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Effect of nutrient management on the incidence of major insect and disease pests in rice-mustard cropping system

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Abstract
Field experiment was carried out for a couple of years (*kharif* 2014 to *rabi* 2016) at Research Farm, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur to evaluate the role of some nutritional packages (Humic acid and Micronutrients) in the oscillation of major insect and disease pests in rice-mustard cropping system. The, lowest yellow stem borer infestation of rice in the form of mean percent dead heart and white head were encountered in RDF ($N_{80}P_{40}K_{40}$) + $ZnSO_4$ 20 kg ha^{-1} + Borax 10 kg ha^{-1} + Humic acid 7.5 l ha^{-1} followed by RDF ($N_{80}P_{40}K_{40}$) + Humic acid @7.5 l ha^{-1} (15 ml plot^{-1}) with compost (10 t ha^{-1}) + Humic acid Foliar Spray one time @ 1 ml litre^{-1} (7.38% and 10.30%) respectively. Similarly, the same treatment also registered lowest number of brown plant hopper population (5.12 per 3 hills), leaf blast and neck blast T_6 (4.63% and 7.31%). Yield potentiality of rice was found to be the highest in same nutritional treatment as compared to control (without humic acid or micronutrient). Similar trend of effectiveness were also encountered in case of mustard where, mean number of aphid population as compared to untreated control plots. *Alternaria* blight infection was also found very low in case of $ZnSO_4$ 20 kg ha^{-1} + Borax 10 kg ha^{-1} + Humic acid 7.5 l ha^{-1} along with RD of NPK. Same nutritional package was also found to be significantly superior in the seed (1.23 t ha^{-1}) yield of mustard.

Keywords: Humic acid, micronutrients, insect pests, fungal disease, rice-mustard cropping system, yield

1. Introduction

Rice-mustard cropping system is one of the most popular practices in the farming community during *kharif* followed by *rabi* season under new alluvial zone of West Bengal. Late onset of monsoon for last few years resulted late transplantation of *kharif* rice which automatically delayed the sowing of succeeding mustard crop on the same field. Micronutrients have received a greater attention for crop production now-a-days, because of its wide-spread deficiency due to intensive cropping system and insufficient use of organic manure compared to high analyzed synthetic fertilizers in crop production. Continuous use of these high analyzed NPK fertilizers accelerated the depletion of soil organic matter and impairs physical and chemical properties of soil in addition to causing micronutrient deficiencies (Saha *et al*., 2013) [1]. In present day agriculture use of liquid organic manures is getting farmers' attraction as because better yield of crops with organic materials could be achieved equally as compared to that with the application of NPK fertilizers. Humic acids (HAs) are water soluble organic acids, comprising a large family of organic compounds with identical characteristics that are products of organic matter transformations by soil microorganisms. Humic substances are readily found in soils and influence plant growth both directly and indirectly (Cimrin and Yilmaz, 2005) [2] because they can improve soil properties, microbial growth, organic matter mineralization and solubilisation and availability of micro and macro elements (Sharif *et al*., 2002) [3]. Moreover, balanced fertilization is highly essential for better growth and disease - pest resistance of crop. Late transplantation of rice automatically delayed the sowing of mustard on the same field and this particular cropping system has increased the susceptibility of crops with the irregular appearance of different chewing and sucking pests along with fungal diseases, leads to economic yield loss (Lastuvka, 2009) [4]. Yellow stem borer (*Scirpophaga incertulas* Walker), brown plant hopper (*Nilaparvata lugens* Stal) and blast disease (caused by *Magnaporthe grisea*) of rice, mustard aphid (*Lipaphis erysimi* K) and *Alternaria* blight of mustard have been appearing drastically for last few years under the umbrella of climate change. Keeping these in backdrop, the present study was undertaken to evaluate different nutritional practices in respect of micro-nutrients (Zn and B) and humic acid against major insect and disease pests of rice followed by mustard *vis.-a-vis*. their yield potentiality in rice-mustard cropping system.

