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Impact of Microbial Products on the Biometric Parameters and Productivity of Rice in Madhya Pradesh, India

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Abstract

Despite the increase in chemical and technological inputs, rice production in India has stagnated due to excessive use of chemical inputs and overexploitation of land. This has given rise to the need for adopting sustainable agricultural inputs and practices. This study explores the effect of two organic microbial consortium based products, Magicgro DripSOL and Magicgro Super when used in combination for improving the productivity of commercially grown varieties of Basmati; PB1 and PS4 as well as local scented variety MTU-1010. The trials were conducted on commercial plots spanning across Mandala and Kotma regions of Madhya Pradesh, which were cultivated organically with no external irrigation. The impact of microbial intervention was assessed through biometric and quantitative yield analysis and the data was compared by unpaired T test analysis. In case of PB1, PS4 and MTU 1010, the mean yield increased by 72, 55 and 36%, respectively as compared to the untreated plots. The results signify that a single point intervention using microbial products is capable of bringing about significant improvement in yield. In addition to this, the microbial product application helped in imparting protection against abiotic stress. Therefore, the usage of such products could be considered as part of the solution towards achieving the Nation's mission of promoting sustainable agriculture.

Article History

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Magicgro DripSOL;
Magicgro Super;
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Introduction

India has the largest area under cultivation for rice, which is nearly 30% of the cultivated area around the world. Rice is one of the most important food crops in the world and feeds more than 60% of the Indian population.[1] The first post-Green Revolution phase (from late-1960s to mid-1980s) was marked by a significant increase in productivity from otherwise poorly yielding but fertile land through the intensification of chemical and machinery inputs.[2] As

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per the Directorate of Rice Development, Govt. of India, rice production has registered an appreciable increase from 20.58 million tonnes in 1950-51 to 104.86 million tonnes in 2014-15. The total yield was 668 kg/ha in 1951, which has increased to 2390kg/ha in 2015.

Despite the increase in chemical and technological inputs, the yields of rice have begun plateauing.[1] Rice is a crop with a very high water requirement. It is a known fact that for every degree of rise in temperature (in absence of ideal rainfall), the productivity of rice is impeded by 10%.[3] Furthermore, intensive rice cultivation has led to various ecological impacts such as decline in the ground water table, rising levels of pollution in the ground water, diversification in weed flora and more frequent and severe outbreaks of insect and pest diseases.[4,5] From an agricultural point of view, it has severely impacted the soil structure, nutrient content and ultimately caused a decline in productivity.[5] With the increasing yield gap, owing to the world's ever increasing population, sustainable agricultural practices are gaining importance.[6] Finding such solutions is further complicated by the looming danger of climate change.[7] The only solution is through cost effective, eco-friendly and continuously evolving innovations in sustainable agricultural technology.[8]

Sustainable agricultural practices include applying innovative farming approaches such as nutrient management in soil, integrated pest management, as well as soil and water conservation methods.[9] Soil fertility replenishment does not only pertain to nutrients but its biological fertility as well. Microorganisms have long been known to have an intimate relationship with all plant life and play a significant role in crop health as well as productivity.[3]

Microorganisms hold the greatest promise for technological advances in crop production, crop protection, and natural resource conservation through soil, plant and environmental application.[10] An example of innovation in microbial technology is the use of multi-microbial consortium to replenish the biological fertility of the soil. Though single organism products are now commercially available, they do not address the multifaceted requirements of nutrient exhausted soils. Buying multiple products is not a financially viable option for most Indian farmers, hence arises the need for a product containing a microbiome of highly selective microbes working in cohesion with each other to replenish the biological fertility of the soil.[11] The advantages of such products include improving nutrient assimilation, strengthening crop immunity, reducing the effect of biotic and abiotic stresses as well as reducing the use of chemical inputs.[12]

This study involves an investigation of the efficacy of two such microbial products, Magicgro DripSOL and Magicgro Super for improving productivity and benefiting the farmers economically. Magicgro DripSOL is a proprietary formulation that is reported to enhance nutrient uptake in the rhizophere, accelerate soil conditioning and improves rhizopheric immunity. Magicgro Super is a commercially available microbial formulation that is reported to improve photosynthetic efficiency, alleviate abiotic stress and improve flower and fruit setting. Conclusively, the socio-economic impact of the product is also assessed.

