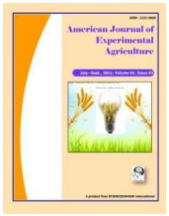

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Effect of Bio-organic Amendments on the Infestation of Major Pests & Foliar Disease, Leaf Productivity in Mulberry (*Morus alba* L)

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Authors' contributions

This work was carried out in collaboration between all authors. Author BC designed the study, wrote the protocol and wrote the first draft of the manuscript. Authors AKC and SKC reviewed the experimental design and all drafts of the manuscript. Authors AKC and SKC managed the analyses of the study. Author AKC identified the plants. Author BC performed the statistical analysis. All authors read and approved the final manuscript.

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ABSTRACT

Massive utilization of inorganic fertilizers for a prolonged period leads to alteration of the soil chemical properties, the availability and uptake of nutrients by the plants. The field experiments aimed at investigating the effect of bio-organic amendments on infestation of major pests, foliar disease and leaf productivity of mulberry (*Morus alba* L) have been conducted during March 2004-February 2007 in lateritic soil condition (having around pH of 5.6) with limited irrigation support in some areas of Midnapur (West) Districts, West Bengal, India. The research was set up as randomized block design, consisted of five treatments and provided with three replications. (T_1 = 20 MT/ha FYM + 336 kg N+180 kg P_2O_5+ 112 kg K_2O /ha /yr, T_2 = 10 MT/hc Vermicompost + *Azotobacter* +AMF + 50% N + 33% P_2O_5 and K_2O /ha /yr of T_1, T_3 = 7 MT/hc of Poultry-manure + *Azotobacter* +AMF + 50% N + 33% P_2O_5 and K_2O /ha /yr of T_1, T_4 = 5 MT/hc Vermicompost + *Azotobacter* +AMF + 50% N + 33% P_2O_5 and K_2O /ha /yr of T_1, T_5 = 3.5 MT/hc Poultry-manure +

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Azotobacter +AMF + 50% N + 33% P_2O_5 and K_2O /ha /yr of T_1). The experimental results revealed that the effect of vermicompost in combination with bio-fertilizers followed by reduced doses of inorganic fertilizers imparted significant effect on leaf productivity and incidence of pests and diseases of mulberry plants. However, maximum leaf yield was recorded with the application of poultry manure along with bio-fertilizers and reduced dose of inorganic fertilizers (T_3) in the third year after the establishment of plants (16.98 MT/ha/yr). Study of surveillance on the incidence of disease and insect pests clearly indicated that no other diseases than foliar disease was recorded under different manurial and fertilizer treatments. Further, population of the insect pests like white fly and thrips were found to be significantly reduced below the economic threshold level in the experimental plots treated with different organic manures along with bio fertilizers over control.

Keywords: Mulberry; organic manures; bio-fertilizers; lateritic soil; pests; disease.

1. INTRODUCTION

Mulberry being deep rooted perennial crop tends to grow and produce leaves throughout the years in the tropical region and represents the only prime food sources for mulberry silkworms (*Bombyx mori*. L). Mulberry leaf is a major economic component in sericulture, since the quality and quantity of leaves produced per unit area have a direct bearing on cocoon harvest [1]. Production of leaves in the tropical countries is largely dependent on the application of inorganic fertilizers. Pests and diseases play significant roles in determining the leaf yield of mulberry per unit area [2]. Fertilization with inorganic nitrogen can often encourage succulent and excessive vegetative growth of the plants that may enhance the multiplication rate of pests leading to more damage to plants. The plants having good growth coupled with biomass impart profound influence on insect population [3]. In order to reduce the chemical pesticides load, adoption of some agronomical practices like inter cultural operation, proper plant spacing and pruning are supposed to reduce the infestation of diseases without adversely affecting the ecosystem. Proponents of organic agriculture have asserted that plants grown with biological sources of nutrients such as manures and composted organic wastes are less susceptible to the attack of the insect pests than other conventionally grown plants [4]. Recently, a great attention has been paid towards the bio organic farming to avoid the heavy use of agrochemicals which resulted in numerous environmental troubles [5]. The coincident application of organic manures and bio-fertilizers is frequently recommended for improving soil properties and obtaining clean agricultural products [6]. Vermicompost is an organic manure obtained in the form of casting of ingested biomass by earthworms after undergoing physical, chemical and microbial transformations. . The water soluble components of vermicompost such as humic acid, growth regulators, vitamins, micronutrients and beneficial microorganism increases the availability of plant nutrients, resulting increased growth, higher yield in crop [7] especially significant growth in tomato [8]. Besides, macro and micronutrients, it also contains humic acids, plant growth promoting substances like auxins, gibberellins, and cytokinins [9]. In addition to vermicompost other organic manures and bio-fertilizers also play a vital role as organic nutrient sources for sustainable soil health and crop growth [10). Kundaswamy et al. [11] reported an increase nitrogen level of mulberry was found due to Arbuscular Mycorrhizal fungal (AMF) inoculation. Beneficial effect of application of Azotobactor in mulberry leaf production was established and demonstrated by Das et al. [12-14]. Therefore, the focus of this investigation was to evaluate the response of bio-organic nutrition through the application of different organic manures and bio- fertilizers in the lateritic soil of Midnapore (West). West Bengal, India and to identify the best suited eco friendly nutrient management practice for sustainable leaf yield of mulberry and suppression of diseases and pest attack.

