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Management of yellow stem borer, *Scirpophaga incertulas* (Walker) and enumeration of soil arthropods in natural farming approaches of paddy ecosystem

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Abstract
Rice (*Oryza sativa* L.) is the staple food at least half of the world's population and is approximately 148 million ha of land globally. Out of more than 100 species of insects attacking rice, stem-borer is reported to cause economic crop losses up to 60 percent. Pesticides are commonly used to control rice stem borer and ensure maximum yield with high market value. However, the accumulation of these chemical inputs in crop fields increases risks to biodiversity and human health. Keeping in view the deleterious effects of chemical pesticides, there is a need to evaluate alternate methods to manage the rice stem borer effectively without any menace to the ecological niche. We examined the incidence of insect pests and their management with botanicals and chemical insecticides and their influence of on beneficial insects (mesofauna population) in rice ecosystem grown with different farming practices *viz*., Organic production system, Zero Budget Natural Farming ZBNF, Recommended package of practices and Farmers practices along with Absolute control in rice at Zonal Agricultural Research Station, VC Farm, Mandya during *kharif* 2019-2022. It was evident from the pooled mean data that among various treatments, the least percent white ears (14.64% white ears) were registered in natural farming practice with hand weeding and UAS, (B) recommended package of practices (14.73% white ear) followed by organic production system (16.10% white ears) natural farming practice (19.31% White ear) andfarmers practices (22.17% white ears) as against highest incidence in absolute control (38.61% white ears). The pooled data over four season ecosystem organic farming practices excelled first by recording maximum number of arthropod population (26.20 arthropods per 400 gm of soil). Considering the efficacy of eco-friendly nature of organic production system and ZBNF are the effective management of the yellow stem borer.

Keywords: Arthropods, organic production system, rice, *Scirpophaga incertulas*, yellow stem borer and ZBNF

Introduction
The continuous use of pesticides and chemicals has severe effects on human health. After witnessing the harmful effects of chemical farming, newly introduced agriculture technique among farmers is Natural farming (NF). It has attained wide success in southern India especially Karnataka where it was firstly evolved (Kumar, 2012) [8]. Now it is spreading all over India, so rapidly. Natural Farming involves the application of Jeevamrutha, Beejamrutha, mixed cropping system, home-made preparations for plant protection and seed/planting materials and mulching. Thus, it envisages complete freedom from chemicals from farming. This method of farming was introduced by Shri Subhash Palekar.

Rice is one of the most important and extensively grown foods in the tropical and subtropical regions of the world (Saxena and Shrivastava, 2007) [17]. Though more than hundred species of insects recorded as pests in rice, few pests *viz*., rice yellow stem borer (YSB), *Scirpophaga incertulas* (Walker), gall midge, *Orseolia oryzae* (Wood-Mason), leaf folder, *Cnaphalocrocis medinalis*, brown plant hopper, *Nilaparvata lugens* (Stal) and white backed plant hopper, *Sogatella furcifera* (Horvath) are of national importance as their incidence has significant impact on rice yields across the diverse rice ecosystems (Gururaj Katti, 2013) [8].

Stem borers (SBs) are key group of insect pests of rice. Among the borers, yellow stem borer (YSB), *Scircophaga incertulas* (Walker) distributed throughout Indian sub-continent and is regarded as the most dominating and destructive pest species (Mahar *et al*., 1985) [11]. About 25-30 percent reduction in yield of rice had been calculated caused by YSB. Severe infestation by YSB often results in complete crop failure (Kushwaha, 1995) [4].

The yellow stem borer, *S. incertulas* causes 27.34 percent loss annually (Pasulu *et al*., 2002) [15] in rice production. From the dark history of YSB attack in India, it has assumed status as national pest (Pasalu *et al*., 2002) [15]. Yellow stem borer larvae feed only on rice plants and causes major economic loss to farmers. Its damage remains incredible level despite use of chemical insecticides as a control measure.

Use of chemical insecticides leads to reduction in beneficial fauna in paddy ecosystem, deterioration of soil health and also leads to health problems to farmers. Furthermore, quite often the indiscriminate and unscientific use of pesticides has led to many problems, such as pests developing resistance, resurgence of once minor pest into a major problem besides environmental and food safety hazards. In such a back drop, the present study was undertaken to know the impact of natural control measures on yellow stem borer and beneficial fauna in paddy ecosystem.

