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ORIGINAL ARTICLE

Natural restraining of mealy bug infestation in Mulberry and China rose by employing bio-organic nutrition sources

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ABSTRACT
The mealybug (Maconellicoccus hirsutus) is usually recognized as the most devastating insect herbivore of forest trees, r oot crops, fruit plants, leafy vegetables, and horticultural cropProlonged use of inorganic fertilizer might stimulate the susceptibility of plants towards insect pests by changing the nutritional level in plant tissue. Crops raised in soils that have been organically grown often exhibit fewer insect problems. The present investigation aimed at the use of organic amendments that might be helpful to adopt pest resistant management strategy to control mealybug infestation in mulberry (Morus alba L) and China rose (Hibiscus rosa-sinensis L) In order to boost agricultural productivity and their ability to elicit plant resistance, a series of studies were carried out using two crops in lateritic soil conditions in the Midnapur (West) and Bankura Districts of West Bengal. The results revealed that the effect of vermicompost in combination with biofertilizers and reduced doses of inorganic fertilizers imparted a significant effect on leaf productivity and infestation of pests of mulberry and China rose. It was observed that the population of the insect pests like mealybugs, was significantly reduced below the economic threshold level in the experimental plots treated with different organic manures along with azotobacter biofertilizers and reduced dose of NPK over control.

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INTRODUCTION

Excessive fertilizations exploiting chemical fertilizers especially inorganic nitrogen and the use of pesticides have increased rapidly and evidence suggests that such exaggerated use of agrochemicals along with the establishment of expanded monoculture has exacerbated pest problems. Mulberry being a deep-rooted perennial crop tends to grow continuously and after establishment, it consistently yields quality leaves throughout the years in the tropical region and represents the only prime food source for mulberry silkworm (*Bombyx mori*. L) [1]. The application of inorganic fertilizers significantly influences the quality and quantity of leaf production per unit area in tropical countries. Mulberry, is prone to attack by a number of insect pests which cause a reduction in mulberry leaf yield besides lowering its nutritional value and making it unsuitable for silkworm rearing [2]. *Maconellicoccus hirsutus* (Green) the pink Hibiscus mealybug (Hemiptera: Pseudococcidae) is one of the most serious insect pests in a wide range of plant species, including agricultural, horticultural, and ornamental crops [3]. This is a polyphagous pest that causes damage by sucking the sap of the host plant with characteristic features like twisted leaves, stems, and fruits, shortening of internodes, bunchy top, etc. [4 & 5]. While feeding, the Pink Hibiscus mealybug inoculates toxic saliva into the plant tissue which enhances the severity of damage [6]. Mealybugs are generally called 'hard-to-kill pests' due to their broad range of habitats [7] .Stunted and distorted growth caused by Pink mealy bug, *Maconellicoccus hirsutus* (green) in mulberry which is popularly known as Tukra leads to dark green, wrinkled and thickened leaves with shortened intermodal distance resulting in a bunchy top appearance [8] .Hibiscus rosa-sinensis, sometimes known as the "shoe flower plant," is a delicate evergreen shrub that is endemic to tropical and subtropical countries and is a member of the Malvaceae family. On hibiscus, the mealybug usually infests young twigs, causing deformed terminal growth (due to the shortening of internodes), deformed leaves and thickened twigs