2. MATERIALS AND METHODS

The plantation was raised in lateritic soil of Vidyasagar University campus (22^o $25^/$ N latitude and 87^o $17^/$ longitude) of Midinapur (West), West Bengal, India with eight months old mulberry saplings of S-1635 variety, which is a triploid variety with better rooting capacity having high leaf yielding ability. The pH of the soil was 5.6 having 0.41% organic carbon as determined following Jackson [15]. The plantation was made with 49 plants in each plot ((5.4 x 5.4 m) with a spacing of 60cm. x 60cm between the plants and was laid out in randomized complete block design having five treatments and three

replications. In the present study, different organic manures and bio-fertilizers were applied after bottom pruning at 15 cm height and they were as follows.

A. Organic manures: Farm yard manure (FYM), Vermicompost and Poultry manures.
B. Biofertilizers: *Azotobacter* (AZB) *chroococcum* and Arbuscular mycorrhizal fungi (AMF)

After pruning and cultural operation, five different plots were earmarked for giving five different treatment combinations (two variable doses of NPK along with farm yard manure, vermicpompost, poultry manure, *Azotobacter* and Arbuscular mycorrhizal fungi). The uniqueness of this standardisation process involves the reduction of recommended dose into half for nitrogen and 1/3rd for phosphorus although recommended dose for potassium remained same and was supplemented with different organic manures and bio-fertilizers. A total of 735 plants were imposed with five different treatments viz., T_1=20 MT/ha FYM+336 kg N+180 kg P2O5+112 kg K2O /ha /yr, T_2=10 MT/ha Vermicompost+*Azotobacter*+AMF+50% N+33% P2O5 and K2O /ha /yr of T_1, T_3=7 MT/ha Poultry-manure + *Azotobacter*+AMF+50% N+33% P2O5 and K2O /ha /yr of T_1, T_4=5 MT/ha Vermicompost + *Azotobacter*+AMF+50% N+33% P2O5 and K2O /ha /yr of T_1, T_5=3.5 MT/ha Poultry-manure + *Azotobacter*+AMF+50% N+33% P2O5 and K2O /ha /yr of T_1. In Treatment-1, plots were maintained with, recommended fertilizer NPK (336 kg/ha/yr nitrogen,180 kg/ha/yr phosphorus and 112 kgha/yr potassium) and 20 MT/ha/yr farm Yard which treated as control, for Treatment-2, plots were provided with 10 Mt/ha/yr vermicompost along with two bio-fertilizers namely *Azotobacter* (20 kg/ha/yr) and *Arbuscular mycorrhizal* fungi (100 kg/ha/4yr) and reduced doses of nitrogen(168kg/ha/yr), phosphorous (60 kg/ha/yr) and normal dose of potassium. In Treatment -3, plots were provided with 7 MT/ha/yr poultry litter along with two bio-fertilizers namely *Azotobacter* and *Arbuscular mycorrhizal* fungi and reduced dose of nitrogen, phosphorous and normal dose of potassium were applied like T_2 plots. In Treatment- 4, 5 Mt/ha/yr vermicompost along with two bio-fertilizers namely *Azotobacter* and *Arbuscular mycorrhizal* fungi with reduced doses of nitrogen, phosphorous and normal dose of potassium were applied likeT_2 and T_3 plots.In Treatment -5, soils of the plots were added with 3.5 MT of poultry litter along with two bio-fertilizers namely *Azotobacter* and *Arbuscular mycorrhizal* fungi(AMF) and reduced dose of nitrogen, phosphorous and normal dose of potassium as recommended for irrigated package like T_2,T_3 and T_4 plots. All the above mentioned organic manures required for organic farming were readily available from the surrounding rural sectors which were almost free of cost. The Azotobactor and AMF bio-fertilizer were obtained from the cultural collection of Central Sericultural Research and Training Institute (CSR&TI) of Berhampur, West Bengal. Though all the bio-fertilizers selected for the study were low cost and indigenous but they differed in their microbial population. As per recommendation of Sudhakar et al. [16] *Azotobactor chroococcum* cells blended with peat soil/charcoal/FYM in powdered form as carrier material containing 10^{8-9} cells per gram was applied at the rate of 20kg/ha/yr which were optimum for the application in mulberry garden. These were was applied at the rate of 20kg/ha/yr in four equal splits to the soil after each crop harvested following the recommended norms of CSR&TI, Berhampur. The Mycorrhizal product was used for the mycorrhizal inoculants, which is a low cost and commercially available product and this containing multi-strain Arbuscular mycorrhizal fungi (Spore density 100 numbers/5 gm soil) and it was reported to retain at the root zone for many years [17]. AMF was applied only once at the rate of 100kg/ha/4years following the same process. The garden was pruned four times in a year. Inorganic fertilizers were applied after 20 days of the bio fertilizer application. Irrigation was provided as and when required. After 65 days of growth, the observations were recorded during the August, November, February and May, 2005-07. Leaf yield was assessed by harvesting the leaves from all the plants available in net plots except the border line effect and then converted into yield per hectare. Before conducting the experiment, the chemical characteristics of organic manures were recorded and presented in the Table-1 following the standard analytical method of Jackson [15], Walkley & Black [18], Subbiah & Asija [19].