Materials and Methods

Location

The field experiment was conducted in the kharif season of 2017 in Mandala District (22.6262° N, 80.5438° E) belonging to Jabalpur Division and Kotma town (23.2075° N, 81.9808° E) belonging to Anuppur district, Madhya Pradesh, India.

Cultivation Technique

The experiment was laid out across varying geographical areas on three distinct varieties of rice: two basmati varieties; PB-1, PS-4 and one non-Basmati variety; MTU-1010. The plots were maintained and cultivated by the organic method of cultivation. Fertigation applied was farm yard manure and green manure. No chemical fertigation or pesticide application was carried out during the particular crop cycle. The application schedule, dosage, mode of application was maintained uniformly across all the treated plots. Each plot size was 0.5 acre with sowing undertaken by the System of Rice Intensification (SRI method) of cultivation.[13] For PB-1 variety, 12 plots of 0.5 acres were treated and correspondingly 8 plots of the same variety were observed as control (untreated) for data analysis. In case of PS-4 variety, 36 plots of 0.5 acres were treated and correspondingly 12 plots of the same variety were observed as control (untreated). For local variety MTU-1010, 28 plots (each of 0.5 acre area) were treated and 28 were observed as untreated. The treated rice plants were compared to the untreated rice plants of the same variety and an average was drawn. Since the trial was not a controlled study, no experimental design methodology was used. Table 1 describes the application schedule followed for the treated plots.

Biometric Parameters

The plant height, number of tillers and panicle weight was observed at harvesting stage. The rice crop was harvested at physiological maturity stage. Thirty plants from each unit area were chosen and observed for the mentioned parameters. The average of these observations per plot was further subjected to statistical analysis as mentioned below.

Yield Parameters

During harvesting, grains were separated from each plot for yield analysis, three 1m x 1m mark-up areas were demarcated and grains were separately harvested and dried under sun for three days. The grains were cleaned and consequently weighed to calculate the yield (total weight of grains harvested / meter^2). The grain yield per acre was calculated and expressed in the units quintals per hectare.[14]

Statistical Analysis

Student's *t* test was used based on PRISM-5 software and P values below 0.05 were considered statistically significant. The values in all graphs are an average of unpaired sample plots for all three varieties studied. All error bars represent standard error of mean.

Benefit-Cost Ratio

Benefit cost ratio was analysed to assess the economic impact of the use of the products Magicgro DripSOL and Magicgro Super. The benefit-cost ratio of each treatment was calculated by dividing net returns by cost of cultivation of respective treatments.[14]

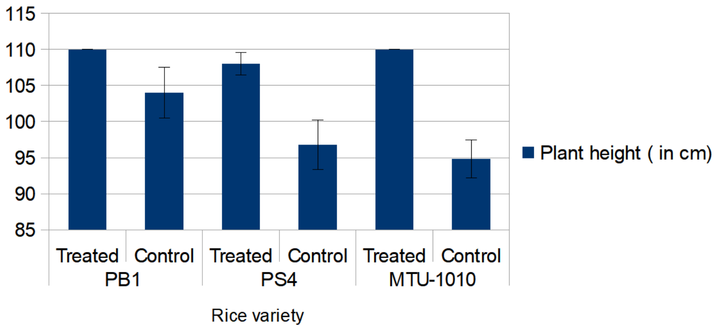

Fig. 1: Plant height (cm) (Mean ± SEM) of the rice varieties was evaluated. (Unpaired T-test, p<0.05)

Table 1: Schedule followed for the utilisation of Magicgro DripSOL and Magicgro Super throughout the crop cycle

Timeline	Application	Mode of Application	Dosage
Day 0	Sowing	Not applicable	Not applicable
Day 12-15 post sowing	Transplantation from nursery to field	Not applicable	Not applicable
Day 17-20 post sowing	1st application of Magicgro DripSOL	Drenching	250 gm/acre
Day 65-70	1st application of Magicgro Super	Foliar	250 gm/acre
Day 90-95 post sowing	2nd application of Magicgro Super	Foliar	250 gm/acre
Day 135-140	Harvest	Not applicable	Not applicable

Benefit-cost Ratio = Net returns (Rs acre-1) /Cost of Cultivation (Rs acre-1)

