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Impact of Inorganic and Bio-Fertilizers and their Combinations on the Incidence of Major Insect Pests of Sunflower (*Helianthus annuus* L.)

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Abstract A field investigation was conducted during the *kharif,* 2012-13 to know the effect of inorganic sources of NPK (i.e., urea, single super phosphate and murate of potash) applied singly as well as in combinations with microbial inoculants (*Azotobacter croococcum, Bacillus subtilis, Trichoderma viridae)* and phosphate solubilising bacteria (PSB-*Bacillus megatarium*) and *(Streptomyces griseus)* on the incidence of major insect pests of sunflower. The study revealed significant differences between the treatments with respect to population of leafhopper *(Amrasca biguttula biguttula)* (Ishida), semilooper (*Thysanoplusia orichalcea* Fab.) and total defoliators at 45 days after sowing (DAS) and significant differences between the treatment with respect to population of capitulum borer, *Helicoverpa armigera* at 60 DAS. Significantly lowest semilooper population (1.73/plant) was recorded in T_9 (75% NP + 100% K + soil application (SA) of *A. croococcum* + phosphate solubilising bacteria (PSB- *Bacillus megatarium)* + *B. subtilis* + foliar spray (FS) with *S. griseus*). Seed yield was significantly highest in T_1 (100% NPK) i.e., 3.65 kg/plot, followed by T_9 (3.61 kg/ plot). It could be inferred that T_9 (75% NP + 100% K + SA of *A. croococcum* + phosphate solubilising bacteria (PSB- *Bacillus megatarium*) + *B. subtilis* + FS with *T. viridae*) was the most superior treatment.

Keywords Bio-fertilizers, Sunflower, *Helianthus annuus* L.)

Introduction

Sunflower being one of the major oilseed crops of Karnataka State is often grown on poor and marginal soils. It has a relatively high concentration of linoleic acid and composition of fatty acids is a main determinant of the oil quality in sunflower. In the recent past, one of the major reasons attributed to the sharp decline in the cultivated area of sunflower, both in India as well as in Karnataka, is the widespread incidence of insect pests. The crop is frequently tormented by a wide array of insect pests which cause considerable yield losses, of which defoliators (*Thysanoplusia orichalcea* Fab. and *Spodoptera litura* Fab.); capitulum borer, *Helicoverpa armigera* Hub. and sucking pests, (*Amrasca biguttula biguttula* (Ishida), *Bemisia tabaci* Genn. and *Thrips palmi* Karni.) are the major ones.

Modern agriculture is dominated by the use of inorganic fertilizers to satisfy the heavy nutrient de-

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mand of crop plants. But, necessity to switch over to organic cultivation has been considered as an indispensable. In recent years, bio-fertilizers and soil microbes play an important role in many critical ecosystem processes, including nutrient cycling and homeostasis, decomposition of organic matter, as well as promoting plant health and growth as bio-fertilization [1]. Certain strains are referred to as plant growth-promoting rhizobacteria (PGPR), which can be used as inoculant biofertilizers [2]. These bacteria include phosphate solubalising bacteria (PSB) and species of *Azotobacter* and *Azospirillum,* both of which provide direct and indirect effects on plant growth and pest resistance [2, 3]. With this background the present study was conducted by including soil and foliar applications of inorganic fertilizers, microbial inoculants and their combinations in order to know their impact on the incidence of major insect pests of sunflower.

Materials and Methods

Based on preliminary laboratory and pot-culture experiments with bio-fertilizers, four types of bio-fertilizers viz., *Azotobacter croococcum, Bacillus subtilis* and *Trichoderma viridae* and *Bacillus megatarium* were found to give encouraging results with respect to the growth and yield parameters of sunflower. In order to know their impact on insect pest incidence in sunflower, a field investigation was conducted during the *kharif* season of 2012-13 at Zonal Agricultural Research, Station UAS, GKVK, Bengaluru. The triol was laid out in randomized complete block design (RCBD) by sowing the sunflower cultivar KBSH-44 on 24th August, 2012; it composed of nine treatments and three replication, with a plot size of 4.2m × 3.0 m. The NPK was applied through inorganic sources (urea, SSP and MOP) singly as well as in different combinations with microbial inoculants viz., *Azotobacter croococcum, Bacillus subtilis* and *Trichoderma viridae* and PSB-*Bacillus megatarium* as soil application. Biofertilizers were applied to soil 7 days after sowing at the rate of 10 kg/ha. Observations were recorded at 45 and 60 days after sowing (DAS) on the incidence of leaf hopper, whitefly, semilooper, total defoliatiors and total number of predators in each treatment. The details of the treatments included in this investigation are as furnished in Table 1.