[7]. Fertilization with inorganic nitrogen frequently promotes succulent and excessive vegetative development in plants, which could speed up the growth of pests and cause more damage to plants. [9] Suitable agronomic packages and practices like intercultural operation, crop rotations ideal spacing between plants and use of resistant variety are essential to adopt healthy crops and to avoid build-up of pest, disease and weed densities to reduce the chemical pesticides load without hampering ecosystem stability. Organic agriculture is now emerging as a sustainable substitute for traditional agriculture using environmentally friendly strategies such as the application of organic fertilizers made from plant and animal waste and pesticides based on plant extracts and microbial [10]. Several reports related to the strategy on the mealybug control are available, but further studies are required to improve the successful management strategies against this mealy bug. The application of conventional insecticides hinders with the activity of naturally-occurring biocontrol agents in horticultural ecosystems. In order to resolve this issue, the use of nontraditional chemicals like botanicals, biopesticides, etc. may be a natural measure that is applicable in mealybug management programs, without affecting the key, local natural enemies [7] However, the use of insecticides, whether biological or synthetic compounds, is none the less detrimental to natural enemies. Organic workers strongly established the fact that plants grown organically are much more resistant to insect herbivory and diseases than plants treated with inorganic fertilizers. Research demonstrated that plants grown using organic amendments have high resistance to insect pests and diseases than plants grown with synthetic inorganic fertilizer amendments [11] It has been documented that improvement of the physical condition of the soil is assured by the use of organic manures and that also provide an adequate amount of necessary nutrients for the soil productivity [12 & 13] even bio-organic amendments have the potential to control soil-borne diseases. [14]. Animal manures when used successfully contribute to improving soil quality and ensure sustainable crop productivity. Organic fertilizers are naturally available mineral sources that contain moderate amounts of plant essential nutrients and gradually release to the soil in order to maintain nutrient balance for healthy growth of crop plants [15]

Therefore, the focus of this investigation was to evaluate the response of bio-organic nutrition through the application of different organic manures along with azotobacter biofertilizer in the lateritic soil of Midnapore and adjacent area of Bankura West Bengal, India and to identify the best suited eco-friendly nutrient management practice for sustainable leaf yield of mulberry and suppression of the attack of pests with special reference to mealy bug.

MATERIAL AND METHODS

Nearly identical sets of field experimental trials were conducted in Paschim Midnapur, West Bengal, and the nearby forest area of Kenduadihi, Bankura for two consecutive years (2017–18 & 2018–19). On average, the highest infestation of mealy bugs was recorded in the month of February followed by January in the year 2017-18 and October to November with the highest infestation in November in the next year i.e., 2018-19 at all the localities under experimental study

Experimental Plot 1:

The plantation was raised with eight-month-old mulberry saplings of the S-1635 variety, a triploid variety with better rooting capacity and high leaf yielding ability, in the laterite soil of the campus of Vidyasagar University in Midnapur (West), (22° 25/ N latitude and 87° 17/ longitude) West Bengal, India. The soil had a pH of 5.6.and it was measured by pH meter [16]. Organic carbon was recorded at 0.41 % which was determined using the Walkley-Black method [17]. The plantation was laid out in a randomized complete block design having five treatments and three replications. After bottom pruning at a height of 15 cm, various organic manures, reduced doses of inorganic fertilizers, and biofertilizers were applied.

The following treatment combinations were taken into account for experimental plot 1: T1=20 MT/ha FYM+336 kg N+180 kg P_2O_5 +112 kg K_2O /ha /yr.

T2=10 MT/ha Vermicompost+Azotobacter +50% N+33% P_2O_5 and 112 kg K_2O

T3=7 MT/ha Poultry-manure +Azotobacter +50% N+33% P_2O_5 and K_2O /ha /yr. of T1

T4=5 MT/ha Pig manure+Azotobacter +50% N+33% P_2O_5 and K_2O /ha /yr. of T1

T5=3.5 MT/ha Goat -manure + Azotobacter+50% N+33% P_2O_5 and K_2O /ha /yr. of T1

Pruning was carried out four times a year, in February, May, August, and November, in accordance with the silkworm rearing timetable. Throughout the research period, Mulberry was kept free from insecticide sprays. Mealy bug colonies were counted for different plant parts such as stems and leaves, and an average was calculated on a weekly basis.

Experimental Plot 2:

The experiment involved a plantation of Chania roses (*Hibiscus rosa chinensis*) that was already infested and grown in an unprotected region of the nearby forest range of Kenduadihi, Bankura, West Bengal,