Materials and Methods

In order to ascertain the influence of natural control measures on yellow stem borer, *Scirpophaga incertulas*(Walker) and beneficial fauna, the field trials were conducted at research farm, ZARS, VC Farm Mandya during *Kharif*-2019, 2020. 2021 and 2022 with the following treatments.

T_1: Absolute control (There is no plant protection measure).

T_2: Organic production system (Spraying of 0.3% neem oil (1500 ppm) at 60 and 90 DAS).

T_3: Natural Farming (NF Protocol as given by Shri. Subash Palekar) (Spraying of agniastra @ 60 and 90 DAS)

T_4: Recommended package of practices (UAS, GKVK, Bengaluru) (Fipronil 5% SC (0.3G) @ 1 kg /ha (10kg/acre) at 60 and 90 DAS)

T_5: Farmers practice (Spraying of Mancozeb 75% WP, Tricyclazole 75% WP and Fipronil 5% SC (0.3G) @ 1 kg /ha (10kg/acre) at 45, 75 and 85 DAS)

T_6: Natural farming practice with hand weeding- spraying agnihastra @ 60 and 90 DAS.

(Note: Treatment-6 was imposed *Kharif*- 2020 onwards)

Field evaluation of Agnihasthra, neem oil and Fipronil 5% SC were used against yellow stem borer was carried during the *kharif*-2019, 2020, 2021 and 2022 at Zonal Agricultural Research Station, VC Farm, Mandya. There were five treatments and an untreated check, with five replications laid out in Randomized Block Design (RBD). Each treatment plot measured 9×16 sq.mt and first spray application was taken up when the yellow stem borer incidence was observed.

Agniastra preparation

For preparing agniastra, mix all the ingredients (Table 1) in a earthen pots by using wooden sticks. The sticks should be moved clockwise while mixing so that positive energy is circulated in the mixture. After that boil the solution for five times then cover the pot with gunny bug. Let the mixture ferment for 48 hours. The content was stirred thrice a day and then filtered using the thin muslin cloth (Badiyala and Sharma, 2021) [2].

Table 1: Details of Agniastra ingredients

Sl. No.	Name of the ingredient	Gram per liter of cow urine
1	Crushed leaves of Tobacco	25
2	Desi hot green Chilly pulp	25
3	Desi Garlic pulp	12.5
4	Crushed Neem leaves	100

White ears and productive tillers from each damaged hill from each plot was recorded and then calculated to percent white ears with the help of following formulas described by Singha and Pandey (1997) [18]. White ears were recorded at one day before spraying at 70 DAS and 3, 7, 10 days after treatment.

$$\text{Percent white ear head} = \frac{\text{Total number of white ear head}}{\text{Total number of tillers}} \times 100$$

For recording observations on pre and post-treatment yellow stem borer damage, from each plot white ears were recorded one day before (pre-treatment) and 3, 7 and 10 days after spray application.

Enumeration of Soil arthropods

Half kilogram of soil was collected from different treatment plots. Collected samples were loaded to Berlese funnels and covered by big sieves to avoid jumping out the arthropods from the samples. Samples were heated from above by an ordinary lamp bulb (25 W), suspended about 20 cm above each sample to continuous heating for maximum extraction of different micro arthropod groups. As the surface of the sample becomes heated and desiccated, the athropods move down and are driven out from the sample, and collected into the specimen tubes filled with tap water placed below.

The Berlese funnel work on the principle that insects and other arthropods that normally live in soil and litter will respond negatively to light. Therefore, a light source is used to force the arthropods to move downward, where they will fall into a funnel and then into a container of ethanol. The arthropods which collected in ethanol was identified up to family level under microscope and tabulated.

Data was analyzed statistically by following the statistical procedure suggested by Gomez and Gomez (1984) [3] after subjecting to angular transformation

(F-test) for percent damage to determine the effective treatment and the percent reduction over control in each treatment.