Materials and methods

Experiment was carried at Research Farm, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal in Randomized Complete Block Desigh with nine treatments *viz*. T_1: RDF ($N_{80}P_{40}K_{40}$) + Humic acid @15 l ha^{-1} (30 ml plot^{-1}) with compost (10 t ha^{-1}); T_2: $^1/_2$ RDF (($N_{40}P_{20}K_{20}$) + Humic acid @7.5 l ha^{-1} (15 ml plot^{-1}) with compost (10 t ha^{-1}); T_3: $^3/_4$ RDF ($N_{60}P_{30}K_{30}$) + Humic acid @7.5 l ha^{-1} (15 ml plot^{-1}) with compost (10 t ha^{-1}); T_4: RDF ($N_{80}P_{40}K_{40}$) + Humic acid @7.5 l ha^{-1} (15 ml plot^{-1}) with compost (10 t ha^{-1}); T_5: RDF ($N_{80}P_{40}K_{40}$) + $ZnSO_4$ 20 kg ha^{-1} + Borax 10 kg ha^{-1}; T_6: RDF ($N_{80}P_{40}K_{40}$) + $ZnSO_4$ 20 kg ha^{-1} + Borax 10 kg ha^{-1} + Humic acid @7.5 l ha^{-1} (15 ml plot^{-1}) with compost (10 t ha^{-1}); T_7: RDF ($N_{80}P_{40}K_{40}$) + Humic acid Foliar Spray @ 1 ml litre^{-1}; T_8: RDF ($N_{80}P_{40}K_{40}$) + Humic acid @7.5 l ha^{-1} (15 ml plot^{-1}) with compost (10 t ha^{-1}) + Humic acid Foliar Spray one time @ 1 ml litre^{-1}; T_9: RDF ($N_{80}P_{40}K_{40}$) + Compost [Control] and each of which was replicated thrice for a consecutive crop seasons from *kharif*, 2014 to *rabi*, 2016. In the rice-mustard cropping system, rice (cv. *Shatabdi*) was cultivated during the *kharif* season in 5 × 4 m^2 plot with 20 cm × 15 cm spacing. The age of rice seedlings used were 21 days old. Mustard (cv. B-9) was sown in *rabi* season after harvesting of rice in the same plots. Typical cultivation practices for both of the crops were followed as per the recommended agronomic practices. Insect pests and rice blast incidences were recorded at weekly interval after the crop establishment. For yellow stem borer, 10 hills were selected at random from each replication and number of dead hearts followed by white ear heads were counted at weekly interval and converted into percent infestation. Leaves from top, middle and bottom canopy of the ten randomly selected and tagged hills were observed to record the population establishment of brown plant hopper at the same interval. In case of mustard, records were taken by visually count the number of aphids (nymphs and adults) with a 10x magnifying lens from 10 cm portion of the terminal shoot of ten randomly selected and tagged plants from each replication (Kumar *et al*., 2007) [5]. For recording the incidence of blast disease in rice, five hills per plot were randomly selected. Disease scoring was done based on 0 – 9 scale (scale: 0= no incidence, 1= less than 1% leaf area affected, 3= 1 – 5% Leaf area affected, 5= 6 – 25% Leaf area affected, 7= 26 – 50% Leaf area affected and 9= 51 – 100% Leaf area affected) as described by Mayee and Datar (1986) [6]. Per cent Disease Index (PDI) was calculated using the following formula:

$$\text{PDI} = \frac{\text{Sum of all numerical ratings}}{\text{Total plants (leaves) observed} \times \text{Maximum disease rating}} \times 100$$

Infection of *Alternaria* blight in mustard was assessed by recording the data on percent leaf area diseased and number of spots per siliqua for 3 times during the entire crop growth stage (Khatun *et al*., 2011) [7].

Statistical assessment was performed by the analysis of variance (ANOVA) after making necessary transformation wherever required, for randomized block design (RBD) based on the guidelines given by Gomez and Gomez (1984) [8]. For comparison of 'F' values and computation of critical difference (CD) at 5% level of significance, Fisher and Yates' table were consulted. The Excel software (version 2007, Microsoft Inc., WA, USA), were used to draw the figures.

Results and discussion

Yellow stem borer of rice

Incidence of yellow stem borer under different treatments imposed on rice during two consecutive years has been shown in Fig. 1 where it is clear that highest mean percent infestation was encountered in T_9. In the first season lowest mean percent dead heart was recorded in T_6 (5.75%) followed by T_8 (7.38%) and T_5 (9.87%) found statistically at par. Likewise, T_6 registered 8.9% mean white head which was at par with T_8 (10.3%) but, significant lower infestations were encountered in T_5 (12.2%) and T_4 (12.5%) as compared to T_7 (16.8%), T_1 (17.6%) and T_3 (18.2%), respectively. A similar trend of effectiveness was also observed during the second season where, T_6 exhibited lowest mean percent dead heart (4.18%) followed by T_8 and T_5, respectively. However, lowest mean percent white head was recorded in T_6 (5.8%) followed by T_8 (7.3%) but, T_5 registered 11.89% and found statistically at par with T_4 (11.6%) and T_7 (13.6%) respectively. Perusal of available literatures revealed that humic acid in conjugation with other micronutrients and bio-pesticides proved to be very much effective in sustainable management of Lepidopteran fruit borer of chilli, supports the present investigation (Patil *et al*., 2014) [9].

