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Promotion of rice seedling growth characteristics by development and use of bioformulation of *Pseudomonas fluorescens*

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ABSTRACT

The effect of various carrier based bioformulation was tested on germination, plant height, dry matter and yield. The seed bacterisation increased seed germination by 4.1 to 11.7% over control in 2007–08 experiment and by 3.5 to 11.2% over control in 2008–09 in pot experiment and by 3.0 to 12.1% over control in 2007–08 experiment and by 2.0 to 11.8% over control in 2008-09 microplot experiment. Among all treatments seed bacterisation with talc based bioformulation increased plant height very significantly. Similarly these carrier based bioformulations increased dry matter and yield in a significant manner. Though the wheat and soybean based bioformulation was found ineffective in enhancing all growth parameters but talc and Kaolinite based bioformulation equally found at par to enhance plant growth characteristics.

Key words: Bioformulation, PGPR, Plant growth parameters, *Pseudomonas fluorescens*, *Xanthomonas oryzae* pv *oryzae*

Increased public concern about environmental problems caused either directly or indirectly by the use of fertilizers, pesticides, herbicides, and fungicides, has prompted researchers to consider alternatives to these established chemical strategies for facilitating plant growth in agriculture, horticulture, and silviculture. Ideally, replacements for the chemicals that are currently in widespread use should not only enhance plant growth, but should also inhibit plant pathogens. One potential alternative may be the use of plant growth-promoting bacteria (Kloepper *et al.* 1989, Glick *et al.* 1999).

Pseudomonas spp are the most extensively studied plant growth-promoting rhizobacteria (PGPR), and are known to protect the plant from many deleterious soil and foliar plant pathogenic microorganisms (Ownley *et al*. 2003). The beneficial effects of *P. fluorescens* have been attributed to: (i) their ability to produce various compounds including phytohormones, siderophores, antibiotics, chitinase, b-1,3 glucanase, and hydrogen cyanide (HCN), phosphate solubilization and (ii) induced systemic resistance against a broad diversity of pathogens (Podile and Kishore 2006).

Fluorescent pseudomonades are often grouped under PGPR because of their ability to promote the plant growth and suppress plant diseases. *Pseudomonas fluorescens* is also a plant growth promoting bacteria and increased plant height 27% over control (Sakthivel *et al.* 1986). A PGPR *Pseudomonas fluorescens* B16 isolated from the roots of graminaceous plants has been shown to colonize the roots of various plants, and to increase the height, flower number, fruit number and total fruit weight of tomato plants (Minorsky 2008).

Apart from plant height and drymatter other yield components such as germination (%), panicle length and the number of spikelets/panicle directly contribute to grain yield and exhibit higher heritability than yield itself (Liu *et al*. 2010). Therefore, it is more feasible to focus on yield components rather than yield as a whole.

MATERIALS AND METHODS

A susceptible variety of rice Pusa Basmati 1 to bacterial leaf blight pathogen *Xanthomonas oryzae* pv. *oryzae* (Xoo) was selected for the experiment in glasshouse and microplot. The highly virulent culture of Xoo (Kaul Isolate) from Haryana was used. Inoculation of pathogen on leaf was done by leaf clip method (Kauffman *et al.* 1973). In this method leaf tips of 5 week old rice plant (Pusa Basmati 1) were clipped off by sterilized scissor and then the cut end of the leaves were submerged in the Xoo suspension. Rhizosphere bacteria, strain RRb-11 was obtained from Bacteriology unit

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of Division of Plant Pathology, IARI, New Delhi, which was biochemically characterized and identified as *Pseudomonas fluorescens*. It has been found to produce HCN, siderophore and 2, 4- diacetylphloroglucinol. The bacterial suspension of RRb-11 has been found effective against bacterial leaf blight of rice. However it is impractical to use cell suspension at commercial level thus in present work RRb-11 has been used to prepare bioformulation using some carriers. Therefore it is very important to understand the adaptability of plant to different carrier based formulations.

The two mineral carriers of talc and kaolinite and three powdered organic compounds of wheat bran, barley bran and soybean bran were chosen as carriers in this study. The carrier materials were autoclaved and dried aseptically in plastic trays at ambient room temperature.

Pseudomonas fluorescens strain (RRb-11) isolate was inoculated in nutrient agar (NA) broth and incubated on a shaker incubator at 150 rpm for 48 hr at 27ºC. After 48 hr of incubation, the broth containing 1×10^8 cfu/ml was used for preparation of talc, Kaolinite, wheat bran, barley bran and soybean bran based formulations.

