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EFFECT OF PLANT GROWTH PROMOTING RHIZOBACTERIA (PGPR) ON GROWTH AND YIELD OF BITTER GOURD

K. S. Naveen Kumar[1], B. V. Sowmyamala[2], P.G. Sadhan Kumar[3], P.N. Vasudev[4], R. Vasantha Kumar[5], H.T. Nagaraj[6]

[1]College of Horticulture, PG center, University of Horticulture Sciences, Bagalkote, GKVK, Bangalore, Karnataka,

[2]Assistant Horticulture Officer, Deputy Director of Horticulture Office, Dharwad, Karnataka, [3]Department of Oleriiculture, College of Horticulture, KAU, Vellanikera, Thrissur, Kerala, [4]Department of Horticulture, College of Agriculture, Bheemrayanagudi, Karnataka. [5]Horticulture Officer, Senior Assistant Director of Horticulture Office, Belgaum, Karnataka, [6]Department of Horticulture, College of Agriculture, VC Farm, Mandya, Karnataka.

ABSTRACT: A field study was conducted to determine the effect of plant growth promoting rhizobacteria (PGPR) on growth and yield of bitter gourd. Four PGPR strains (Azospirillum, Phosphorous solubilising bacteria, Pseudomonas flourescens and Bacillus subtilis), one commercial organic product (Aishwarya) and non inoculated control were used. The study revealed that seeds inoculated with Azospirillum (basal @ 5 kg ha^{-1} + 40 days after sowing (DAS) @ 5 kg ha^{-1}) recorded early germination (6.48 days). The maximum vine length (4.42 m) was recorded in basal @ 2 l/plant application of both Bacillus subtilis and Pseudomonas flourescens @ 2.5 kg ha^{-1}. Number of primary branches was maximum (4.80) in plants applied with phosphorous solubilising bacteria (PSB) as basal @ 5 kg/ha and 40 DAS @ 5 kg/ha. Tap root length (23.57 cm) and secondary root length (39.88 cm) were highest in the plants supplied with Azospirillum (basal @ 5 kg ha^{-1} + 40 DAS @ 5 kg ha^{-1}) where as, dry root weight (4.64 g) was more in case of double application of Bacillus subtilis basal @ 2 l $plant^{-1}$ + 40 DAS @ 2 l $plant^{-1}$. Two time application of Bacillus subtilis basal + 40 DAS @ 2 l $plant^{-1}$ produced the maximum yield $plant^{-1}$ and yield $plot^{-1}$ (2.72 kg and 16.33 kg respectively).

Key words: bitter gourd; PGPR; plant growth; yield;

INTRODUCTION

Vegetables are rich source of vitamins, proteins, carbohydrates and minerals, which constitute an important component in human nutrition. Besides the nutritional value of vegetables, increased interest is being bestowed on the functional and therapeutic benefits of vegetables in human health. Cucurbit vegetables are fair source of thiamine and riboflavin. Bitter gourd is the leading vegetable crop of India, the higher yield and maximum returns make it the most preferred vegetable crop of Indian farmers. Agriculture is highly dependent on the use of chemical fertilizers, growth regulators, fungicides and pesticides for obtaining increased yield. This dependence is associated with problems such as environmental pollution, health hazards, interruption of natural ecology, nutrient recycling and destruction of biological communities that otherwise support crop production. The use of bioresources to replace these chemicals is gaining importance. In this context, plant growth promoting rhizobacteria (PGPR) are often considered as novel and potential tool to provide substantial benefits to agriculture.

During the past one decade, scientists are looking back at the rhizospere system and have identified PGPR, which have a great potential and promise for promoting plant growth and improving soil health (Tilak et al., 2003). PGPR are free living bacteria that have the ability to improve plant growth through suppression of deleterious root colonizing microorganisms and by production of plant growth regulators (Kloepper and Schroth, 1981). PGPR are present in large number on the root surface where the plants exudates and lyrates provide nutrients (Nelson, 2004). The beneficial response of crops to inoculation with these PGPR is attributed to better seed germination and seedling emergence, improved nutrition, and reduction in disease incidence and increased crop production.