Brown plant hopper of rice

Population of brown plant hopper on rice was observed from 3 WAT (weeks after transplanting) to 13 WAT during two consecutive years in different treatment schedules which is depicted in Table 1. Both the nymph and adult populations started to build up gradually from 4 WAT and attained peak at 11 WAT irrespective of all the treatments imposed. At 6 WAT, brown plant hopper population was more or less similar in all the treatments (5.95-9.60 per 3 hills) whereas, T_6 (7.10 per 3 hills) and T_8 (7.80 per 3 hills) registered lowest mean population as compared to T_9 (17.85 per 3 hills) at 9 WAT. At 11 WAT, T_6 and T_8 registered 9.35 and 10.50 numbers of hopper population per 3 hills found to be significantly lower than T_5 (13.25 per 3 hills), T_7 (14.56 per 3 hills), T_1 (15.18 per 3 hills) and control plots T_9 (25.90 per 3 hills). Afterwards, the populations of brown plant hoppers started to decline and overall lowest mean population was encountered in T_6 (5.12 per 3 hills) found statistically at par with T_8 (6.18 per 3 hills) followed by T_4 and T_5 respectively. Potassium-humate based suspension humic acid has been recognized as a plant growth stimulant or soil conditioner for enhancing the natural resistance of plants against different pests (Scheuerell and Mahaffee, 2006) [10] which fully supports the present investigation.

Mustard aphid

Table 2 revealed that mustard aphid population varied significantly in different treatment schedules from 7 WAS till 12 WAS where population started to build up from 6 WAS during both the years. Mean population was found to be significantly higher at 9 WAS (10.25-25.32 per 10 cm shoot) irrespective of all the treatments where, T_6 and T_8 were statistically at par to each other. Incidence of mustard aphid was visible under the field condition which has gradually increased till 11 WAS and attained their peak population. Significantly higher population was encountered in T_1 (44.20

per 10 cm shoot), T_3 (42.85 per 10 cm shoot), T_7 (41.82 per 10 cm shoot) including untreated control as compared to T_6 (20.15 per 10 cm shoot) and T_8 (19.86 per 10 cm shoot), found statistically at par. Interestingly it was observed that nutritional manipulation like T_6 and T_8 effectively reduced the mustard aphid population under the field condition and this sowing time of mustard by following the *kharif* rice able to avoid the yield loss caused by aphid by desynchronizing the suitable crop phenology of aphid attack and the time of their peak incidence. Presence of significant amount of humic acid in vermicompost was proved to be a major factor in the reduction of aphid population builds up on crop plants corroborates the present findings (Yassen *et al*., 2015) [11].

Blast of rice and *Alternaria* blight of mustard

Mean percent incidence of blast disease on rice as well as *Alternaria* leaf blight on mustard crop against different treatments during two consecutive experimental years is shown in Fig. 2 (A). T_6 registered lowest mean percent leaf blast (4.63%) and found statistically at par with T_8 (5.05%), T_4 (5.38%) and T_5 (5.46%) respectively. Besides, mean percent neck blast incidence was higher in T_9 (14.22%) as compared to T_6 (7.31%) and T_8 (7.88%) respectively where, T_5 (8.06%) and T_4 (8.12%) found to be statistically at par to each other. Thangavelu and Ramabadran (1992) [12] documented that humic acid itself has a significant contribution in successful reduction of rice blast infection which is in parity with the present findings. Similarly, in case of *Alternaria* leaf blight of mustard, lowest mean percent leaf area diseased was encountered in T_6 (10.37%) followed by T_5 (13.29%) and T_8 (14.18%) respectively amongst all other treatments. Moreover, mean number of fungal spots per siliqua was also found to be significantly lower in T_6 (6.12%) and T_8 (8.96%) while, T_3 and T_2 registered 15.76% and 15.87% respectively after T_9 (Fig. 2B). Successful control of late blight disease of tomato under field condition by using humic acid has been elaborated by El-Mohamedy and Abd-El-latif (2015) [13] that corroborates the findings of the present authors.