Results and Discussion

The results obtained from the field experiment have been summarized under following heads:

Plant Height

The plant height was measured prior to harvest of varieties PB1, PS4 and MTU-1010. The data was analysed and plotted as per Figure 1. The results showed a significant increase in all three rice varieties. The average plant height in PB-1 increased from an average of 104 cm in the untreated plots to 110 cm in the treated plots with a percentage increase of 5.7%. In case of PS-4, average plant height increased from an average of 97 cm in the untreated plots to 108 cm in the treated plots with a percentage increase of 131 cm. For the local variety MTU-1010, the average plant height increased from an average of 94.8 cm in the untreated plots to 110 cm in the treated plots with a percentage increase of 15.7%. Similarly, in another study it was observed that the highest increase in height was found in paddy after receiving 75% RDF + biofertilizers (*Azospirillum* and *Phosphobacteria viz.*) at all stages of its growth cycle.[15] They attributed this to the fact that biofertilizers have the ability to mobilize nutritionally important elements from non-usable forms to usable forms. The heightened nutrient assimilation may give way to improving biometric characteristics such as plant height, number of tillers etc.

Number of Tillers

Tillering is an important agronomic trait for gauging rice population quality and grain production. It indicates extent of the panicle formation and thereby is an indirect indication of improvement in yields.[16] The average number of tillers in PB-1 variety increased from an average of 11 tillers per plant in the untreated plots to 14 tillers per plant in the treated plots with a percentage increase of 27%. In case of PS-4, average number of tillers increased from 11 tillers per plant in the untreated plots to 14 tillers per plant in the treated plots with a percentage increase of 27%. For the local variety MTU-1010, the average number of tillers increased from an average of 11 tillers per plant in the untreated plots to 15 tillers per plant in the treated plots with a percentage increase of 36%. The data in figure 2 reveals that the mean number of tillers increased. This was a positive indication in terms of increasing productivity as an increase in number of tillers directly reflects increase in number of grain bearing panicles. The number of tillers is directly proportional to the increase in yield. These findings were in agreement with similar studies in which addition of phosphate solubilising organisms like *Burkholderia* sp. resulted in an increase of 5-10% in the number of tillers between the treated and control plants,[17] even when the nutrient dosage was reduced to half. Similarly, another study claimed that co-supplementation of biofertilisers with fertilisers had a positive effect on the tiller formation in rice.[1]

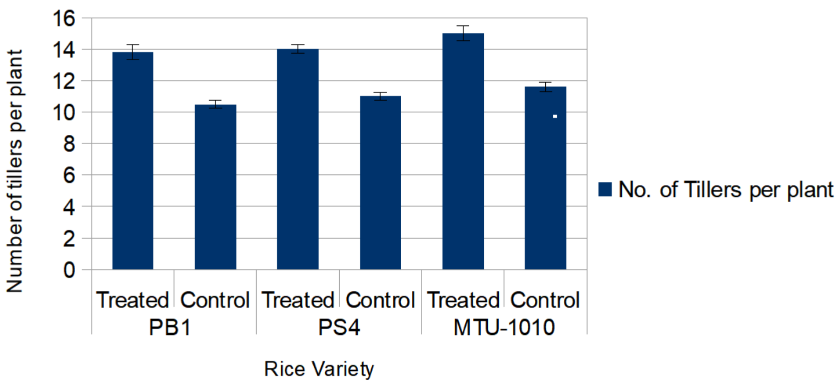

Fig. 2: Number of tillers (Mean ± SEM) of the rice varieties was evaluated. (Unpaired T-test, p<0.05)

Number of Grains Per Panicle

The numbers of filled grains per panicle were studied for all the three rice varieties between the treated and untreated plants. In all three varieties as per figure 3, the number of filled grains per panicle was positively affected due to the treatment schedule between 12-16%. The number of filled grains per panicle in PB-1 variety increased from an average of 129 in the untreated plots to 145 in the treated plots with a percentage increase of 12.4%. In case of PS-4, number of filled grains per panicle increased from 118 in the untreated plots to 137 in the treated plots with a percentage increase of 16.1%. For the local variety MTU-1010, the number of filled grains per panicle increased from an average of 129 in the untreated plots to 148 in the treated plots with a percentage increase of 36%. Secondly, there was a significant impact on the number of grains per panicle as well as the weight of grains per panicle in all three varieties. This is in agreement with a study conducted on rice where the crop was treated with *Azospirillum* co-supplemented with nitrogen, the treatment resulted in 24% increase in number of grains per panicle.[18] A similar study presented findings that addition of commercially available biofertilizer caused a significant improvement in the number of fertile grains per panicle amongst other parameters studied.[19]