India. (23.2313̊ N, 87.0784̊ E). Shoe flower plants with a spacing of 50 to 70 cm and a heavy infestation of mealy bugs were identified in the field. Six shoe flower plants were carefully selected at random from each plot to study the pest populations, which were counted every week. In net plots, the population of mealy bugs was counted from the center of the plot in order to minimize the borderline impact. Because the amount of nitrogen needed by the plants varies from medium to high, a balanced basal dose of moderate nitrogen, low phosphorus or phosphate, and high potash (NPK @ 10:5:20) was applied to each plot before the administration of the necessary treatments. The remaining experimental techniques were thought to use similar attention, settings, and accuracy.
For experimental plot 2, the following treatment combinations were taken into consideration:
T1=20 MT/ha FYM+400 kg N+150 kg P_2O_5 +150 kg K_2O /ha /yr.
T2=10 MT/ha Vermicompost+Azotobacter +50% N+33% P_2O_5 and150 kg K_2O
T3=7 MT/ha Poultry manure +Azotobacter +50% N+33% P2O5 and 150 kg K_2O
T4=5 MT/ha Pig -manure+Azotobacter +50% N+33% P_2O_5 and 150 kg K_2O
T5=3.5 MT/ha Goat -manure + Azotobacter+AMF+50% N+33% P_2O_5 and 150 kg K_2O
The plants were pruned in four times per year viz early spring i.e., in March, August October and. Late winter i.e., in December.The cropswere largely controlled by the application of insecticides
Five different plots were earmarked for the application of different treatment combinations (two variable doses of NPK along with farm yard manure, vermicompost, poultry manure, Pig manure, Goat manure and Azotobacter) All those organic manures required for the experimental trial were readily available from the surrounding rural sectors which were almost free of cost. The Azotobactor bio-fertilizer was obtained from the cultural collection of the Central Sericultural Research and Training Institute (CSR&TI) of Berhampur, West Bengal.
*Azotobactor chroo*coccum cells combined with peat soil/charcoal/FYM in powdered was applied at the rate of 20kg/ha/yr which were optimum for the application to the experimental plots in four equal splits. 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. The leaf yield of mulberry was assessed by harvesting the leaves from all the plants available in net plots except the borderline effect and then converted into yield per hectare. Flower yield in the case of China rose was assessed by harvesting the leaves from all the plants available in net plots Before conducting the experiment, the chemical characteristics of organic manures were recorded and presented in Table-1 following the standard analytical method. Organic carbon was determined using the Walkley-Black method by De Vos *et a*l.,2007 [17]and N, P, and K of the manure were standardized by the method of Pansu *et al*., 2006 [18]

Table-1. Phisico-chemical properties of organic manures used in the experiment

Organic manures	**pH**	**Organic carbon %**	**N%**	**P%**	**K%**
Farm Yard Manure (FYM)	6.9	38.8	1.08	0.43	1.81
Vermicompost	7.1	14.9	1.69	0.93	1.9
Poultry Litter	7.0	27.8	2.98	2.85	2.65
Goat manure	8.4	46.58	1.34	0.54	1.56
Pig Manure	6.46	18-23	1.40	2.40	1.88

Observations on the incidence of Mealy bug per plant was carried out for two consecutive years during 2017-18 to 2018-19 after 55-60 days of pruning, by randomly taking 10 plants in each replication. In order to count the pests, a number of nymphs/adults for mealy bug were recorded from ten plants in each plot following the same procedure for mulberry and China rose and 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 pest attack was 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% levels of significance.

RESULT AND DISCUSSION

Experimental Plot 1:

Data related to the leaf Yield of mulberry as shown in Table 2, Fig.1 reveal that an increasing trend of leaf yield exposed in different treatments for two consecutive years. Soil productivity of mulberry had been recorded to the tune of 14.09 MT/ha/yr. after the application of poultry litter along with Azotobacter biofertilizers and a limited dose of NPK (T3). Analysis of two years of leaf yield data under different nutrient sources showed that all the treatments related to the bio-organic amendments recorded higher leaf yields which were found to be resistant against a wide array of pests. Overall, a 13.38% increase in leaf yield was recorded. The results in Table 4 show that all the treatments were inevitably effective on the mealybug population within 2 weeks of application of the treatments but the maximum reduction was recorded after 4 weeks of treatments. The pretreatment count of mealybug ranged between 18.35 to 23.04 numbers/ leaf which was statistically non-significant. The pooled mean incidence of mealybug on mulberry over two years of observation indicated that variability in the mealybug population driven on by treatments was significant. The overall mean efficacy of two observations recorded at two, and four weeks after incorporation of five treatments indicated that the plots treated with vermicompost along with Azotobacter biofertilizers recorded the highest reduction of mealybug population and remained significantly superior over all the other treatments with 93 percent reduction over control after four weeks of treatment. The next best treatments in the descending order of efficacy were T4 and T3 with 92.92 and 92.46 percent reduction over control, respectively and both treatments were at par with each other. The next treatments in the descending order of efficacy were T5 with a 90.16 percent reduction over control. was least effective in reducing the leafhopper population compared to the above treatments (Table 4). So the data illustrated in Table 4 showed that although T2 was found consistently effective in reducing the incidence of pests and recorded the lowest mealybug population but the treatments T4, T3, and T5 were the next in order of effectiveness in reducing the population of mealy bug per plant and sustainable yield in mulberry.