Seed and biological yield of rice and mustard

Yield potentiality of different treatments in rice grain, straw, mustard seed and stover have been shown in Table 3. From the agronomic point of view it was very clear that T_6 (4.84 t ha^{-1}) followed by T_8 (4.69 t ha^{-1}) exhibited highest rice grain yield and proved superior over T_5 (4.55 t ha^{-1}) and T_1 (4.36 t ha^{-1}), respectively. Biological yield of rice in the form of straw was also found to be significantly higher in T_6 (6.54 t ha^{-1}) and was statistically at par with T_8 (6.28 t ha^{-1}) followed by T_5 (5.41 t ha^{-1}), T_3 (5.38 t ha^{-1}) and T_4 (5.28 t ha^{-1}), respectively. Application of humic acid proved to be very effective in increasing the seed yield of a graminacious crop like wheat (Ulukan, 2008) [14] supports the present findings. Likewise, highest mean seed yield of mustard crop was encountered in T_6 (1.23 t ha^{-1}) followed by T_8 (1.20 t ha^{-1}) while, T_4 and T_7 registered equal amount of yield to the tune of 1.11 t ha^{-1} and found to be statistically at par. Mustard stover yield was also significantly highest in T_6 (2.66 t ha^{-1}) and proved to be superior amongst all other treatments.

Table 1: Incidence of brown plant hopper *Nilaparvata lugens* against different treatments on *kharif* rice during 2014 and 2015 (pooled data of two year)

Treatment	Mean incidence at different weeks after transplanting (Number of nymphs and adults/ 3 hills)											
	3 WAT	4 WAT	5 WAT	6 WAT	7 WAT	8 WAT	9 WAT	10 WAT	11 WAT	12 WAT	13 WAT	Overall mean
T_1	1.70	2.53	6.18	8.20	10.25	11.85	13.25	12.25	15.18	14.75	9.60	9.61
T_2	1.15	1.80	5.10	8.00	8.55	13.54	15.90	17.50	20.20	15.19	11.10	10.73
T_3	1.10	1.65	4.95	7.85	8.20	12.26	15.86	14.10	18.25	15.65	9.00	9.90
T_4	1.20	1.75	4.00	7.50	7.15	10.25	8.00	9.25	16.10	12.35	9.00	7.87
T_5	1.00	1.38	5.10	6.98	7.60	10.10	8.05	11.20	13.25	14.10	9.17	7.99
T_6	0.50	1.00	4.15	6.30	3.54	5.60	7.10	7.95	9.35	7.56	3.29	5.12
T_7	1.75	2.85	6.29	8.50	9.55	12.50	10.65	13.00	14.56	9.54	9.05	8.93
T_8	0.65	1.15	4.70	5.95	5.65	8.25	7.80	9.15	10.50	8.40	5.75	6.18
T_9	1.95	3.60	6.80	8.25	9.50	15.28	17.85	22.35	25.90	23.57	19.90	14.09
SEm±	NS	NS	0.11	NS	0.52	0.23	0.71	0.44	0.19	0.26	0.87	0.54
CD (p=0.05)	NS	NS	0.56	NS	1.98	1.10	1.39	0.96	0.82	1.06	1.77	1.26

WAT = Weeks after transplanting

Table 2: Incidence of mustard aphid *Lipaphis erysimi* against different treatments on mustard during 2015 and 2016 (pooled data of two year)