Results and Discussion

One day before treatment imposition

There was no significant difference in the percent white ears between treatments before spraying during *Kharif* 2019, 2020, 2021 and 2022. Percent white ears ranged from 31.66 to 32.45, 30.15 to 32.11, 30.01 to 31.42 and 31.66 to 32.44 during *Kharif* 2019, 2020, 2021 and 2022 respectively. Pooled data of one day before spraying revealed that percent white ears ranged from 30.72 to 31.73 (Table 2).

Three day after spraying

Significant increase in percent white ears was observed in all the treatments at third day after spraying. During *Kharif* 2019, UAS (B) recommended package of practice recorded the lowest *i.e*., 21.42 percent of white ears followed by organic production system which recorded 22.89 percent of white ears. Whereas, natural farming system and farmer's practice recorded 27.15 and 28.16 percent of white ears respectively. Control plot recorded 33.13 percent white ears.

During *Kharif* 2020, the lowest percent of white ears were recorded in UAS (B) recommended package of practice (21.33 percent). This was followed by natural farming with hand weeding system and organic production system which recorded 23.42 and124.89 percent white ears and these were on par with other. Natural farming and Farmer's practice recorded 28.16 and 30.01 percent white ears during *Kharif* 2020 respectively, while 33.56 percent of white ears were recorded in control plot. Similar trend was observed during 2021 and 2022.

Pooled data of all the four seasons on percent white ears in paddy revealed that UAS (B) recommended package of practice recorded the lowest of 21.42 percent white ears, which was followed by natural farming with hand weeding system (23.21%WE). Organic production system and natural farming practice recorded 23.99 and 27.05 percent white ears respectively.

Seven day after treatment application

At seventh day after spraying, UAS (B) recommended package of practice recorded lowest damage *i. e.*, 19.74 percent white ears during *Kharif* 2019, which was followed by organic farming practices20.89 percent and these were on par with each other. The next best treatments are Natural farming and Farmer practices which recorded 24.16 and 25.87 percent white ear respectively.

During *Kharif* 2020, the low percent of 19.70 and 20.45 white ears were recorded in UAS (B) recommended package of practice organic and natural farming with hand weeding system of production respectively. This was followed by organic farming which recorded 21.89 percent white ears. Natural farming and farmer's practice recorded 27.16 and 28.11 percent white ears respectively and these were on par with each other. 36.23 percent of white ears were recorded in control plots. Similar trend was observed during 2021 and 2022.

Pooled data revealed that the lowest percent of white ears was recorded in UAS (B) recommended package of practice (18.68%WE) at seventh day after treatment followed by natural farming practices with hand weeding system (19.00%WE). Organic production system, natural farming system and farmer's practice recorded 20.08, 24.82 and 26.51 percent white ears respectively, while 35.59 percent white ears were recorded in control plot.

Ten day after treatment application

During *Kharif* 2019, 16.08 percent of white ears were recorded in UAS (B) recommended package of practice and 17.56 percent of white ears were recorded in organic production system and these treatments found to be significant by recording lowest white ear damage over other treatments. This was followed by natural farming system and farmer's practice which recorded 20.42 and 23.95 percent white ears respectively while, control plot recorded 38.25 percent white ears.

UAS (B) recommended package of practice and natural farming with hand weeding recorded 16.18 and 16.56 percent white ears during *Kharif* 2020 respectively and these treatments were on par with each other. The next best treatment was and organic system of production (18.32% WE) followed by natural farming system and farmer's practice which recorded 20.22 and 24.95 percent white ears respectively. Control plots recorded 37.95 percent white ears during *Kharif* 2020. Similar trend was observed during *Kharif* 2021 and 2022.

Pooled data of four seasons revealed that the lowest percent of white ears was recorded in natural farming practices with hand weeding (14.64% WE) which was conducted for only three seasons (2020, 2021 and 2022) and UAS (B) recommended package of practice (14.73%WE) at tenth day after treatment followed by organic production system (16.06% WE) natural farming system (19.31% WE) and farmer's practice recorded 22.17 percent white ears while, 38.61 percent white ears was recorded in control plot.