MATERIALS AND METHODS

In the present investigation, the crop was raised during the Rabi season from September to January. The high yielding variety Preethi, developed by Kerala Agricultural University was selected for the study. Four plant growth promoting rhizobacteria (PGPR) viz., Azospirillum, Phosporous solubilising bacterias (PSB), Pseudomonas fluorescens, Bacillus subtilis were used along with a commercial product Aishwarya. The experiment was laid out in Randomized Block Design (RBD) with three replications. There were six plants in a plot with two rows of three plants each with common border rows. Spacing adopted was 2 x 0.75 meters. The manurial and fertilizer doses were based on the POP recommendation for bitter gourd. As per this the FYM and NPK were applied at the rate of 20 – 25 tonnes and 70:25:25 kg $N:P_2O_5:K_2O$ ha $^{-1}$ respectively.

Treatments

T_1 - Manures and fertilizers as per POP recommandations
T_2 - T_1 + Azospirillum-5kg/ha (basal)
T_3 - T_2 + Azospirillum-5kg/ha (40DAS)
T_4 - T_1 + PSB - 5kg/ha (basal)
T_5 - T_4 + PSB - 5kg/ha (40 DAS)
T_6 - T_1 + Pseudomonas flourescens - 2.5kg/ha (basal)
T_7 - T_6 + Pseudomonas flourescens - 2.5kg/ha (40DAS)
T_8 - T_1 + Bacillus subtilis suspension - (10^8 cfu/ml) 2 l/plant (basal)
T_9 - T_8 + Bacillus subtilis - (10^8 cfu/ml) 2 l/plant (40DAS)
T_{10} - T_1 + Aishwarya - 30g/plant (basal)
T_{11} - T_{10} + Aishwarya - 30g/plant (40DAS)

The talc based PGPR viz., Azospirillum, Phosporous Solubilising Bacteria (PSB), and Pseudomonas fluorescens were applied to the soil and Bacillus subtilis suspension having concentration of 10^8cfu ml^{-1} was applied. Aishwarya was applied to the soil as granular application.

Growth parameters

Number of days taken from sowing to germination was recorded. Vine length at 90 days after sowing (DAS) was recorded in five plants per plot and the average was taken and measurement was taken from base of the vine to the growing tip of the plants. Number of branches in five plants per plot was counted at 50 DAS. Root length was recorded in five plants per plot at the end of crop and average was taken. Measurement was taken from base of the vine to the tip of the mother root.

Yield characteristics

Weight of fruits from five plants was recorded and average was calculated to get fruit yield per plant. Weight of fruits from each plot after each harvest was recorded and added to get the total yield per plot.

Statistical analysis

Data were analyzed as per MSTATC package. To determine the influence of PGPR on each character pooled analysis over treatments was carried out.

RESULTS AND DISCUSSION

Growth characters

Analysis of variance showed that there was significant difference among the treatments for the characters vine length (90DAS) and root length. Means of various vegetative characters of bitter gourd at various stages of growth are given in Table 1. Days to germination was the earliest in Azospirillum treatment (T_3) followed by Pseudomonas flourescens application (T_7) which recorded 6.48 and 6.59 days respectively. Phosphorous solubilizing bacteria (PSB) treated seeds (T_4) took more days to germination (7.85days). The influence of different treatments in improving the vegetative characters of bitter gourd, in relation to days to germination, vine length, number of primary branches and root length are discussed (Fig 1 & 2). Two time application of Azospirillum (T_3) was the best treatment which took 6.48 days for germination. The early germination could be due to the ability of Azospirillum to produce some growth promoting substances like auxins which might have led to enhance the physiological process in seeds, increased uptake of the nutrient and moisture (Kloepper, 2003). The colonization of this bacterium reduced the incidence of seed mycoflora which indirectly enhanced seed germination. Similar results have been obtained for Azospirillum on germination of watermelon and okra as reported by Nallathambi et al. (2003) and Prabhu et al. (2003) respectively.