Table 1. Bio-rational treatments evaluated against *H. armigera.* NB : N-Nitrogen, P - Phosphorus, K–Potassium, PSB–Phosphate solubilising bacteria *(Bacillus megatarium),* T.V–*Trichoderma viridae*, B.S– *Bacillus subtilis, Azotobacter croococcum.*

Sl. No.	Treat-ments	Treatment details
1	T_1	100% NPK (RDF)
2	T_2	75% NP+100% K
3	T_3	50% NP+100% K
4	T_4	100% NPK+*A.croococcum*+PSB+T.V+folar spray of T.V
5	T_5	75% NP+100% K+*A. croococcum*+PSB+T.V +foliar spray of T. V
6	T_6	50% NP+100% K + *A.croococcum*+PSB+T.V + foliar spray of T. V
7	T_7	100$ NPK+ *A. croococcum*+ PSC+B. S+ foliar spray of T. V
8	T_8	75% NP+100% K+*A. croococcum*+PSB+B. S +foliar spray of T.V
9	T_9	50% NP+100% K+*A.croococcum*+PSB+B.S +foliar spray of T. V
10	T_{10}	Untreated check (UTC)

Preparation of bio-control agents for spraying

Fungal bio-control agents were first grown on potato dextrose agar (PDA) plates and then 5 mm mycelial disc of bio-control agent was transferred to sterile potato dextrose broth aseptically and incubated at 28 ± 1^{0}C on a rotary shaker at 150 rpm for 5 days. Then shaking was stopped and allowed to form a mat and after 7 days the bio-control agent culture was homogenized thoroughly to break themycelial bits and the culture was filtered aseptically using. Whatman No. 44 filter paper and the filtrate containing cell suspension was used for spraying at the rate of 0.5% concentration.

Bacterial bio-control agents first grown on the respective medium and then transferred to sterile respective broth aseptically and incubated at 28 ±1^{0}C on a rotary shaker at 150 rpm for 5 days. Then shaking was stopped and allowed till good turbidity was formed, the biocontrol agent culture was homogenized thoroughly and filtered aseptically using Whatman No. 44 filter paper and the filtrate containing cell suspension was used for spraying at the rate of 0.5 % concentration. The experimental area was ploughed

Table 2. Effect of inorganic fertilizers, microbial inoculants and their combination on insect pests of sunflower. N-Nitrogen, P- Phosphorus, K - Potassium, PSB -Phosphate solubalising bacteria *(Bacillus megatarium),* T. V – *Trichoderma viridae,* B. S,– *Bacillus subtilis, Azotobacter croococcum.* Means in the column followed by same alphabet do not differ significantly by DMRT (0.05). Figures in parentheses are √x+0.5 transformed values.

Treatments details	No. per plant Leaf hopper 45 DAS	Leaf hopper 60 DAS	Whiteflies 45 DAS
T_1 - 100% NPK (RDF)	1.067 (1.23)^{abcd}	0.067 (0.75)	0.333 (0.91)
T_2 - 75% NP+100% K	1.400 (1.37)^{cd}	0.467 (0.98)	0.600 (1.04)
T_3 - 50% NP + 100% K	0.800 (1.13)^{abc}	0.267 (0.86)	0.267 (0.86)
T_4 - 100% NPK + *A. croococcum* + PSB + T. V + foliar spray of T.V	1.467 (1.40)^{d}	0.200 (0.82)	0.467 (0.98)
T_5 - 75% NP + 100% K + *A.croococcum* + PSB + T. V + foliar spray of T. V.	0.533 (1.01)^{a}	0.000 (0.70)	0.267 (0.86)
T_6 - 50% NP + 100% K + *A. croococcum* + PSB + T. V+ foliar spray of T.V.	1.267 (1.32)^{cd}	0.333 (0.91)	0.333 (0.89)
T_7 - 100% NPK + *A.croococcum* + PSB + B. S + foliar spray of T. V	0.600 (1.03)^{ab}	0.067 (0.75)	0.400 (0.93)
T_8 - 75% NP + 100% K + *A. croococcum* + PSB + B. S + foliar spray	0.733 (1.17)^{abcd}	0.133 (0.78)	0.267 (0.86)
T_9 - 50% NP + 100% K + *A. croococcum* + PSB + B. S + foliar spray of T. V	0.733 (1.11) ^{abc}	0.000 (0.70)	0.800 (1.13)
T_{10} - Untreated control	1.200 (1.29)^{bcd}	0.133 (0.78)	0.467 (0.98)
F-test	*	NS	NS
SEm±	0.09	0.06	0.07
CD at *p*=0.005	0.26	0.18	0.22
CV (%)	12.45	13.02	13.44