Significantly maximum percent white ears (30.04, 30.04, 32.54 and 39.45 during *kharif* 2019, 2020, 2021 and 2022 respectively) at 10 days after spraying was recorded in control (T_1) treatment, whereas T4 and T5 treatments recorded 27.99 and 28.16 percent white ears respectively, in these treatments there was no fresh damage and was evident by percent white ears recorded at seven days after spraying. These results are in conformity with Neena Bharti *et al.* (2018) [14] who reported that the lowest incidence of rice stem borer 3.3 and 3.6 was recorded in fields treated with Carbofuran 3G @ 30 kg/ha at 5 DBT in nursery with application of 2 spray of Fipronil 5% SC at 30 & 50 DAT. The highest grain yield (30.3 q/ha), net return (Rs. 15050.00/ha) and maximum benefit: cost ratio (1.8) were recorded and found best with application of Carbofuran 3G @ 30 kg/ha along with 2 spray of Fipronil 5% at 30 and 50 DAT followed by application of Carbofuran 3G @ 30 kg/ha in nursery + *T. chilonis* @ 5 cards/ha. Sontakke and Dash (2000) [19] also reported that application of chlorpyriphos, ethoprophos, carbofuran, fipronil at 50 DAT afforded effective control of stem borer.

There was slight increase in percent white ears in T2 and T3 treatments and the increase was 4.68 and 2.00 percent respectively compared to infestation at seven days after spraying this might be due to slow action of botanical insecticides results are in conjugation with Islam *et al*., 2013[5], who reported that significant result was observed in Fipronil treatment after 21 days of spraying which showed the reduction of 51.89% dead heart and 65.05% white head over control. Neem extracts reduced dead heart and white head by 38.38% and 58.08% respectively. Considering the efficacy and eco-friendly nature of Neem extract it could be considered as an effective botanical in successful management of the pest yellow rice stem borer, *S. incertulas* infestation was not increased and this might be due to spraying of chemical insecticide. Insecticidal activity may be attributed to azadiractin in neem and cow urine, used of in preparation of neemastra. Rajpoot *et al*. (2018) [16] reported that application of Neemazal @ 1.0 ml/l was found most effective against yellow stem borer of rice resulted with lower dead heart percent 3.5 (30 DAT), 3.2 (50 DAT) and white ear 1.9 percent.

Table 2: Incidence of yellow stem borer, *Scirpophaga incertula* in direct seeded rice ecosystem in different treatments

Treatments	Percent white ear									
	1 DBT					3 DAT				
	2019	2020	2021	2022	Pooled	2019	2020	2021	2022	Pooled
Control	32.44	32.01	30.01	32.44	31.73	33.13	33.56	32.85	34.13	33.42
OF	32.11	30.15	30.22	31.66	31.04	22.89	24.89	24.33	23.83	23.99
NF-1	32.44	30.18	30.54	32.07	31.31	27.15	28.16	26.79	26.11	27.05
RPP	31.66	31.23	31.42	32.21	31.63	21.42	21.33	21.83	21.08	21.42
FP	32.07	32.11	30.22	32.11	31.63	28.16.	30.01	29.13	27.61	28.92
NF-2	-	30.25	30.46	31.45	30.72	-	23.42	23.44	22.76	23.21
S Em±	-	-	-	-	0.14	0.07	0.34	0.23	0.28	0.13
CD @ 5%	NS	NS	NS	NS	0.41	0.21	1.02	0.66	0.82	0.38
Treatments	Percent white ear									
	7 DAT					10 DAT				
	2019	2020	2021	2022	Pooled	2019	2020	2021	2022	Pooled
Control	35.13	36.23	34.55	36.43	35.59	38.25	37.95	38.77	39.45	38.61
OF	20.89	21.89	21.36	16.19	20.08	17.56	18.32	16.87	11.65	16.10
NF	24.16	27.16	24.74	23.21	24.82	20.42	20.22	19.94	16.67	19.31
RPP	19.74	19.70	19.76	15.50	18.68	16.08	16.18	16.08	10.58	14.73
FP	25.87	28.11	28.50	23.55	26.51	23.95	24.95	22.77	17.01	22.17
NF-2	-	20.45	20.71	15.84	19.00	-	16.56	16.25	11.12	14.64
S Em±	0.08	0.34	0.15	0.19	0.16	0.09	0.32	0.2	0.22	0.16
CD @ 5%	0.24	1.01	0.44	0.55	0.46	0.27	0.94	0.58	0.65	0.46