Experimental Plot 2:

On the other side among the treatments, higher flower yield was recorded in T3 in the second year after the establishment of plants (4.4MT/ha/yr.), Overall, a 91.30% increase in flower yield was recorded. (Table-3; Fig. 2) Pooled data recorded for two years with respect to total flower yield of China rose raised under different treatments revealed that flower yields were not hampered due to attack of pests were supposed to be due to the effect of organic inputs. The incidence of occurrence of pests in China rose under different treatments has revealed that there were significant differences among the treatments with regard to the attack of pests like mealybugs at early stages of treatment as well as after 4 weeks of the application of treatments along with biofertilizers. The results in Table 4 demonstrate that all treatments consistently reduced the population of mealy bugs within two weeks of application, although the greatest reduction was observed after four weeks of treatment. Mealybug pretreatment counts varied from 18.97 to 23.06 per leaf and were statistically insignificant. The plots raised with china rose treated with vermicompost along with Azatobactor biofertilizers recorded the highest reduction of mealybug population and continued to be significantly superior over all the other treatments with 90.18% reduction over control after four weeks of treatment, according to the overall mean efficacy of two observations made at two and four weeks after the incorporation of five treatments. The next best treatments in the descending order of efficacy were T4 and T3 with 85.51 and 80.25 per cent reduction over control, respectively and both the treatments were at par with each other. The next treatments in the descending order of efficacy were T5 with 80.36 percent reduction over control. was least effective in reducing leafhopper population compared to above treatments (Table 4).

As a result, the data presented in Table 5 demonstrated that, while T2 was consistently effective in reducing pest incidence and recorded the lowest mealy bug population, treatments T4, T3, and T5 were the next in order for effectiveness in lowering the population of mealy bugs per plant and sustaining yield in mulberry. Higher crop productivity requires maintaining a higher level of soil fertility and crop nutrient availability, according to the findings of our current analysis into crop yield using combination of bio and organic fertilizers, which are also similar with the others finding in earlier [1]. According to the current investigation results, the plot treated with inorganic fertilizer (the control plot) had the highest population of mealy bugs. These results partially corroborate those of previous studies of Bokhtiar and Sakurai [19], which found that persistent use of chemical fertilizers results in an imbalance of nutrients in the soil, increases crop susceptibility to disease outbreaks, and causes other problems. In a field study using vermicompost, Panda et al.[20] discovered that the quantity of sucking pests, such as jassids and thrips, was kept to a minimum. The aforementioned results support our observation that vermicompost can help with insect population management [21] reported that attacks by sucking pests had been declining due to the application of vermicompost. In contrast to soils used to grow groundnuts that had been modified with inorganic fertilizer, [22] found that groundnuts grown in soils treated with vermicompost, neem cake, or farmyard manure had the lowest pest population of sucking pests such as jassids and aphids Recent study showed that increased fertilization with higher doses of NPK application causes insect pest invasion; whereas, organic manures and bio fertilizers had the opposite impact. The earlier investigation [23] revealed that adding organic amendments to soil may assist increase its nutrient status while reducing the incidence of pests, which was in line with the findings of the study described above. The same conclusions were also validated by the by the study of Ullah et al [24] who discovered that organic amendments had a substantial impact on the citrus canker disease and shown a decrease in disease incidence on plants affected by citrus leaf miner that received biofertilizer and vermicompost compared to synthetic fertilizer. Additional research by Karungi [25] indicates that organic amendments have a lot of potential for lowering crops' susceptibility to insect pest attack. The progressive nitrogen release that made those plots less susceptible to insect pest attack may be the cause of the decreased insect pest infestation rates on plots treated with animal manures. In the context of the same research findings, [26] reported that greater nitrogen levels have also been associated with an increase in rice pest problems, particularly the plant brown hopper. The present investigation backs up their conclusion.

