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Effect of conjoint use of indigenous PGPR and chemical fertilizers on soil health and yield of capsicum

S GUPTA, R KAUSHAL, RS SPEHIA* and G SOOD

Department of Basic Sciences
***Department of Soil Science and Water Management**
Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan 173230 HP, India
Email for correspondence: shivi_rs88@yahoo.co.in

ABSTRACT

In the context of increasing international concern for nutrition, food and environmental quality the use of plant growth promoting rhizobacteria (PGPR) for reducing chemical inputs in agriculture is a potentially important issue. The present investigation was undertaken to study the effects of integrated nutrient management systems on soil health and growth and yield of capsicum mid-hills of northwestern Himalayas under open conditions. Two PGPR namely (*Bacillus subtilis*) and PM_9 (*Bacillus* sp) were tried singly or consortia at varying (60 and 80%) doses of N and P chemical fertilizers and compared with 100 per cent recommended doses (RD) of NPK (control) under randomized block design replicated thrice. The application of consortia of PGPR with 80 per cent RD of N and P fertilizers not only produced maximum yield (22.68 tons/ha) but also saved 20 kg N/ha and 15 kg P/ha fertilizers over control. Maximum N (144.71 kg/ha) and P (16.68 kg/ha) uptake was noted under control which was significantly at par with treatment comprising 80 per cent RD of chemical fertilizers and consortia of PGPR. The results therefore suggest that application of PGPR isolates along with 80 per cent chemical fertilizer doses may be used for enhanced yield without destructing of soil health in mid-hills of northwestern Himalayas.

Keywords: PGPR; integrated; capsicum; NPK; yield; soil health

INTRODUCTION

Plant growth promoting rhizobacteria (PGPR) are considered as efficient microbial competitors in the root zone to enhance plant growth through various modes of action such as fixation of atmospheric nitrogen, phosphate solublization, synthesis of phytohormones and siderophores, induction of disease resistance/antagonism against soil borne pathogens, xenobiotics degradation and enhancing efficiency of applied inputs.

In the context of increasing international concern for food and environmental quality the use of plant growth-promoting rhizobacteria (PGPR) for reducing chemical inputs in agriculture is a potentially important issue. PGPR have

been applied to various crops to enhance seed germination, growth, crop yield and quality but only a few isolates have been commercialized (Datta et al 2011).

Capsicum annuum L commonly known as bell pepper or sweet pepper or Shimla Mirch is a domesticated species of genus *Capsicum* that belongs to nightshade family ie Solanaceae.

In order to meet the growing demand of burgeoning population large amount of herbicides, pesticides and fertilizers are being applied to the fields every year to achieve maximum production. The indiscriminate use of these chemical inputs has deleterious effects on agro-ecosystem as well as productivity of the crop. Also the ever increasing cost of pesticides or fertilizers coupled with consumer preference for organic food has led to supplementation and/or substitution of these inputs with organic or biodegradable inputs to sustain soil health. Further the integrated use of different organics not only increases the nutrient status of the agricultural soil but also helps to improve the various physical, chemical and biological properties of soil leading to improved soil fertility and also to increase fertilizer use efficiency (Mrkovacki and Bjelic 2011).

Therefore PGPR are gaining importance as cost-effective, eco-friendly, non-hazardous and non-bulky agri-inputs which can supplement about 25-50 per cent of chemical fertilizers and decrease the deleterious effects of environmental stresses (Mishra et al 2010). However the extent of benefits from PGPR depends on their number and efficiency which are governed by a large number of soil and environmental factors (Lucy et al 2004). Therefore the present study was carried out to see the effect of conjoint use of indigenous PGPR and chemical fertilizers on soil health and productivity of capsicum.

MATERIAL and METHODS

The experiment was conducted at research farm of Department of Soil Science and Water Management, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh. Study area is located at an altitude of 1150 m amsl and lies between $30^{o}50^{'}30^{"}$ N latitude and $77^{o}08^{'}30^{"}$ E longitude. Capsicum variety California Wonder was used in the experiment. Cultures of PGPR isolates (RS_2 and PM_9) originally isolated from roots and rhizosphere of capsicum were procured from culture collection centre of microbiology section of Department of Basic Sciences, Dr YS Parmar University of Horticulture and Forestry.

The experimental soil was sandy loam, nearly neutral (pH 7.2), without soluble salt problem (EC 0.28 dS/m) and low in organic carbon (0.40%). Available N, P and K content of soil was 227.3, 36.2

and 224.5 kg/ha respectively. The PGPR inoculum was applied as seedling dip in liquid culture of RS_2 and PM_9 strains (cell density about 10^8 cfu/ml) for 30 minutes and planted at 60 × 45 cm distance. The experiment was laid out in randomized block design replicated thrice. Treatments used were T_1 (Recommended doses (RD) of NPK), T_2 (80% RD + RS_2), T_3 (80% RD + PM_9), T_4 (80% RD + RS_2 + PM_9), T_5 (60% RD + RS_2), T_6 (60% RD + PM_9), and T_7 (60% RD + RS_2 + PM_9). recommended doses of N, P_2O_5 and K_2O were 254, 77 and 350 kg/ha respectively. Calcium ammonium nitrate (25% N), single super phosphate (16% P_2O_5) and muriate of potash (60% K_2O) were used as chemical fertilizers. Other intercultural practices such as insect pest and disease management were followed as per standard recommendations.