Note: DBS- Days Before Spray; DAT: Days After Treatments
Absolute control OF: Organic farming practices with spray of 0.3% neem oil (1500 ppm) at 60 and 90 DAS.
NF-1: Natural farming practices with spraying of agniastra at 60 and 90 DAS. RPP: UAS (B) Recommended Package of Practices
FP: Farmer's Practice; NF-2: Natural farming with hand weeding (spraying of agniastra at 60 and 90 DAS)

Population of natural enemies (spiders) in different treatment plots

Spider population was almost similar in all the treatments before spraying with the mean population ranged from 8.40 to 9.00 but there was slight increase in spider population after three days of spraying in control, organic and natural farming with maximum mean population recorded in control (9.87) followed by natural farming (9.73) and organic system of production(9.13). Mean spider population was decreased after three days of spraying in UAS (B) recommended package of practice (3.00) and farmer's practice (3.13) was due to effect of broad-spectrum insecticide sprayed in these two treatments during 2019-20 (Table 3).

A slight increase in spider population of 9.87, 4.00 and 4.07 was recorded in natural farming, UAS (B) recommended package of practice and farmer's practice respectively, at seven days after spraying but the population was less in control (9.33) and organic production system (9.00) at seven days after spraying. There was increase in spider population in all treatments at 10 days after spraying and significantly differed among treatments with maximum population was recorded in natural farming system(10.40) and was followed by control (10.20) and organic production system (10.13) whereas, significantly low population was recorded in UAS (B) recommended package of practice(8.07) and farmer practices (8.00). Similar trend was observed during 2022 (Table 3).

Status of mesofauna in paddy ecosystem

Soil arthropods abundance differed significantly among all the treatments. The soil arthropod species recorded were, Collembolans, Rove beetle, Mites and Thrips.

In paddy ecosystem, the highest *i.e.*, 20.2 arthropods per 400 gm of soil were recorded in organic production system followed by natural farming system (19.8 arthropods per 400 gm of soil) before sowing of the crop during *Kharif* 2019 (Table 11). UAS (B) recommended package of practice and farmer's practice recorded the lowest arthropods (6.6 and 5.8 arthropods respectively), while control plot recorded 8.6 arthropods per 400 gm of soil.

After harvest of paddy during *Kharif* 2019, organic production system recorded the highest of 25.6 arthropods per 400 gm of soil followed by natural farming system which recorded 23.8 arthropods per 400 gm of soil. UAS (B) recommended package of practice and farmer's practice recorded 10.6 and 8.6 arthropods per 400 gm of soil respectively, while control plot recorded 12.4 arthropods per 400 gm of soil.

Table 3: Population of natural enemies (spiders) in different treatment plots

Treatments	Spider population (number/one sq.mt)							
	1 DBT		3 DAT		7 DAT		15 DAT	
	2019	2022	2019	2022	2019	2022	2019	2022
Control	8.40	7.94	9.87	8.14	9.33	10.35	10.20	10.48
OF	9.00	8.12	9.13	8.38	9.00	10.18	10.13	10.21
NF-1	8.87	8.56	9.73	8.83	9.87	10.14	10.40	10.45
RPP	8.73	8.13	3.00	4.15	4.00	3.65	8.07	7.56
FP	8.80	8.65	3.13	4.03	4.07	3.05	8.00	7.14
NF-2		8.12		8.45		8.67		8.85
S Em±	0.26	0.31	0.24	0.34	0.24	0.32	0.28	0.29
CD @ 5%	0.77	0.92	0.73	1.03	0.72	0.96	0.83	0.88

Note: DBS- Days Before Spray; DAT: Days After Treatments
Absolute control OF: Organic farming practices with spray of 0.3% neem oil (1500 ppm) at 60 and 90 DAS.
NF-1: Natural farming practices with spraying of agniastra at 60 and 90 DAS. RPP: UAS (B) Recommended Package of Practices
FP: Farmer's Practice; NF-2: Natural farming with hand weeding (spraying of agniastra at 60 and 90 DAS

During *Kharif* 2020, natural farming system recorded 26.6 arthropods while organic production system recorded 25.8 arthropods per 400 gm of soil before sowing of paddy.