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

Treatments	2017-18 (MT/HA/YR)	2018-19 (MT/HA/YR)	Average leaf Yield of two years (MT/HA/YR)	Total leaf yield (MT/Ha/Yr.)	% of increase in yield
T1	12.26	12.40	12.33	24.66	-
T2	13.32	13.71	13.52	27.03	9.65
T3	13.88	14.09	13.98	27.97	13.38
T4	13.38	13.47	13.42	26.85	8.84
T5	12.87	13.02	12.94	25.89	4.94

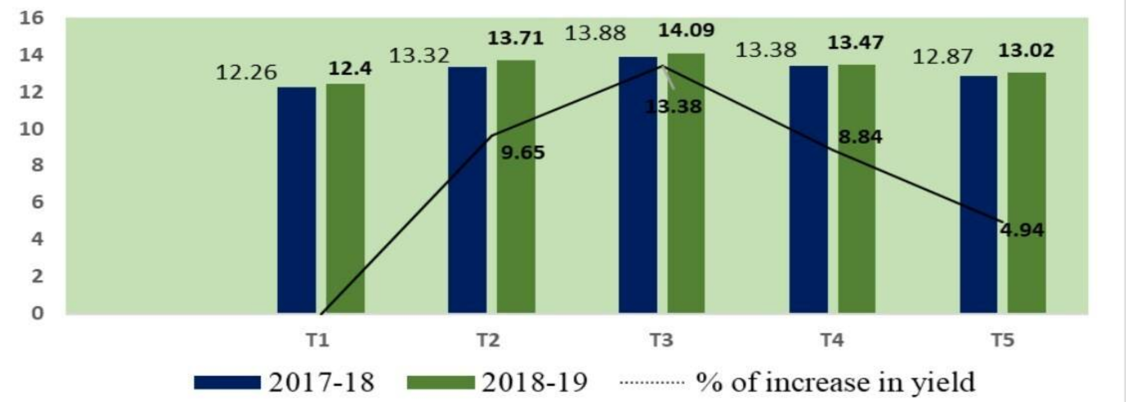

Fig. 1. Effect of bio-organic fertilizers on leaf productivity (MT/ha/yr) of mulberry (Var. S-1635)

Table 3. Effect of bio-organic fertilizers on yield of flower (MT/Ha/Yr.) of China rose (Tropical hibiscus)

Treatments	2017-18 (MT/HA/YR)	2018-19 (MT/HA/YR)	Average flower Yield oftwo years (MT/HA/YR)	Total leaf yield (MT/Ha/Yr.)	% of increase in yield
T1	2	2.5	2.3	4.5	
T2	3	3.8	3.4	6.8	47.82
T3	4	4.7	4.4	8.7	91.30
T4	3.5	3.9	3.7	7.4	60.86
T5	3.8	4.3	4.05	8.1	76.08

