW) and reached the peak of 0.54± 0.10 larvae plant^{-1} in ZBNF system, during the third week of February, 2020 (8th SW); while, in CF system, peak was at 0.88± 0.16 larvae plant^{-1}) in the second week of February, 2020 (7th SW) (Fig.1D). Likewise, cabbage head borer started infesting the crop during 3rd SW in both the systems in both the seasons with peak incidence being during the 8th SW (Fig.1E). Cabbage butterfly infestation started in the first week of February, 2019 and 2020 i.e. 6th SW, with its larval counts reaching the peak in the fourth week of February, 2019 and 2020 (9th SW- 6.52± 2.37 and 16.00± 3.97 larvae plant^{-1} in ZBNF and CF systems, 2019; and 6.86± 2.15 and 16.06± 3.94 larvae plant^{-1} in 2020, respectively (Fig.1F). Cabbage semilooper was recorded only in CF system and infestation started on 7th SW, with peak incidence recorded on 9th SW during second year (Fig.1G). In case of natural enemies *D. rapae* parasitization was observed on 44th and 46th standard weeks in of ZBNF and CF systems during 2018-19 and its peak incidence (1.28± 0.35 and 1.94± 0.39 mummified aphids plant^{-1}) were recorded on 5th and 6th SW in CF and ZBNF systems. During 2019-20 the peak incidence of 1.60± 0.33 and 2.26± 0.47 mummified aphids plant^{-1} was observed on 5th and 6th SW in CF and ZBNF systems, respectively.

The maximum parasitization (13.56 and 4.61%) was observed on 1st and 5th SW, 2019 in ZBNF and CF systems, respectively. During 2019-20 peak parasitisation (22.22 and 6.40%) was observed on 52nd and 46th SW in ZBNF and CF systems, respectively (Fig. 2A). Activity of coccinellids started (0.10± 0.04 and 0.08± 0.04 beetles plant^{-1}) on 46th and 47th SW during 2018-19, and 0.16± 0.06 and 0.08± 0.04 beetles plant^{-1} during 2019-20, in ZBNF and CF systems. Peak occurrence of coccinellids (0.58± 0.12 and 0.28± 0.09 beetles plant^{-1}) was observed during 6th and 7th SW in 2018-19, and (0.86± 0.17 and 0.42± 0.11 beetles plant^{-1}) during 2019-20, in ZBNF and CF systems (Fig. 2B). Syrphids appeared during 50th and 51st SW in ZBNF and CF systems during both seasons with maximum counts observed on 8th SW (Fig. 2C); *D. semiclausam* appeared on 5th SW in ZBNF, while it was not observed in CF system during both seasons- maximum was on 9th SW in ZBNF system in both seasons (Fig. 2D). Similarly, parasitic wasp, *C. glomerata* was seen only in ZBNF system during 2019-20 and this occurred during 8th SW with peak being in 9th standard week (Fig. 2E).

In ZBNF system organic amendment and intercropping had an impact on natural enemies and use of intercrop also repelled certain insect pests up to a remarkable level. Sharma et al. (2020) also observed similar insect pests in their study from cauliflower, revealing 14 species of insect pests, of which seven are similar as in this study. Rana (2019) also reported these pests from the cruciferous ecosystem from Himachal Pradesh and revealed a better impact of ZBNF than CF system. Current study recovered all insect pests reported by Rana (2019) except green peach aphid *Myzus persicae* (Sulzer). Similar results were obtained by Mishra et al. (2018) where cabbage aphids (*B. brassicae*) appeared from 35th to 47th SW in cauliflower ecosystem. Mandal and Patnaik (2008) also observed insects of cole crops with peak incidence of *B. brassicae* during January and February. Patra et al. (2013) documented the seasonal abundance of DBM during late February to early March, which is in accordance with the present results. Singh et al. (2015) reported DBM from the 2nd SW and peak in 8th SW. Embaby (2015) observed similar incidence of *B. brassicae* and DBM. Dewanda and Khan (2016) also found DBM on cauliflower during the first week of September which gradually increased and reached its peak during first week of November. Similar results were reported by Meena and Singh (2012) on DBM that it appeared 35 days after transplanting of cabbage with peak in the last week of January. Das et al. (2017) studied the effect of temperature (ºC) on species richness of whitefly in mustard- incidence was very low at 20 November, 2015, which gradually reached the peak in 19 March, 2016.