Weight of Grains Per Panicle

The weight of filled grains per panicle was assessed amongst the treated and control plants across the three rice varieties (Figure 4). Improvement in the weight of grains also is a contributing factor towards improvement in yield. The weight of filled grains per panicle in PB-1 variety increased from an average of 2.64 grams in the untreated plots to 3.87 grams in the treated plots with a percentage increase of 46.5%. In case of PS-4, weight of filled grains per panicle increased from 3.31 grams in the untreated plots to 2.64 grams in the treated plots with a percentage increase of 25.37%. For the local variety MTU-1010, the weight of filled grains per panicle increased from an average of 3.26 grams in the untreated plots to

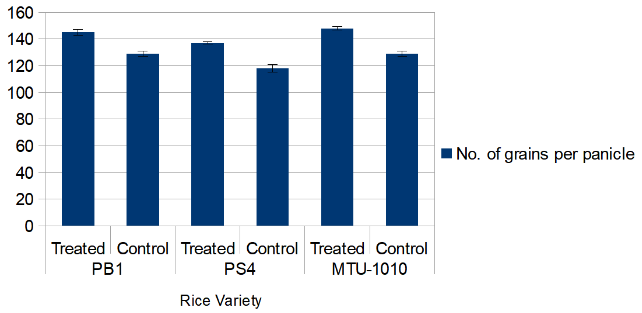

Fig. 3 : Number of grains per panicle (Mean ± SEM) of the rice varieties were evaluated. (Unpaired T-test, p<0.05)

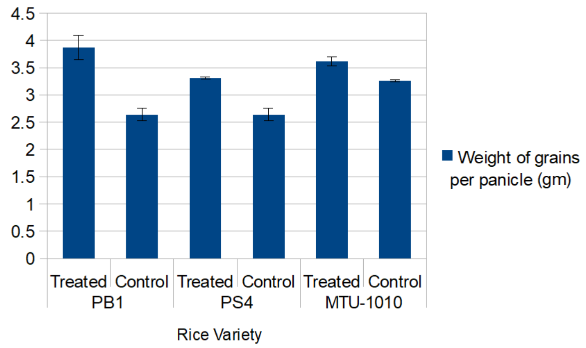

Fig. 4: Weight of grains per panicle (Mean ± SEM) of the rice varieties was evaluated. (Unpaired T-test, p<0.05)

3.62 grams in the treated plots with a percentage increase of 11.04%. In another study, the highest panicle weight to a combined treatment of NPK + *Azospirillum* +PSB+ Vermicompost (2.59 g) as compared to standard recommended NPK + FYM (1.98 g)20. This was mainly due to better assimilation of photosynthetic product indirectly which could be attributed to better elemental nutrient assimilation and distribution in crop.

Quantitative Observations

The mean harvested yield was calculated in quintals per acre for each of the three varieties. The mean increase in yield was calculated. In case of PB1, the mean yield increased by 72% (from 19.46 q/hectare in the untreated plot to 34.06 q/hectare in the treated plot). For PS4, the mean yield increased by 55% (from 24.7 q/hectare in the untreated plot to 38.35 q/hectare in the treated plot). In case of MTU-1010, the percentage increase recorded was 36% (from 27.1 q/hectare in the untreated plot to 37 q/hectare in the treated plot). A comparative evaluation is present in figure 5.

Similar to our findings, Tejaswini et al (2017)21 conducted a study on the effect of application of biofertilisers on two varieties of rice cultivated aerobically. *Azospirillum*, phosphorus solubilizing bacteria and potash mobilisers were used for this study and dosed at 5 kg/hectare. The nitrogen levels combined with biofertilizers were found to have a significant impact on grain yield for both the-cultivars. Maximum yield was obtained with the highest N level amended with biofertilizer in variety PA-6444.