The incidence of occurrences of the diseases and out breaks of pests per plant were recorded for two consecutive years (2005-06 to 2006-07) after 55-60 days of pruning , by randomly taking 10 plants in each replication. Foliar disease such as leaf spot caused by *Myrothaium roridum* was observed during September 2006 and

Table 1. Chemical properties of organic manures

Organic manures	pH	Organic carbon %	N%	P%	K%
Farm Yard Manure (FYM)	7.2	39.4	1.1	0.42	1.82
Vermicompost	7.2	15.4	1.65	0.92	1.2
Poultry Litter	7.0	7.7	3.1	2.84	2.70

September 2007. Observations on Percent Incidence (PI) in respect of leaf spot disease were recorded and the data during both the years were pooled and analyzed. The Percent Incidence (PI) was calculated by applying formula given by Wheeler [20].The total number of leaves (normal leaves + infected leaves) and infected leaves were counted on each shoot of mulberry; three shoots per plant were taken for the count and the mean scoring was expressed in percentage:

$$\text{Disease Incidence (\%)} = \frac{\text{Total number of infected leaves}}{\text{Total number of leaves}} \times 100$$

During this period, two types of pests populations were recorded namely White fly (*Dialeuropora decempuncta*); December-06 and September-07 and Thrips (*Pseudodendrothrips mori*); April-06 and May-07). For those pests incidence ,numbers of nymphs/adults for White fly as well as Thrips were recorded from ten plants in each plot. Leaf Yields from those plots were recorded and calculated in respect of per hectare. Data on leaf yield were recorded at the end of every crop and were subjected to analysis of variance (ANOVA) for a randomized block design with three factors (Treatment, Season & Year). Data on disease incidence and pest attack were also taken into consideration and were subjected to analysis of variance (ANOVA). The significance of different sources of variation was tested using Fisher and Snedecor's F-Test at 5% and 1% level of significance.

3. RESULTS AND DISCUSSION

Leaf Yield showed an increasing trend in different treatments for the three consecutive years (Table 2). Soil productivity of mulberry had been recorded in the tune of 16.98 MT/ha/yr after application of poultry litter along with biofertilizers (*Azotobacter*+AMF) and curtailing dose of NPK (T_3). Analysis of three years leaf yield data under different nutrient sources indicated that bio-organic amendments recorded higher leaf yields which were found to be antagonistic against diseases and pests attack. Among the treatments, a maximum leaf yield was recorded in T_3 in the third year after the establishment of plants (16.98 MT/ha/yr.), Overall 16.69% increase in leaf yield was recorded. Pooled data recorded for three years with respect of total leaf yield of the plants raised under different treatments revealed that treatments were found to be differed significantly from each other. Leaf yields were not hampered due to attack of pests and foliar disease incidence were supposed to be due to effect of organic usage.