Khan and Talukder (2017) studied the influence of weather factors on the abundance and population dynamics of *P. brassicae* on cabbage- and found that larval incidence ranged from 0.58 to1.98 larvae/ plant with peak on 5th February. Sharma et al. (2020) found *C. septempunctata* was the most abundant predator of aphids in cauliflower with relative proportion of 74.55 and 52.98% and the parasitization of *P. xyllostella* by *D. semiclausam* was 28.94 and 30.77%; they also found that *C. glomerata* was the most abundant parasitoid of the larva of *P. brassicae* and *P. rapae* (42.43 and 57.58% during 2017 and 2018, respectively) which is quite similar to present results; and 10 predators and 4 parasitoids were observed in contrast to 5 predators and 3 parasitoids in the present study. The incidence of *P. brassicae* observed now is similar to that reported by Dwivedi et al. (2015). Jakhar and Singh (2018) observed the occurrence of coccinellids in cauliflower with *C. septempunctata* as the most dominant. Gaikwad et al. (2018) studied the insect pests and natural enemies of cauliflower during 2017 and reported the incidence of *B. brassicae, P. xylostella* and *H. undalis*. In addition, they

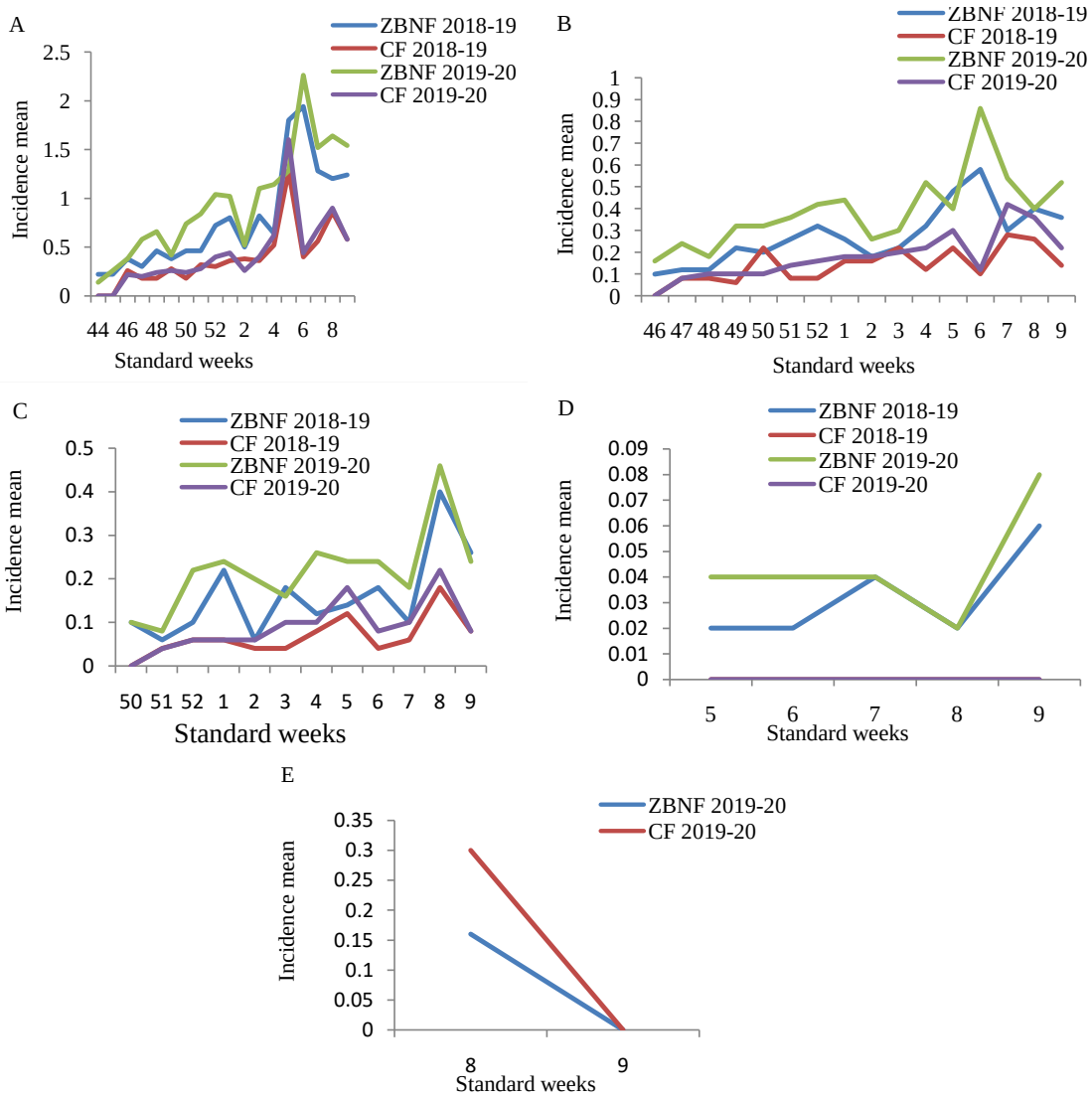

Fig. 2. Seasonal abundance of natural enemies of insect pests of cauliflower under ZBNF and CF systems (2018-19, 2019-20)

recorded the occurrence of syrphid flies and mummified aphids. Evidences and results of current study provide a platform to conclude that ZBNF is a better farming system than CF system as it not only repels the pests, but conserves the natural enemies and improves the crop ecosystem.

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