The formulation was developed as described by Amer and Utkhede (2000) using different carriers. The CMC, carrier and bacterial suspension in broth (10^8 cfu/ml) were used in the ratio of 1:50:4. The bioformulation was prepared as: talc powder (5.0g carboxy methyl cellulose (CMC) + 250 g talc powder (autoclaved at 121^0C at 15 p.s.i. for 30 min) + 20 ml of bacterial suspension in broth; kaolinite powder (5.0g CMC + 250 g autoclaved kaolinite powder + 20 ml of bacterial suspension in broth); wheat bran (5.0g CMC + 250 g autoclaved wheat bran + 20 ml of bacterial suspension in broth); barley bran (5.0g CMC + 250 g autoclaved barley + 20 ml of bacterial suspension in broth); soybean bran (5.0g CMC + 250 g autoclaved soybean bran + 20 ml of bacterial suspension in broth) and 20 ml of bacterial broth suspension alone as a control. The materials were stored in sealed plastic bags at room temperature. Three independent samples were analysed with three replications for each analysis. This experiment was set up as completely randomised design (CRD) for glasshouse study and as randomised block design (RBD) for miniplot (1×1 m^2) and field study.

Seeds of Pusa Basmati 1 were surface sterilized with 1% sodium hypochlorite for 1-2 min. and washed and rinsed in sterilized distilled water (SDW) four times and dried overnight in shade. The rhizobacterial culture was separately grown in nutrient broth for 48 hr at 28ºC in shaker incubator. The broth obtained is dissolved in sterilized distilled water to obtain the population density of 10^7 cfu/ml (0.1 OD at 620 nm).The suspension was mixed with 2 % CMC and different carriers. The seeds were allowed to dry overnight in aseptic condition after coating with carrier mixed bacterial culture and CMC. Care was taken to avoid clumping of seeds. Seeds coated with slurry of CMC (without bacteria) served as control.

The different formulations prepared were assessed for their efficacy on the plant growth parameters in glasshouse conditions in 2007–08 and 2008–09. The pot culture study was undertaken with the different treatments by using completely randomised block design (CRD) with three replications. Eight rice seeds treated with different formulations of *P. fluorescens* were sown in each pot. An untreated control was also placed.

A field study conducted in microplot experiment in 2007–08 and 2008–09. The seeds treated with different bioformulations and grow for nursery. The 21 days old seedlings than transplanted in microplot of size 1×1 m^2. The study was framed with three replications for different treatments by using randomised block design (RBD).

A separate experiment was conducted at Agriculture Research Station, Banswara in 2009–10 and 2010–11 to test the efficacy of best performed bioformulation at field level against bacterial leaf blight zone. Being humid zone Banswara district is hot spot for bacterial leaf blight of rice thus this experiment was done by taking GP Dhan as susceptible cultivar under natural infection. Plot size of the experiment was 2 m × 1 m with three replications and the experiment was laid out in randomized block design (RBD). The treatments include hot water treatment (52ºC for 15 min.) seed treatment and sprays with copper oxy chloride (2.5g/kg seeds), streptomycin (100 ppm), 2- bromo-2 nitro propane-1,3-diol (Bactinash-200) (500 ppm) and talc based bioformulation of *Pseudomonas fluorescens* (5g/kg seeds). The control treatment was maintained without any spray. Disease Intensity (%) was recorded by following formula given by Jayaraman and Meena (2004).

$$\text{Disease Intensity (\%)} = \frac{\text{Leaf length - Lesion length}}{\text{Leaf length}} \times 100$$

N, P_2O5, and K_2O fertilizers were applied at the rate of 70: 35: 35 kg/ha. The prophylactic sprayings were given at 40 days after sowing (DAS) and second curative spray at the appearance of the disease (around 60-65 DAS). The disease intensity was recorded at 20, 40 and 60 days after transplanting (DAT).

A PGPR strain RRb 11 when mixed with different carriers; bioformulations developed were treated to rice seeds singly or in combination at the rate of 10^8 CFU/ml. Seeds were gently shaken on an orbital shaker in bioformulation suspension prepared in sterile distilled water for 24 hr. Seeds soaked in sterile distilled water served as control.