Table 2. Continued

Treatments details	No. per plant Semilooper 45 DAS	Semilooper 60 DAS	Total defoliators 45 DAS	*H. armigera* 60 DAS
T_1 - 100% NPK (RDF)	2.667 (1.77)*	0.333 (0.90)	2.733 (1.79)^{bd}	1.533 (1.39)^{ab}
T_2 - 75% NP+100% K	3.933 (2.09)^{b}	0.133 (0.79)	3.933 (2.07)^{c}	1.467 (1.39)^{ab}
T_3 - 50 NP+100% K	2.200 (1.64)^{a}	0.267 (0.87)	2.200 (1.64)^{ab}	1.200 (1.27)^{a}
T_4 - 100% NPK + *A. croococcum* + PSB+T.V+foliar spray of T. V	1.867 (1.52)^{a}	0.200 (0.83)	1.200 (1.35)^{a}	1.533 (1.41)^{abc}
T_5 - 75% NP+100% K + *A. croococcum*+PSB+T. V+foliar spray of T. V	1.867 (1.52)^{a}	0.067 (0.75)	1.867 (1.52)^{ab}	1.400 (1.36)^{ab}
T_6 - 50% NP+100% K + *A. croococcum*+PSB+T. V+foliar spray of T. V	2.400 (1.69)^{a}	0.267 (0.87)	2.533 (1.73)^{b}	1.533 (1.42)^{bc}
T_7 - 100% NPK+*A. croococcum*+PSB+B. S+foliar spray of T. V	2.733 (1.79)^{ab}	0.133 (0.78)	2.800 (1.80)^{bc}	1.533 (1.41)^{bc}
T_8 - 75% NP+100% K+*A. croococcum*+PSB+B.S+foliar spray of T.V	1.867 (1.52)^{a}	0.067 (0.75)	2.000 (1.56)^{ab}	2.000 (1.57)^{c}
T_9 - 50% NP+100% K + *A.croococcum*+PSB+B. S+foliar spray of T.V	1.733 (1.48)^{a}	0.067 (0.75)	1.733 (1.48)^{ab}	1.333 (1.34)^{b}
T_{10}- Untreated control	2.167 (1.60)^{a}	0.200 (0.83)	4.033 (2.12)^{c}	3.733 (2.04)^{d}

Table 2. Continued.

Treatments details	No. per plant Semilooper		Total defoliators	*H. armigera*
	45 DAS	60 DAS	45 DAS	60 DAS
F-test	*	NS	*	*
SEm ±	0.11	0.06	0.13	0.05
CD at p = 0.005	0.32	0.23	0.40	0.16
CV (%)	11.17	12.03	13.62	10.89

twice and harrowed to bring the soil to a fine tilth. The FYM was applied at the rate of 7.5 t ha^{-1} 15 days prior to sowing of seeds.

The recommended dose of chemical fertilizers viz., 62.5 kg nitrogen, 75 kg phosphorus and 62.5 kg potassium per hectare was applied in the form of urea, single super phosphate and muriate of potash respectively as per treatments requirement. Fifty per cent of nitrogen and full dose of phosphorus and potash were applied as basal dose and remaining 50% nitrogen was top dressed at 35^{th} days after sowing. Two seeds per hill were hand dibbled at 4 cm depth at 30 cm apart in 60 cm spaced furrows. Protective irrigations were given to the crop depending upon the rainfall during the growth period. Foliar sprays of bioagents were given at 45 and 60 days after sowing.The capitulum of five randomly selected and labelled plants were harvested and threshed separately. After thorough cleaning seeds were sun dried and the weight was recorded from each plot. Further, the mean seed yield was computed and expressed in grams per plot and also in kilograms per hectare.