Incidence of occurrence of leaf spot disease and pests of mulberry (variety S-1635) under different treatments has revealed that there were no significant differences among the treatments with regard to leaf spot disease and attack of pests like thrips. Regarding infestation of white fly, significant differences were observed among the treatments (CD value 2.265 at 5% level) (Table 3) It was also observed that maximum infestation of white fly was recorded in T_1 (control). The infestation in case of T_3 was 17.17% which was followed by T_2 (16.71%), T5 (16.66%) and T_4 (15.97%). But the infestation in these three (T_2, T_3 and T_4) and T_5 differed significantly from each other. Similarly in foliar disease (leaf spot), the infestation was maximum in control (9.48%) and minimum in T_3 (8.43). Maximum infestation with thrips was noticed in T_2 (14.23%) followed by T_4 (13.10%) and T_5 (12.40%) respectively (Table 3). In the treatment combination of (T_2-T_5) the treatment T_4 was found consistently effective in reducing the incidence of pests and recorded the lowest whitefly population. The treatments T_5 and T_2 were the next in order of effectiveness in reducing the population of white fly and sustainable yield in mulberry. The result is more or less in conformity with Ravi et al. [21] who also recorded significant reduction of the incidence of sucking pests namely whitefly and leaf hoppers under organic manures and bio-fertilizer treated plots. Similarly in foliar diseases, infestation was maximum in control and minimum in the plot treated with organic composts like poultry litter along with bio-fertilizers. These findings also corroborates with the study of Ghorbani et al. [22] who stated that organic composts must have direct anti-disease effects or stimulate competitor micro-organisms and/or induce plant resistance .The use of organic soil amendments can result in a better soil quality and greater plant disease suppressiveness [23]. Sharma et al. [2] also concluded that reduction in disease development might be due to the production of

various growth substances or hormones by *azotobacter*, azospirillum and partial application of nitrogen which enables plants to develop resistance power in the plant against certain pathogens. In the present investigation, highest abundance of white fly in control plot (FYM+NPK) has also corroborated the research outcomes of Prestidge & Neill [24] who found that plants grown with high levels of nitrogen fertilizer resulted in larger infestation of pest. Integration of different sources of nutrients tended to release essential plant nutrients gradually throughout the growth period that might have induced development of resistance which subsequently helped in escaping whitefly infestation in tomato. Walkley & Black [25] highlighted the pest suppressing ability of vermicompost and found that vermicompost based treatments harboured lowest population of sucking pests namely jessids and thrips in the plantation of chilli.

The lowest disease incidence was recorded in the plots treated with poultry manure at the dose of 7 MT/ha. The results generated out of the present research studies are in conformity to the findings of Sullivan [26] who concluded that excessive nitrogen levels may further boost different diseases which are rarely a problem in organic production.

Table 2. Effect of bio-organic fertilizers on leaf productivity (MT/ha/yr) of mulberry (Var. S-1635)

Treatments	2004-05 (MT/ha/yr)	2005-06 (MT/ha/yr)	2006-07 (MT/ha/yr)	Average leaf Yield of three years (MT/ha/yr)	Total Leaf yield (MT/ha/yr)	% of increase in yield
T_1 (FYM +NPK)	13.14	13.45	14.49	13.70	41.08	-
T_2 (Vermicompost+ *Azotobacter*+AMF+50% N+33% P_2O_5 and K_2O)	14.71	14.42	15.56	14.90	44.69	8.77
T_3 (Poultry-manure+ *Azotobacter*+AMF+50% N+33% P_2O_5 and K_2O)	15.09	15.88	16.98	15.98	47.95	16.69
T_4 (Vermicompost+ *Azotobacter*+AMF+50% N+33% P_2O_5 and K_2O)	14.42	14.48	15.45	14.78	44.34	7.94
T_5 (Poultry-manure+ *Azotobacter*+AMF+50% N+33% P_2O_5 and K_2O)	14.02	14.09	15.19	14.43	43.30	5.39
CD at 5%	NS	NS	NS	-	2.834	-
CD at 1%	NS	NS	NS	-	4.123	-

Table 3. Effect of bio-organic fertilizers on incidence of disease and pests of Mulberry (Var. S-1635)

Treatments	Disease of Mulberry	Pests of Mulberry (number/leaf)	
	Leaf spot disease incidence (%)	White fly	Thrips
T_1 (FYM +NPK)	9.48	20.02	13.10
T_2 (Vermicompost + *Azotobacter* +AMF + 50% N + 33% P_2O_5 and K_2O)	9.43	16.71	14.23
T_3 (Poultry-manure + *Azotobacter* +AMF + 50% N + 33% P_2O_5 and K_2O)	8.43	17.14	11.57
T_4 (Vermicompost + *Azotobacter* +AMF + 50% N + 33% P_2O_5 and K_2O)	8.69	15.97	11.27
T_5 (Poultry-manure + *Azotobacter* +AMF + 50% N + 33% P_2O_5 and K_2O)	9.30	16.66	12.40
CD at 5%	NS	2.265	NS
CD at 1%	NS	NS	NS
CV %	4.69	6.953	11.49

4. CONCLUSION

The present study has revealed that Bio-organic amendments with the application of organic manures and bio-fertilizers have sound effect on the protection of natural enemies of mulberry under field condition. Bio-organic fertilizers have contributed the higher leaf yield of mulberry as compared to chemical fertilizers and thereby tend to improve the fertilizer use efficiency as well as reducing the inorganic pesticide load on soil and ground water which subsequently ensure sustainable agriculture.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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