Treatments	Mean incidence at different weeks after sowing (Number of nymphs and adults/ 10 cm shoot)											
	1 WAS	2 WAS	3 WAS	4 WAS	5 WAS	6 WAS	7 WAS	8 WAS	9 WAS	10 WAS	11 WAS	12 WAS	Overall mean
T_1	0.00	0.00	0.00	0.00	0.00	2.00	4.20	7.80	20.55	39.52	44.20	20.35	11.55
T_2	0.00	0.00	0.00	0.00	0.00	3.00	4.85	6.38	18.25	44.96	40.38	15.87	11.14
T_3	0.00	0.00	0.00	0.00	0.00	0.50	2.85	5.70	15.20	35.68	42.85	21.32	10.34
T_4	0.00	0.00	0.00	0.00	0.00	1.50	3.90	6.00	17.85	40.62	38.59	19.87	10.69
T_5	0.00	0.00	0.00	0.00	0.00	0.00	5.32	8.29	15.55	48.39	40.10	19.00	11.39
T_6	0.00	0.00	0.00	0.00	0.00	0.00	1.58	4.20	10.25	18.44	20.15	9.56	5.35
T_7	0.00	0.00	0.00	0.00	0.00	2.50	5.68	6.32	17.55	35.40	41.82	19.32	10.72
T_8	0.00	0.00	0.00	0.00	0.00	0.00	0.75	6.82	10.49	21.53	19.86	12.66	6.01
T_9	0.00	0.00	0.00	0.00	0.00	2.54	8.39	10.59	21.28	37.68	45.81	25.46	12.65
SEm±	-	-	-	-	-	NS	0.04	0.36	0.58	0.64	0.42	0.61	0.09
CD (p=0.05)	-	-	-	-	-	NS	1.08	1.22	1.79	2.45	1.88	2.32	0.68

WAS = Weeks after sowing

Table 3: Yield of rice and mustard as influenced by different nutrient management treatments during *kharif* 2014 to *rabi* 2016 in rice-mustard cropping system (pooled data of two year)

Treatment	Rice Yield (t/ha)		Mustard Yield (t/ha)	
	Grain	Straw	Seed	Stover
T1	4.36	4.99	1.04	2.03
T2	4.05	4.52	0.93	1.59
T3	4.15	5.38	0.84	1.53
T4	4.18	5.28	1.11	2.15
T5	4.55	5.41	1.09	2.16
T6	4.84	6.54	1.23	2.66
T7	4.31	4.95	1.11	1.97
T8	4.69	6.28	1.20	2.28
T9	3.67	4.40	0.92	1.80
SEm (±)	0.33	0.32	0.05	0.10
CD (p≤0.05)	0.95	0.94	0.13	0.28

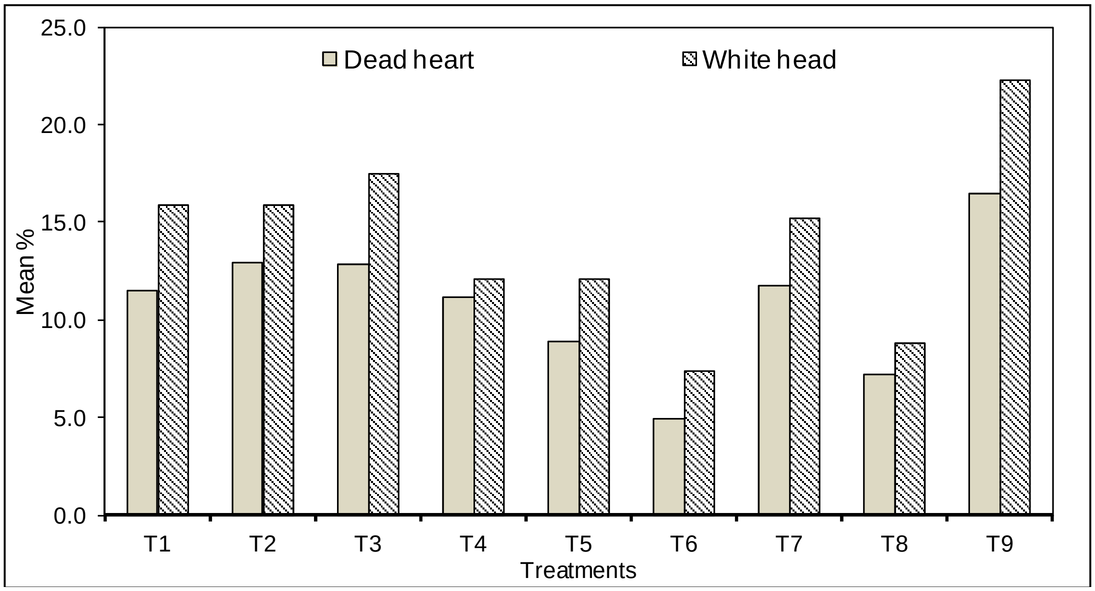
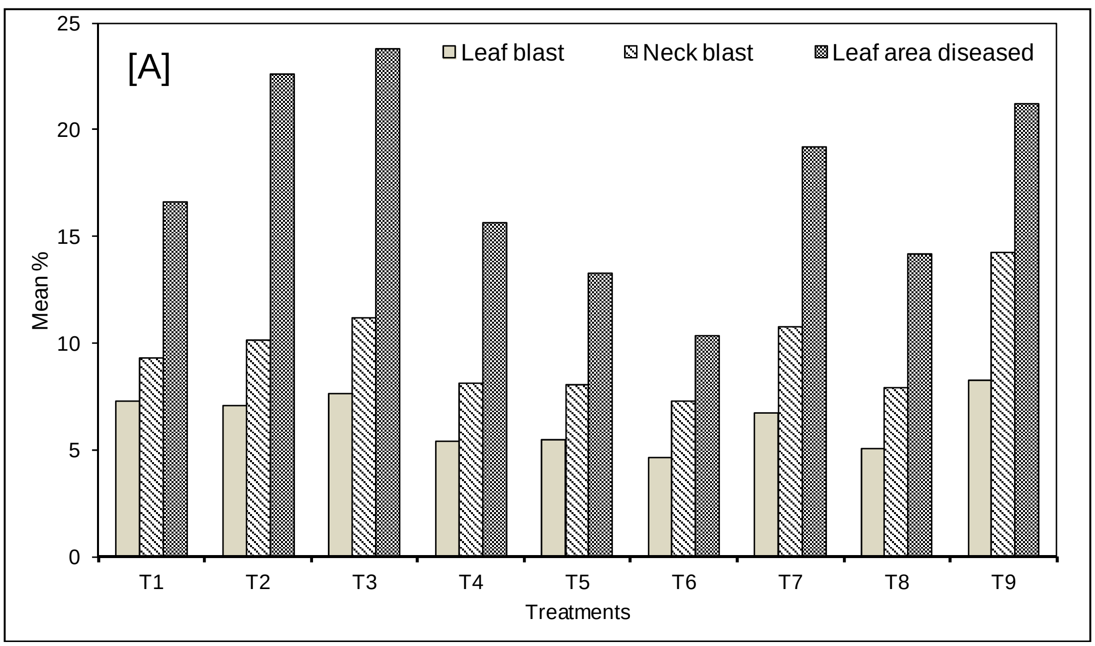