Germination tests were carried out by the paper towel method (ISTA 2003). The germination paper was soaked in distilled water, the PGPR treated and untreated seeds were seeded onto paper towels at the rate of 100 seeds/paper towel, rolled and wrapped with polythene to prevent drying, then incubated at 28ºC for seven days. After seven days of incubation, the towels were unrolled and the number of seed germinated were counted and represented as percentage

germination. The germination percentage was calculated from 8 days after sowing (DAS) to 12 DAS. Morphological parameters such as plant height was measured at 50 days after transplanting (DAT).Ten plants in the middle of the two rows of each plot were selected for trait measurements. Plant height was recorded from field surface to the top of the highest panicle of each plant. Plant samples (above ground portions) were collected at 50 days after planting (DAT) and to estimate total dry matter content. Grain yield was recorded at harvest.

RESULTS AND DISCUSSION

Effect of seed bacterisation in glasshouse experiment

Biological control of plant diseases using antagonistic microorganisms is becoming an important component of integrated plant disease management. Seed bacterisation with different bioformulations of *P. fluorescens* have influenced seed germination very effectively. It is found that the seed bacterisation increased seed germination by 4.1 to 11.7% over control in 2007–08 experiment and by 3.5 to 11.2% over control in 2008–09 experiment. The maximum seed germination was recorded when seeds were treated with talc based bioformulation in both the years. Seed treatment with different carriers based bioformulation able to improve plant growth parameters, viz. plant height (cm), dry matter (g/pot) and yield (g/pot). Talc based bioformulation significantly increased the plant height to 104.1 cm and 101.3 cm as compared to plant height in control (79.0 cm and 81.3 cm) respectively in 2007–08 and 2008–09 experiment. Kaolinite and talc+ kaolinite based formulations also showed good results in both the years (Table 1). All treatments *P. fluorescens* RRb-11 were found to be effective in increasing seed quality variables to various extents upon seed treatment. The most effective treatment was seed treatment with talc based bioformulation which significantly increased seed germination to 94.1% , plant height to 104.1 cm, dry matter to 328.1 and yield to 72.1 g/pot . Such plant growth promotion activities of *P. fluorescens* were reported earlier in crops such as, rice, wheat, sorghum, tomato, brinjal, chilli, redgram, blackgram, cucumber and sunflower (Hussain *et al*. 1990, Umesha *et al.* 1998, Raju *et al.* 1999, Prasad *et al*. 2002, Jeun *et al*. 2004).

Similarly these carrier based bioformulation treatment significantly increased dry matter to 328.1 g/pot and 317.3g/pot in talc based bioformulation treatment in 2007–08 and 2008–09 respectively. Kaolinite (321.0 g/pot), barley (315.1g/pot) and talc + kaolinite (318.4 g/pot) based combination in 2007–08 experiment while kaolinite (304 g/pot) in 2008–09 were also equally effective as compared to control. Seeds of PB 1 treated with RRb-11 based bioformulation also showed significant increase in yield. In 2007–08 experiment, seed treatment with talc based bioformulation significantly increased the yield to 72.1 g/pot as compared with 66.1 g/pot in 2008–09 experiment. Treatment with kaolinite (69.4 g/pot) and talc + kaolinite combination (67.4 g/pot) in 2007–08 experiment showed better results as compared with control (51.1 g/pot). Inoculation of wheat plants with *Pseudomonas*

Table 1 Effect of seed treatment with bioformulation of *P.fluorescens* on plant growth parameters in glasshouse experiment (2007–08 and 2008–09)

Treatment	Plant growth parameters							
	Seed germination (%)		Plant height (cm)		Dry matter (g/pot)		Yield (g/pot)	
	07-08	08-09	07-08	08-09	07-08	08-09	07-08	08-09
Kaolinite powder	90.3	91.2	100.3	96.4	321.0	304.1	69.3	61.5
Talc powder	94.1	93.2	104.1	101.3	328.1	317.3	72.1	66.1
Soybean bran	88.2	86.5	86.1	84.2	273.0	269.5	61.0	58.0
Barley bran	90.2	91.2	97.4	93.1	315.1	296.2	65.7	60.3
Wheat bran	86.5	85.5	88.1	84.0	275.1	270.5	62.1	60.5
Soybean bran + barley bran	90.0	91.7	90.3	87.3	297.5	290.3	63.0	65.5
Soybean + wheat bran	85.3	84.5	83.0	83.0	271.5	268.1	59.5	57.0
Barley bran + talc powder	91.5	92.0	93.1	90.5	309.3	290.0	63.1	59.3
Soybean bran + kaolinite powder	89.5	90.0	86.3	85.1	273.0	275.5	61.5	63.2
Barley bran + wheat bran	88.0	87.0	83.2	82.3	265.0	268.5	59.5	58.5
Soybean bran + talc powder	88.5	88.3	85.4	85.3	270.1	271.3	60.5	62.1
Barley bran + kaolinite powder	91.0	92.5	91.3	89.1	298.4	280.5	63.3	58.5
Wheat bran + talc powder	87.1	89.3	89.1	83.3	292.0	288.5	63.0	60.1
Wheat bran + kaolinite powder	89.5	89.0	88.0	82.1	277.1	278.2	62.1	59.3
Talc + kaolinite powder	92.5	92.0	98.2	93.5	318.4	298.1	67.4	61.3
Control	82.4	81.0	79.0	74.3	213.0	224.3	51.1	49.3
CD (P = 0.05)			3.21	3.01	17.58	21.3	3.52	3.41