Natural farming with hand weeding and control system of production recorded 16.4 and 13.4 arthropods per 400 gm of soil respectively. UAS (B) recommended package of practice and farmer's practice recorded the lowest arthropods of 12.8 and 10.2 per 400 gm of soil before sowing of paddy during *Kharif* 2020.

After harvest of paddy, enumeration of soil arthropods different farming practices revealed that organic and natural farming system recorded the highest soil arthropods (28.4 and 27.8 arthropods per 400 gm of soil). This was followed by natural farming with hand weeding and control, which recorded 17.6 and 16.2 arthropods per 400 gm of soil. the lowest quantification of arthropods were recorded in UAS (B) recommended package of practice and farmer's practice among the treatments (14.4 and 12.4 arthropods per 400 gm of soil).

During *Kharif* 2021, organic production system recorded 28.6 arthropods per 400 gm of soil before sowing of paddy followed by natural farming system (27.2 arthropods per 400 gm of soil). Natural farming with hand weeding and control have recorded 17.6 and 16.2 arthropods per 400 gm of soil respectively. The lowest population of arthropods among the treatments was recorded in UAS (B) recommended package of practice and farmer's practice (14.8 and 13.4 arthropods per 400 gm of soil).

After of the harvest of paddy during *Kharif* 2021, organic and natural farming systems have recorded the highest arthropods population of 29.6 and 28.4 arthropods per 400 gm of soil. This was followed by natural farming with hand weeding and control systems which have recorded 19.4 and 17.2 arthropods per 400 gm of soil. UAS (B) recommended package of practice and farmer's practice have recorded the low population of arthropods (15.4 and 13.8 arthropods per 400 gm of soil).

During *Kharif* 2022, organic production system recorded 30.20 arthropods per 400 gm of soil before sowing of paddy followed by natural farming system 29.80 arthropods per 400 gm of soil. Natural farming with hand weeding and control has recorded 19.60 and 18.40 arthropods per 400 gm of soil respectively. The lowest population of arthropods among the treatments was recorded in UAS (B) recommended package of practice and farmer's practice was 16.00 and 14.40 arthropods per 400 gm of soil respectively.

Table 11: Status of mesofauna in paddy ecosystem in organic production, natural farming and UAS (B) package of practices treatment plots at VC Farm, Mandya

Treatments	Mesofauna (No)									
	2019		2020		2021		2022		Pooled	
	Initial	Harvest	Initial	Harvest	Initial	Harvest	Initial	Harvest	Initial	Harvest
Control	8.60	12.40	13.40	16.60	16.20	17.20	18.40	19.60	14.15	16.45
OF	20.20	25.60	25.80	28.40	28.60	29.60	30.20	30.80	26.20	28.60
NF-1	19.80	23.80	26.60	27.80	27.20	28.40	29.80	30.20	25.85	27.55
RPP	6.60	10.60	12.80	14.40	14.80	15.40	16.00	17.20	12.55	14.40
FP	5.80	8.60	10.20	12.40	13.40	13.80	14.40	15.40	10.95	12.55
NF-2			16.40	17.80	17.60	19.40	19.60	20.20	17.87	19.13
S Em±	0.82	0.84	0.96	0.97	1.07	0.84	1.19	1.04	0.55	0.69
CD @ 5%	2.44	2.53	2.83	2.87	3.17	2.47	3.51	3.07	1.61	2.04

Note: DBT- Days Before Treatment; DAT: Days After Treatments
Control: Absolute control OF- Organic farming practices with spray of 0.3% neem oil (1500 ppm) at 30 and 45 DAS.
NF-1: Natural farming practices with spraying of neemastra 30 and 45 DAS.
RPP: UAS(B) Recommended Package of Practices
FP: Farmer's practice
NF-2: Natural farming practices with hand weeding

After of the harvest of paddy during *Kharif* 2022, organic and natural farming systems have recorded the highest arthropods population of 30.80 and 30.20 arthropods per 400 gm of soil and these treatments were on par with each other. This was followed by natural farming with hand weeding and control systems which have recorded 20.20 and 19.60 arthropods per 400 gm of soil. UAS (B) recommended package of practice and farmer's practice have recorded the lowest population of 17.20 and 15.40 arthropods per 400 gm of soil respectively.