Results and Discussion

The results of the investigation on effect of inorganic sources of NPK (i.e., urea, SSP and MOP) applied singly as well as in combinations with microbial inoculants *(Azotobacter croococcum, Bacillus subtilis, Trichoderma viridae)* and PSB *(Bacillus megatarium and Streptomyces griseus)* on the incidence of major isect pests of sunflower that were evaluated *kharif*-2012-13 are furnished in the subsequent paragraphs and discussed in the light of earlier reports.

There was no significant difference with respect to population of whitefly at 45 days after sowing (DAS), leaf hoppers and semilooper (at 60 DAS) and total predators (at 60 DAS) (Table 2 and 3). However, these results are not in agreement with the findings of Nelson et al. [4] who reported the different sources of nutrient have significant effect in reducing the whitetly population and the treatments containing higher amount of FYM or vermicompost and biofertilizer showed better result over sole inorganic fertilizers and they are superior in minimizing the whitefly population as compared to farm yard manure.

Moreover, significant differences were observed between the treatments, with respect to the population of leathopper, semilooper and total defoliators at 45 DAS. Likewise, a significant difference existed between the treatments with respect to population of *H. armigera* at 60 DAS. The treatment T_5 (75% NP+100% K+*Azotobacter croococcum* + PSB + *Trichoderma viride* soil applications + foliar spray of *T. viride*) recorded significantly lowest population of leafhopper (0.53/plant), followed by T_7 (100% NPK + *A. croococcum* + PSB 100 % K) also recorded significantly lower population of leafhopper (0.733 and 0.800/ plant) respectively, at 45 DAS which were on par with each other (Table 2). These results were in accordance with the findings of Ravi et al. [5] recorded application of farm yard manure @ 12.5 t ha^{-1} alone and in combination with biofertilizers (2 kg ha^{-1}), vermicompost (250 kg ha^{-1}) + biofertilizers (2 kg ha^{-1}) and neem cake (250 kg ha^{-1}) reduced the incidence of leafhopper and whitefly against the application of NPK straight synthetic fertilizers. The organic amendments comparatively increase the total phenols in the plant and also the activity of enzymes viz., polyphenol oxidase and peroxidase, which might be responsible for the reduced pest incidence. The results provided an insight into the manipulation of host plant ecology

Table 3. Effect of inorganic fertilizers, microbial inoculants and their combinations on predatory fauna seed yield in sunflower. N-Nitrogen, P-Phosphorus, K- Potassium, PSB-Phosphate solubalising bacteria *(Bacillus megatarium)*, T. V–*Trichoderma viridae,* B.S.– *Bacillus subtilis, Azotobacter chrococcum*. Means in the column followed by same alphabet do not differ significantly by DMRT (0.05). Figures in parentheses are$\sqrt{x + 0.5}$ transformed value.

Treatments details	No. per plant: Spiders	Total predators 45 DAS	Total predators 60 DAS	Seed yield (Kg/plot)	Seed yield (Kg/ha)
T_1 - 100% NPK	0.00 (0.70)	0.06 (0.75)[a]	4.26 (2.17)	3.65 (2.03)[a]	3660.00 (60.42)[a]
T_2 - 75% NP + 100% K	0.267 (0.86)	0.40 (0.94)[bc]	5.06 (2.30)	3.58 (2.02)[a]	3580.00 (59.84)[c]
T_3 - 50% NP + 100% K	0.13 (0.79)[ad]	0.13 (0.79)	2.53 (1.73)	3.14 (1.91)[ace]	3140.00 (56.04)[g]
T_4 - 100 % NPK + *A. croococcum*+PSB+T. V+foliar spray of T. V	0.20 (0.83)	0.20 (0.83)[ab]	4.06 (2.13)	3.22 (1.93)[bed]	3220.00 (56.75)[f]
T_5 - 75% NP + 100% K+*A. croococcum*+PSB+T. V+foliar spray of T. V	0.13 (0.78)	0.13 (0.78)[ab]	4.26 (2.18)	3.31 (1.95)[bed]	3310.00 (57.54)[e]
T_6 - 50% NP+100% K+ *A. croococcum* +PSB+T. V+foliar spray of T. V	0.00 (0.70)	0.06 (0.75)[a]	4.13 (2.07)	2.92 (1.85)[de]	2920.00 (54.61)[b]
T_7 - 100% NPK+ *A. croococcum* + PSB B.S + foliar spray of T.V.	0.06 (0.75)	0.06 (0.75)[a]	3.86 (2.08)	3.59 (2.02)[b]	3590.00 (59.92)[e]
T_8 - 75% NP+100% K + *A. croococcum* +PSB+B.S+foliar spray of T.V	0.20 (0.83)	0.53 (1.01)[e]	5.53 (2.45)	3.41 91.98)[bc]	3410.00 (58.40)[d]
T_9 - 50% NP+100% K+*A. croococcum* + PSB+B.S+foliar spray of T.V	0.13 (0.79)	0.13 (0.79)[ab]	5.20 (2.36)	3.61 (2.03)[a]	3610.00 (60.09)[b]
T_{10} - Untreated control	1.10 (1.55)	2.06 (1.59)[d]	5.133 (2.33)	2.81 (1.82)[e]	2810.00 (53.01)[l]
F-test	NS	*	NS	*	*
SEm±	0.05	0.06	0.18	0.03	27.50
CD at p=0.005	0.14	0.17	0.54	0.10	90.50
CV (%)	10.89	10.97	14.59	15.85	13.95