The data were recorded on plant growth, number of fruits/plant, average fruit weight and fruit yield. Plant nitrogen (N), phosphorus (P) and potassium (K) content was determined as per methods described by Jackson (2005). Nutrient uptake (kg/ha) was worked out by multiplying total NPK concentration of whole plant with total dry matter content. Available N, P and K content of soil was determined following standard procedures (Tandon 2009). The data on plant growth, yield and nutrient uptake were subjected to statistical analysis using SPSS (16v) and MS excel at 5 per cent level of significance.

RESULTS and DISCUSSION

A perusal of data (Table 1) reveals that the maximum plant height (70.2 cm) was under T_4 that was statistically at par with T_1, T_2 and T_3. Maximum dry matter accumulation (37.54 q/ha) was observed under T_1 followed by T_4 (35.89 q/ha). Gupta et al (2014) also reported that the application of *B subtilis* resulted in increased shoot length (41.54%) and shoot biomass (41.46%) over un-inoculated control.

Similarly maximum fruit yield (22.68 tons/ha) was also noted under T_4 which was significantly at par with T_1 (22.66 tons/ha). Higher yield under these treatments was due to more number of fruits per plant and average fruit weight. Maximum number of fruits (10.7/plant) was noted under treatment T_4 which was statistically at par with T_1. However maximum fruit weight (87.5 g) was noted under treatment T_1 which was statistically at par with T_2, T_3 and T_4. Zaghloul et al (2007) also reported that application of *B subtilis, Trichoderma harzianum* either individually or in combination produced significantly more number of fruits per plant, weight of fruits and consequently total yield of tomato fruits.

The data on available soil nutrient status (Table 2) reveal maximum available N (257.6 kg/ha) in T_1 which was about 11.8 per cent higher over initial soil test value. Such an increase was statistically at par with T_2, T_3 and T_4. Similar trend was observed

Table 1. Effect of bacterial inoculums on the growth and yield of capsicum under open conditions

Treatment plant	Plant height (cm)	Plant biomass (q/ha)	# fruits/plant	Fruit weight (g)	Yield/ (tons/ha)
T_1	66.3	37.54	10.6	87.5	22.66
T_2	68.3	34.08	9.6	84.0	19.78
T_3	68.4	34.83	9.4	83.8	19.41
T_4	70.2	35.89	10.7	86.6	22.68
T_5	55.0	30.53	8.9	67.1	14.74
T_6	54.4	30.72	9.0	69.7	15.38
T_7	59.8	32.55	9.4	70.9	16.28
$CD_{0.05}$	4.0	82.80	1.0	6.7	2.83

Table 2. Effect of bacterial inoculums on soil parameters

Treatment	Available nutrients (kg/ha)			Nutrient uptake (kg/ha)		
	N	P	K	N	P	K
T_1	257.6	46.7	280.2	142.29	15.00	163.52
T_2	237.3	43.7	229.5	127.45	11.59	121.87
T_3	238.6	44.2	231.3	125.06	12.07	124.06
T_4	247.9	46.2	232.4	133.48	13.99	128.36
T_5	196.6	34.4	203.0	103.62	8.98	113.79
T_6	206.4	35.0	203.5	104.59	9.11	112.62
T_7	213.3	36.8	204.1	111.49	10.63	121.46
$CD_{0.05}$	22.2	4.2	20.7	8.76	1.50	9.56

in available phosphorus status of soil. The higher available N in 80 per cent RD of chemical fertilizers in conjunction with either RS_2 or PM_9 isolate or their consortium may be attributed to more asymbiotic nitrogen fixation as well as the mineralization of the organic matter in the soil by bacterial isolates.

The significant increase in available phosphorus may be attributed to the phosphate solubilising activity of the microorganisms which might have brought some P from unavailable to available pool. The enhanced nutrient availability especially N and P in the presence of plant growth promoting rhizobacteria has also been reported by Bertrand et al (2000). Furthermore T_1 registered maximum available K (280.2 kg/ha) followed by treatment T_2, T_3 and T_4. Since available K was comparable among T_1, T_2, T_3 and T_4 it is inferred that the differences in available K in soil were only due to different rates of fertilizer application.

The data on nutrient uptake (Table 2) indicate maximum N (142.29 kg/ha) and P (15.0 kg/ha) uptake in T_1 which was statistically at par with T_2, T_3 and T_4. Potassium uptake on the other hand was maximum in T_1 (163.52 kg/ha) followed by T_4. The increased N and P uptake in PGPR treated plants may be explained in light of the observations made by Chang et al (2005) who reported increased fertilizer use efficiency when applied along with PGPR strains.

CONCLUSION

PGPR (RS_2 and PM_9) have increased availability and uptake of N and P thereby resulting in higher growth and yield of capsicum. The response of capsicum was statistically at par for T_1 (recommended doses (RD) of NPK) and T_4 (80% RD + RS_2 + PM_9). It is therefore concluded that conjoint application of consortia of RS_2 and PM_9 isolates at 80 per cent recommended doses of chemical fertilizers may be recommended for capsicum under mid-hills of northwestern Himalayas.

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