fluorescens in potted soil naturally infested with *Gaeumannomyces graminis* var. *tritici*, showed 29% higher grain yield over untreated control (Mroz *et al.* 1994).

Pal *et al.* (2003) reported four PGPR strains belonging to fluorescent *Pseudomonas* group increased root length, shoot length and pod yield of groundnut which were attributed to production of siderophores and IAA like substances. Two strains of fluorescent *Pseudomonas* isolated from potato epidermis and celery roots significantly increased growth of potato plants up to 50 per cent greater than control in greenhouse assays (Kleopper *et al.* 1980). Vrany and Fiker (1984) reported that inoculation of tuber pieces with the isolates of *Pseudomonas fluorescens* caused better growth of potato, tomato, cucumber and lettuce. Potato plants bacterized with plant growth promoting *Pseudomonas* strain showed increased root and shoot fresh weight and observed simultaneous suppression of deleterious pathogenic microflora (Vanpeer and Schippers 1989).

Effect of seed bacterisation in microplot experiment

Similar to the seed bacterisation in glass hose, the seed bacterisation with different bioformulations in microplot also found effective in plant growth promotion. The treatment with different bioformulation increased seed germination by 3.0 to 12.1% over control in 2007–08 experiment and by 2.0 to 11.8% over control in 2008–09 experiment. Maximum seed germination was recorded when seeds were treated with talc based bioformulation in both the years. The talc based bioformulation treatment increased plant height to 98.4 cm and 99.3 cm as compared with control (78.1 cm and 78.4 cm) respectively in both the years. Similarly the treatment with kaolinite and talc + kaolinite based bioformulation was found equally effective in both the years. The treatment with talc based bioformulation significantly increased dry matter to 77.1 g/pot and 76.7 g/pot in 2007–08 and 2008–09 respectively. Plant growth promoting strains of *Pseudomonas fluorescens* ANP15 and *Pseudomonas aeruginosa* 7 NSK-2 were found to protect maize seeds from cold stock damage and significantly increased germination of maize seeds and enhanced dry matter content of inoculated plants (Hofte *et al.*, 1991). In 2007–08 experiment the seed treatment with talc based bioformulation significantly increased the yield to 366.1 g/m^2 as compare with 365.1 g/m^2 in 2008–09 experiment (Table 2). Bharti *et al.* (2004) evaluated the efficacy of 13 plant growth promoting rhizobacterial strains against chilli fruit rot and dieback incited by *Colletotrichum capsici*. They found that among these formulations, *P. fluorescens* and *B.subtilis* to be effective in increasing the seed germination and seedling vigour apart from reducing disease incidence under glasshouse conditions.

The overall results of the study showed that most bioformulations promoted growth characteristics of the rice seedlings compared to the control treatment. This is probably because the bioformulations may play effective roles in increasing and establishment and durability of antagonistic microorganisms in soil and possibly produce antibiotics, siderophores, hydrolytic enzymes, phytohormones and/or other volatile extra-cellular metabolites.