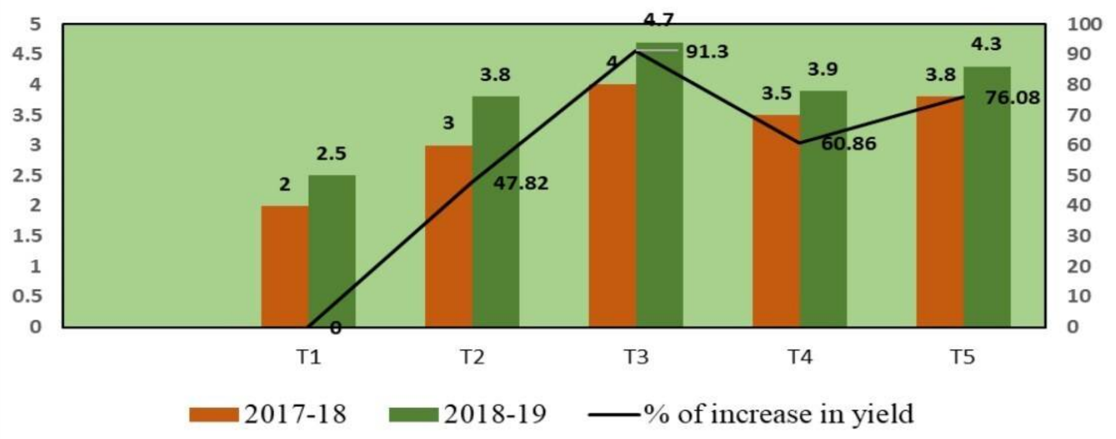

Fig. 2. Effect of bio-organic fertilizers on yield of flower (MT/ha/yr.) of China rose (Tropical hibiscus)

Table-4 Effect of bio-organic inputs against infestation of Mealy bug on Mulberry (*Morus alba*)

Treatments	Pre-treatments	Post treatments		Suppression of Mealy bug over control (after 4 weeks)	Reduction %
	Number of Mealy bug/plant	Number of Mealy bug/ plants (after 2 weeks)	Number of Mealy bug/ plants (after 4 weeks)		
T1(control)	18.97	15.49	13.01	-	-
T2	23.05	1.23	0.91	12.1	93.00
T3	21.93	2.02	0.98	12.03	92.46
T4	22.03	1.98	0.92	12.09	92.92
T5	23.06	2.0	1.28	11.73	90.16
CD 5 %	NS	0.05	0.03		
CD 1 %	NS	0.06	0.04	-	-
SE Mean	2.030	0.026	0.0146	-	-
CV%	9.306	0.571	0.4291	-	-

Table-5 Effect of bio-organic inputs against infestation of Mealy bug on China rose (*Hibiscus rosa sinensis)*

Treatments	Pre-treatments	Post treatments		Suppression of Mealy bug over control (After 4 weeks)	Reduction %
	Number of Mealy bug/ plant	Number of Mealy bug/ plants (after 2 weeks)	Number of Mealy bug/ plants (after 4 weeks)		
T1	18.35	14.33	10.29	-	
T2	23.05	1.52	1.01	9.28	90.18
T3	21.93	2.1	1.97	8.32	80.25
T4	21.99	2.61	1.49	8.8	85.51
T5	23.04	2.8	2.0	8.27	80.36
CD 5 %	NS	0.12	0.02	-	-
CD 1 %	NS	0.16	0.03	-	-
SE Mean	2.109	0.064	0.013	-	-
CV%	9.730	1.392	0.401	-	-

CONCLUSION

The current study's findings indicate that using bio-organic amendments along with organic manures and bio-fertilizers can significantly improve the protection of mulberry and China rose plants in field settings. Higher leaf yields of mulberry and rose in China when compared to chemical fertilizers tend to increase the effectiveness of fertilizer use, lower the load of synthetic pesticides on soil and groundwater, and eventually assure sustainable agriculture. The overall results of this field study show that for effective management of mealy bug infestation, local crop growers should utilize organic amendments in addition to nitrogenous biofertilizers along with the sparing use of chemical fertilizers. These issues can only be solved through future experimental studies comparing the degree of insect pest suppression on plants grown with vermicompost replacements but with the essential nutrients supplied as supplements. Clearly, more research on insect populations on plants fed with inorganic versus organic fertilizers is urgently needed. Understanding the most advantageous effects of organic fertilization on plant health may motivate us to introduce new, more potent techniques for boosting soil organic fertilization and biological pest control systems without compromising crop productivity.

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AUTHORS CONTRIBUTIONS
BC: Conceptualization; Investigated; prepared methodology; Validated, visualized; Supervised; written–original draft; Edited.
PB: Done sampling; Data collected; prepared methodology; data analyzed; written – review

ETHICS APPROVAL
No issues had been raised in this paper.

COMPETING INTERESTS
The authors have declared that no competing interest exists

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