A study was conducted in the Philipines where they evaluated the integrated effect of standard available biofertiliser on the productivity of rice under irrigated

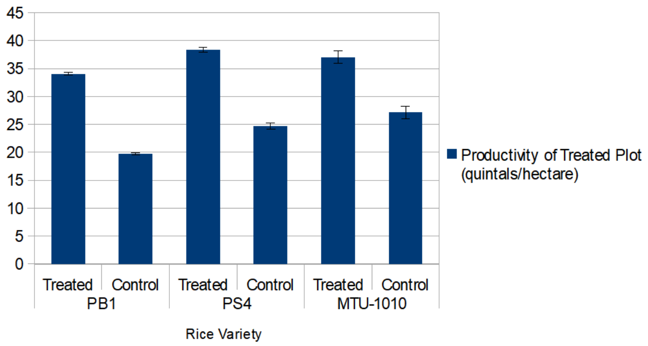

Fig. 5: Weight of grains harvested per hectare (Mean ± SEM) of the rice varieties were evaluated. (Unpaired T-test, p<0.05)

Table 3: Benefit cost ratio analysis of PB1, PS4 and MTU 1010

Variety		Average harvested yield (q/hectare)	Benefit-cost ratio
PB1	Treated	34.06	3.3
	Control	19.76	3.02
PS4	Treated	38.35	3.83
	Control	24.7	3.72
MTU-1010			
	Treated	37.05	1.99
	Control	27.17	1.86

conditions.[22] They found that the overall increase in yield was between 0.2-0.5 t/ha. They further highlighted that the use of these product would be most optimum in low to medium input systems, where there is a lot of room for improvement. It would be important to test the efficacy of the products under conditions of abiotic stress. The efficacy of a product will vary depending upon the environmental factors that govern that particular crop cycle. Since academic trials occur only in optimal conditions for growth of the crop, these studies never provide any insight into how the product in question would perform under conditions of stress.

The timing, application methodology and doses during the crop cycle are just as important as suggested.[23] They observed an increase in shoot and root length at seedling stage, followed by increase N uptake at the panicle post transplantation. However, it did not translate into a significant increase in yield in our study.

Benefit Cost Ratio Analysis

The cost benefit ratio for cultivating the two Basmati varieties and one local scented variety of rice was calculated. The total yield, the rate achieved per quintal was calculated and measured against the total expenditure incurred by the farmer were taken into consideration. Amongst the three varieties taken into consideration in this study, the proposed application schedule maximally benefited PB1 variety in terms of cost. The increase in yields in all three varieties was found to be statistically significant. In case of MTU-1010 being a local scented variety, the price it commands is much lesser than the basmati varieties, owing to which the benefit cost ratio is lesser. The improved benefit cost ratio, in all three varieties, therefore establishes the efficacy of the products Magicgro DripSOL and Magicgro Super economically.

In a similar study, the economic implications for improving the productivity of rice through benefit cost analysis[1] were discussed. Among the different combination of nutrient source higher mean benefit cost ratio of 3.41 was recorded from nutrient applied NPK in the ratio 150:60:40 with supplementation of *Azotobactor* and phosphate solubilising bacteria in the ratio (5 kg/ ha). They postulated that this particular treatment significantly provided better yield in comparison to the other treatments thus implying that it has improved productivity, nutritional status and profitability on a long term basis

The aim of this study was to assess the impact of microbial interventions in real time conditions as a part solution to the implementation of sustainable agriculture in commercial farming in India today. Magicgro DripSOL and Magicgro Super were tested and found to maximize the potential of the three rice varieties. Despite the varying geo-climatic conditions, the results remained consistent with a favourable improvement in the cost benefit cost ratio.

During the execution of this project, the region faced a drought of unparalleled severity. The untreated plots suffered major losses as the crop was not able to withstand the onslaught of abiotic stress and resulted in poor yields. The treated plots were still able to reach the average productivity for the particular varieties despite being rainfed. This study will be continued over time and definitive data will be obtained through trials conducted with various agricultural universities. It is important that the industry and Government work towards the development of products that are able to perform consistently with maximum benefit to the farmers of our country.

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Conflict of Interest

All the authors of this paper declare that they have no conflict of interest in publishing this paper.

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