Table 2 Effect of seed treatment with bioformulation of *P.fluorescens* on plant growth parameters in microplot experiment (2007–08 and 2008–09)

Treatment	Plant growth parameters							
	Seed germination (%)		Plant height (cm)		Dry matter (g/plant)		Yield (g/m^2)	
	07-08	08-09	07-08	08-09	07-08	08-09	07-08	08-09
Kaolinite powder	89.4	88.7	97.0	93.8	71.5	71.0	353.0	342.4
Talc powder	92.5	91.3	98.4	96.4	77.1	74.5	366.1	361.5
Soybean bran	86.4	85.5	83.0	85.6	56.0	55.6	314.0	308.5
Barley bran	90.0	87.5	95.1	88.1	70.3	69.0	347.1	340.5
Wheat bran	87.5	84.3	81.1	78.5	61.2	58.5	321.4	307.2
Soybean bran + barley bran	88.5	88.0	83.1	81.5	58.5	55.0	315.4	311.5
Soybean + wheat bran	83.4	81.5	80.1	83.5	51.9	52.4	303.1	298.5
Barley bran + talc powder	89.5	87.1	89.3	87.4	68.4	69.4	337.3	332.4
Soybean bran + kaolinite powder	86.2	89.4	83.3	82.5	56.4	55.1	313.2	310.0
Barley bran + wheat bran	85.2	86.4	84.2	85.0	53.3	55.4	307.0	305.5
Soybean bran + talc powder	87.4	86.0	83.4	81.4	55.3	51.2	311.1	313.2
Barley bran + kaolinite powder	88.0	88.5	89.0	86.1	65.7	67.5	334.0	334.5
Wheat bran + talc powder	85.0	88.1	84.1	85.3	60.0	62.4	325.4	314.1
Wheat bran + kaolinite powder	88.2	86.4	85.4	87.5	61.8	64.5	329.4	325.1
Talc + kaolinite powder	91.5	90.5	97.2	95.3	73.2	71.3	357.1	349.5
Control	80.4	79.5	78.1	74.3	42.0	50.1	272.1	285.4
CD (P=0.05)			2.01	3.52	7.42	4.31	37.45	42.45

Effect of seed treatment on bacterial leaf blight

When seeds were treated with various carrier based bioformulation of *Pseudomonas fluorescens* in microplot conditions, the talc based bioformulation treatment showed minimum disease intensity of 8.47% and found to reduce disease intensity to the extent of 83.87% as compared with control . The seed treated with kaolinite based bioformulation exhibited disease intensity of 12.66% which reduce disease intensity by 75.9% as compared with control. The % disease intensity in untreated control was 52.6%.Talc based formulation of *P. fluorescens* Pf1 was coated on to seeds at the rate of 4 g/kg (10^7 cfu/g) of chickpea seeds (cv Shoba) for the management of chickpea wilt. Sowing of treated chickpea seeds resulted in establishment of rhizobacteria on chickpea rhizosphere (Vidhyasekaran and Muthamilan 1995). Treatment of pigeonpea seeds with talc based formulation of *P. fluorescens* (Pf1) effectively controlled fusarial wilt of pigeonpea under greenhouse and field conditions (Vidhyasekaran *et al*. 1997). Soaking of rice seeds in water containing 10g of talc based formulation of *P. fluorescens* consisting mixture of PF1 and PF2 (10^8 cfu/g) for 24 hr controlled rice sheath blight under field condition (Nandakumar *et al*. 2001). Previous research has shown the practicality of introducing various carrier based commercial substrates for crop production in order to increase plant vigour, control disease and increase yields (Kokalin-Burelle 2003, 2006, Kloepper *et al.* 2004). In the present work most

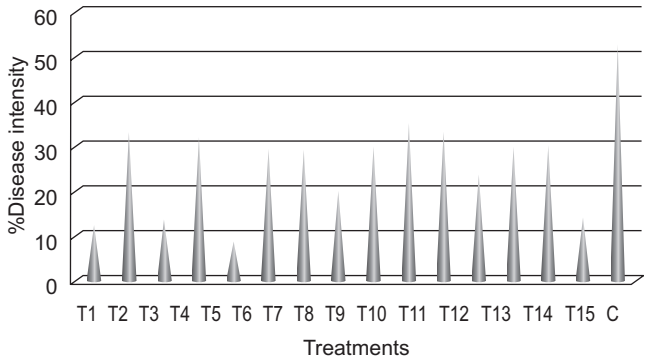

Fig 1 Effect of seed treatment with different carrier based bioformulations of *Pseudomonas fluorescens* against bacterial leaf blight of rice in microplot condition. T1- Kaolinite powder+ RRb11, T2- Talc powder + RRb11, T3- Soybean bran+ RRb11, T4- Barley bran +RRb11, T5- Wheat bran+RRb11, T6- Soybean bran + Barley bran +RRb11, T7- Soybean bran + wheat bran+ RRb11, T8- Barley bran + talc powder+RRb11, T9- Soybean bran + Kaolinite powder + Rrb11, T10- Barley bran+ Wheat bran + RRb11, T11- Soybean bran +Talc powder+ RRb 11, T12- Barley bran + Kaolinite Powder+ RRb11, T13- Wheat bran+ Talc powder+RRb11, T14- Wheat bran + Kaolinite Powder +RRb11, T15-Talc Powder+ Kaolinite Powder +RRb11, T16- Control

treatments reduced disease intensity as compared to control, indicating that systemic resistance was induced by PGPR treatments. Application of PGPR strain RRb-11 did not adversely affect population of beneficial indigenous