Table 1. Effect of different treatments on vegetative characters of bitter gourd

Treatments	Days to germination	Vine length (m)	Primary branches (No)	Root length (cm)
T1	6.76	3.15	4.43	15.64
T2	7.07	3.80	3.23	18.57
T3	6.48	3.41	4.40	23.57
T4	7.85	3.60	3.93	16.89
T5	6.91	3.50	4.80	17.58
T6	6.93	4.42	3.66	18.24
T7	6.59	3.24	4.13	17.62
T8	7.63	4.42	4.33	14.78
T9	7.05	3.88	3.60	18.24
T10	7.57	3.37	4.40	14.21
T11	7.71	4.10	4.26	17.27
CD (0.05)	NS	0.56	NS	4.76

NS - Not significant

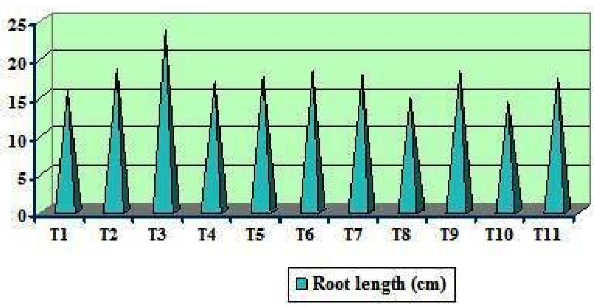

Fig. 2 Effect of different treatments on root length of bitter gourd.

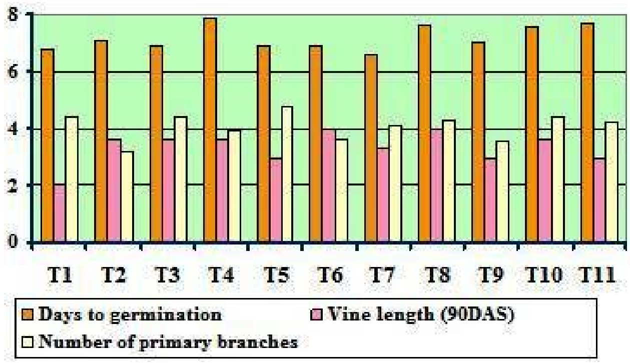

Fig. 1 Effect of different treatments on days to germination, vine length and number of primary branches of bitter gourd.

The maximum vine length of bitter gourd was recorded in Bacillus subtilis suspension (10^8 cfu/ml) (T_8) and Pseudomonas flourescens (T_6) with 4.42 m. Control (T_1) recorded the minimum vine length (3.15 m). The probable, reason for the increase in the biometrical characters of the crop may be a blend of volatile organic compounds (Kloepper, 2003). Kevin (2003) reported that some of the strains of Bacillus were found to produce mixtures of lactic acid, isovalaric acid, isobutaric acid and acetic acid which might have directly or indirectly promoted the growth attributes. This finding is in confirmation with the results of Lucas-Garcia et al. (2004) in tomato and pepper.

The maximum number of primary branches was recorded in PSB treatment (T_5) followed by Aishwarya application (T_{10}) which recorded 4.80 and 4.40 respectively. Azospirillum (T_2) recorded minimum number of primary branches (3.23). The maximum length of taproot was recorded in Azospirillum (double application) treatment (T_3) followed by Azospirillum (single application) treatment (T_2) which recorded 23.57 cm and 18.57 cm respectively. Root length was minimum in T_{10} (14.21 cm). Highest number of primary branches in bitter gourd due to inoculation of PSB may be because of the ability of PSB to solubilize and increase the availability of inorganic phosphorous from insoluble or other wise fixed form to soluble or readily available phosphorous (Bahadur et al., 2004). The principle mechanisum of PSB for mineral phosphorous solubilization is the production of organic acids and acid phosphatases which play a major role in the mineralization of organic phosphorous in soil. Gluconic acid seems to be the most frequent agent of mineral phosphate solubilization along with 2 keto gluconic acid, another organic acid identified in PSB strains with phosphorus solubilizing ability (Kevin, 2003). Anburani and Manivannan (2002) reported the increase in number of secondary branches in brinjal by PSB application. This result is also supported by the findings of Naidu et al. (2002) who has reported that the brinjal plants supplied with PSB produced the highest number of primary branches.