Fig 1: Incidence of yellow stem borer (*Scirpophaga incertulas* Walker) in rice as influenced by different nutrient treatments (based on pooled data of two years)



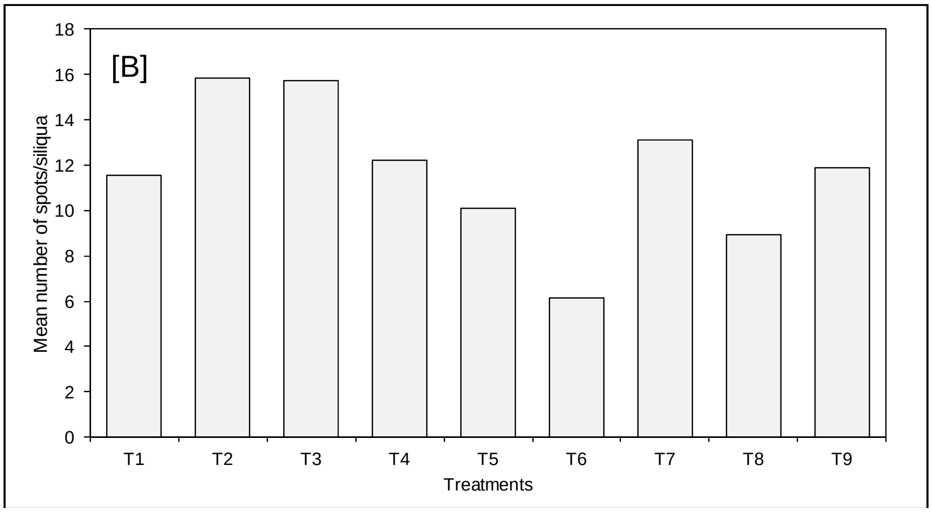


Fig 2: Incidence of blast on rice and *Alternaria* blight on mustard as influenced by different nutrient treatments in rice-mustard cropping system (based on pooled data of two years)

Conclusions

From this present study, it can be concluded that application of zinc and boron in accompanied with humic acid and compost can be an effective nutritional manipulation by fixing the recommended dose of NPK to successfully reduce the pest and disease incidence in rice-mustard cropping system under the umbrella of climate change.

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