Table 3 The comparative effect of chemical treatment and talc based bioformulation of *Pseudomonas fluorescens* against bacterial leaf blight of rice

Treatment	09-10		10-11		Cumulative mean %DI		Yield (q/ha)	
	%DI	% ROC	% DI	% ROC	% DI	% ROC	Mean	% IOC
Seed treatment with COC + streptomycin	21.2 (27.4)^{b}	27.8	19.3 (26.0)^{ab}	25.5	20.2	26.8	28.43	13.4
Spray with Bactinash-200	22.8 (28.5)^{ab}	22.4	19.8 (26.3)^{ab}	23.5	21.3	22.8	28.15	12.4
T1 +2 sprays of COC + streptomycin	10.2 (18.2)^{d}	65.3	8.5 (16.9)^{d}	67.2	9.3	66.3	34.22	36.6
Hot water treatment +2 spray of COC + streptomycin	14.7 (22.5)^{cd}	50	11.4 (19.6)^{cd}	66	13.1	52.5	31.27	24.8
ST with *Pseudomonas fluorescens* bioformulation	18.1 (25.4)^{bc}	38.4	15.1 (22.7)^{bc}	41.7	16.6	39.8	30.88	23.3
ST + spray with *P.fluorescens* bioformulation	12.2 (20.4)^{d}	58.5	12.2 (20.4)^{cd}	52.9	12.2	55.8	32.46	29.6
Hot water treatment + spray of Bactinash-200	14.1 (22.0)^{cd}	52	11.9 (20.1)^{cd}	54	13	52.9	31.08	24.1
Control	29.4 (32.8)^{a}		25.9 (30.6)^{a}		27.6		25.05	
CV	11.2		11.7					
CD (*P*= 0.05)	4.8		4.7					

DI, Disease Intensity; ROC, Reduction over control; IOC, Increase over control

Figures in parentheses are arcsine transformed values

rhizosphere bacteria including fluorescent pseudomonads and did not increased disease intensity.

Comparative effect of treatments against bacterial leaf blight

The above results encouraged us to test the talc based bioformulation against bacterial leaf blight of rice. Thus an experiment was conducted to test the comparative effect of chemical treatment and talc based bioformulation of *Pseudomonas fluorescens* against bacterial leaf blight (BLB) of rice. The treatments comprising chemicals and biological control agent, a powder formulation of *P. fluorescens* RRb-11 was tested against BLB.

There was a significant reduction in disease intensity in most of the treatments except those treatments where only prophylactic spray was done, ie seed treatment with copper oxychloride (COC) and streptomycin and one spray with 2-bromo-2 nitro propane-1,3-diol (Bactinash-200). Maximum reduction of 65.3% and 67.2% in disease intensity over control was recorded when seed treatment and two sprays with copper oxychloride and streptomycin was done in both the years respectively. There was also a significant reduction in disease intensity was recorded when seed treatment and spray with talc based bioformulation of *P.fluorescens* was done. This treatment reduced disease intensity by 58.5% and 52.9% in 2009 and 2010 respectively. In 2009–10 experiment the seed treatments and spray with COC+ streptomycin and *Pseudomonas fluorescens* showed at par results. Lowest cumulative mean % disease intensity of 9.3% was recorded when seeds were treated and plants were sprayed with copperoxychloride and streptomycin. But more interestingly the seed treatment and spray with talc based bioformulation also showed significantly low cumulative mean % disease intensity of 12.2%. The mean maximum yield of 34.22 q/ha was recorded when seeds were treated and plants were sprayed with copperoxychloride and streptomycin which is very closely followed by seed treatment and spray with talc based bioformulation of *P.fluorescens.*

Our study has shown that seed treatment with bioformulation of *Pseudomonas fluorescens* overall increase plant growth promoting parameters. The treatment with talc based bioformulation not only reduces disease intensity but enhances germination, increase height, increase dry matter and ultimately increase yield. Also the field trial revealed at par efficacy against bacterial leaf blight of rice. Thus this bioformulation can be exploited commercially.

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