Yield characteristics

Analysis of variance showed that there was significant difference among the treatments for the characters fruit yield per plant and fruit yield per plot. Means of yield parameters of bitter gourd for different treatments are given in Table 2. There was significant effect of application of PGPR on fruit yield per plant. Application of Bacillus subtilis suspension (10^8 cfu/ml) 2.l/plant as basal and also 40 days after sowing (T_9) significantly increased the yield in bitter gourd up to 2.72 kg/plant. The second best treatment was Pseudomonas flourescens (T_6) application (2.36 kg/plant) this was on par with Aishwarya (T_{11}). The lowest yield (1.42 kg/plant) was recorded in control plot (T_1) which was on par with Azospirillum (T_2), Azospirillum ($T_{.3}$), PSB (T_4), PSB (T_5) and Aishwarya (T_{11}).

Table 2. Effect of different treatments on yield of bitter gourd

Treatment	Yield per plant (kg)	Yield per plot (kg)
T1	1.42	8.55
T2	1.47	8.85
T3	1.43	8.54
T4	1.52	9.08
T5	1.51	9.08
T6	2.36	14.19
T7	1.94	11.61
T8	1.72	10.30
T9	2.72	16.33
T10	1.61	9.65
T11	2.06	12.35
CD (0.05)	0.29	1.74

Fig. 4 Fruits harvested from T_9 (Bacillus subtilis @ 2 l plant^{-1}, basal and 40 DAS) plot

Fig. 3 Fruits harvested from control plot

There was significant effect of application of PGPR on fruit yield per plot. Application of Bacillus subtilis suspension (10^8 cfu/ml) as basal and also 40 days after sowing (T_9) significantly increased the yield in bitter gourd (16.33 kg/plot), the second best treatment was Pseudomonas flourescens (T_6) application (14.19 kg/plot) which was on par with Aishwarya (T_{11}). The lowest yield (8.55 kg) was recorded in control plot (T_1) and was on par with Azospirillum (T_2), Azospirillum (T_3), PSB (T_4), PSB (T_5) and Aishwarya (T_{11}). This noticeable increase in yield might be due to the production of phytohormones such as zeatin, gibberellic acid and abscisic acid by Bacillus subtilis (Kilian et al., 2000). Woitke et al. (2004) also observed that Bacillus subtilis isolate increased yield of plants in addition to inducing resistance to biotrophic fungal plant pathogens. These are presumably transported into the shoot via the xylem. Intensified and prolonged synthesis of these phytohormones may be regarded as a cause of delayed senescence and improved yields (Kilian et al., 2000). Since the application of Bacillus subtilis leads to stronger root growth, there may also be an increased synthesis of plant cytokinins, which also cause delayed senescence and higher yields, as described above. The results of this experiment are supported by the findings of Yobo et al. (2004), who recorded significantly higher fruit yield in pepper by application of Bacillus subtilis. Omar and El-Kattan (2003) and Boehme et al. (2005) reported that cucumber plants inoculated with Bacillus polymyxa had positive effect on enzymatic activities of cucumber plants and had positive and significant effect on cucumber yield up to 25% more than control and produced good quality fruits.

CONCLUSION

It can be inferred that inoculation of bitter gourd with plant growth promoting rhizobactreia (PGPR) enhanced its growth, yield and quality attributes. Among the different PGPR studied, Bacillus Subtilis suspension (10^8 cfu/ml) with two time application first as basal @ 2 l plant $^{-1}$ and second at 40 DAS @ 2 l plant $^{-1}$ performed best with respect to yield, flower and biometrical characters. The next best treatments were two time application of Pseudomonas flourescens, Azospirillum and PSB respectively.

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