through host plant nutrition to accord resitance in plants against the insect pests.

With regards to semilooper counts, significantly lowest population (1.73/plant) was recorded in T_9 (50% NP + 100% K + *A. croococcium* + PSB + *Bacillus subtilis* soil applications + foliar spray with *T. viride*) and remaining treatment like T_3, T_4, T_5, T_6 and T_8 have recorded significantly lower population of semilooper (2.200, 1.867, 1.867, 2.400 and 1.867/plant) respectively, which were on par with each other at 45 DAS. Similarly, in case of total defoliator counts all the treatments were significantly superior over untreated control (4.033/plant) at 45 DAS by recording the lowest defoliator population, Likewise, the total defoliator count was significantly lowest (1.20/plant) in T_4 (100% NPK + *A. croococcum* + PSB + *T. viride soil* applications + foliar spray with *T. viride*), followed by T_9, T_8, T_3 and T_5 (1.73, 2.000, 2.200 and 1.867/plant), respectively, which were on par with each other. Similarly, with respect to *H. armigera* population, T_3 (50% NP + 100% K) recorded significantly lowest larval counts (1.20/plant), followed by T_9 (1.33/plant) (Table 2). Significant differences were observed in relation total predator population at 45 DAS, T_8 (0.53/plant) recorded the highest predator counts no treatments exhibited significant difference with respect to mean number of spiders (Table 3). Where in the plots receiving only NPK, vermicompost @ 3.75 ton per ha and neem cake @ 770 kg per ha recorded higher population of coccinellids in cotton ecosystem.

In the present study, the seed yield was highest in T_1 (100% NPK) i.e., 3.65 kg/plot (3650 kg/ha), followed by T_9 (50% NP + 100% K + *A. croococcum* + PSB + *Bacillus subtilis* soil applications + foliar spray with *T. viride*) (3.61 kg/plot i.e., 3610 kg/ha) (Table 3).

These findings are in agreement with the findings of Akbari et al. [6] who reported that the biofertilizers improved crop productivity and quality of sunflower seeds. Maximum grain and biological yields of 2,823.3 kg ha^{-1} and 9,917.9 kg ha^{-1} were obtained with the NPK combination with bio-fertilizer treatment, respectively. Application of biofertilizer resulted in a significant increase in seed oil content (47.7%) over that of the control. The seed oil yield was also significantly increased (1,141.5 kg oil ha^{-1}) as compared with the untreated control. The present results throw light on the fact that the treatment T_9 (50% NP+100% K + *A. croococcum*+ PSB +*Bacillus subtilis* soil applications + foliar spray with *T. viride*) was significantly superior by virtue of recording the lowest population of most of the target pests, besides higher seed yield (3,610 kg/ha). Further studies to explore the feasibility of utilising the combination of microbial inoculants (*Azotobacter croococcum, Bacillus subtilis, Trichoderma viridae* and phosphate solubalishing bacteria *(Bacillus megatarium)* and *Streptomyces griseus)* with inorganic fertilizers to effectively suppress the incidence of major insect pests of sunflower is the need of the hour.

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