The pooled data over four seasons of observation in paddy ecosystem organic farming practices excelled first by recording maximum number of arthropod population (26.20 arthropods per 400 gm of soil) followed by natural farming system (25.85 arthropods per 400 gm of soil) and these cultivation practices on par with each other. The next best treatments are natural farming with hand weeding system and absolute control recorded 17.87 and 14.15 arthropods per 400 gm of soil respectively. Whereas in UAS (B) recommended package of practice and farmer's practice have recorded the lowest population of 12.55 and 10.95 arthropods per 400 gm of soil respectively, before sowing of paddy crop. Similar trend was recorded after harvesting of the crop.

From the present investigation it was found that soil arthropods population was abundant in the entire crop ecosystem where organic and natural farming practices were adopted. Application of organic amendments like vermicompost, paddy/ finger millet straw mulch and incorporation of previous crop *i.e.*, cowpea haulm after harvest, application of Ghana jeevamrutha and jeevamrutha has contributed to increased activity of soil arthropods in organic and natural farming system. Use of inorganic fertilizers, chemical pesticides for pest and disease management affected the soil arthropod activity reducing their population where UAS (B) recommended package of practices and farmer practices were adopted.

The present findings are supported by earlier reports of Abilasha *et al.*, (2013) [1] and Narasa Reddy *et al.*, (2013) [13] who reported that a relatively higher abundance of meso-arthropods (collembolan, cryptostigmatids, other acari and other invertebrates) was recorded with heavy application of Farm Yard Manure (FYM, 20 t/ha) in fields compared to recommended fertilizer alone.

However, in conventional farming system /farmer's practice and UAS (B) package of practice treatments recorded least number because using of fertilizers and pesticide application affect the soil arthropod population in soil. The results are in line with the earlier reports of Letourneau and Bothwell (2008) [10] who reported that the higher input of chemical fertilizers and pesticides decline biological diversity. Also, mechanical and chemical perturbations produced by conventional agricultural management practices and by particular abiotic soil conditions present in the intensively managed sites that are unfavorable for collembolans, pauropods and mites densities etc. (Jose *et al.*, 2006a and Jose *et al.*, 2006b) [6, 7].

With its roots purely of Indian Origin, Zero Budget Natural Farming shows the purpose driven base for an environment friendly ecosystem. However the newer approaches like Integrated farming system (Mir*et al.*, 2022) [12] Resource conservation based cropping systems, circular agriculture based farming systems, vertical farming and climate smart agriculture are also focusing on the judicious utilization of chemical inputs so as to cover the aspects of food production with special emphasis on disease and pest management as well as weed management. Though the Natural farming assures a chemical free produce, but it cannot sustain the global food crisis and food security under changing population dynamics. Therefore, it becomes imperative to cover the aspects of global food crisis so as to boost the food production in ZBNF.

Conclusion

Zero budget farming is both cost-effective and eco-friendly. Crop protection chemicals and fertilizer costs are reduced as a result maintaining soil health is aided by the constant retention of crop residues. In addition, pest and disease management is critical in zero-budget natural farming systems. Regardless of the debates and criticisms, the fact that ZBNF was developed with a very positive mentality to benefit the farming community cannot be disputed. Many small-scale farmers across the country have benefited from it. For researchers, scientists, and extension workers, possibilities are two factors that show the gaps in the system and the benefits to adopters, and policy intervention is required to make success. However, a thorough scientific evaluation or validation of the claim is required before it can be recommended. There is a need to conduct multi-locational trials to study ZBNF's effects on the soil nutrient content, land and environment health as well as the economic status of farmers and national food security.

Spraying of Fipronil 5% SC (0.3G) @ 1 kg /ha (10kg/acre) at 60 and 90 DAS Zero percent increase in white ears was recorded in UAS (B) recommended package of practices and farmer's practices treatments but increase in white ears observed in organic, natural farming and natural farming with hand weeding system of production. This might be due to slow action of botanical insecticides. Though, insecticides offer better control of in2sect pests there are several problems associated with the use of synthetic chemicals. The growing knowledge of environmental safety and ecosystem conservation techniques urge to change to strategy for insect pest management to switch to non-chemical approaches. Botanicals and animal based products are excellent alternate strategy for the efficient pest management without disturbing ecological balance.

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