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Effect of microbial inoculants on cumin (*Cuminum cyminum* Linn.) growth and yield

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Abstract

An experiment was conducted during 2016-17 and 2017-18 to evaluate the effect of locally isolated beneficial *Bacillus* sp. strains on cumin growth and yield at experimental farm of ICAR-NRC on Seed Spices, Ajmer. The experiment was consist of seven treatments with three replicates in RBD design on a plot size 3×3 m for each, having line to line spacing of 30 cm and plant to plant spacing of 10-12 cm. The maximum number of secondary branches (30 plant^{-1}) was recorded in T_2- *Bacillus megaterium* which was at par with T_5- *Bacillus megaterium* + *Bacillus*. sp. and minimum number of secondary branches (23.33 plant^{-1}) was recorded with T_7-control. The highest dry weight (5.26 g plant^{-1}) was observed with T_6- *B. subtilis* + *B. megaterium* + *B*. sp. followed by T_4- *B. megaterium* + *B*. sp. (4.85 g plant^{-1}). However, there was statistically non-significant difference with respect to number of primary branches plant^{-1} and number of umbellets umbell^{-1}. Maximum seed yield (451.6 Kg ha^{-1}) was recorded with T_6 *B. subtilis* + *B. megaterium* + *B. sp*. and minimum was recorded with control (353.70 Kg ha^{-1}) however, the highest essential oil content in cumin seeds was recorded with T_4- *B. subtilis* + *B*. *megaterium* (4.05%) and the lowest (3.28 %) was recorded with T_5- *Bacillus megaterium* + *Bacillus*. sp.

Key words : *Bacillus* sp., cumin, *Cuminum cyminum*.

Introduction

Exhaustive agricultural practices relying heavily on chemical pesticides are major causes of wide extend environmental imbalances resulting in severe problems of insecticide resistance, pest resurgence and pesticide residues. There is a growing wakefulness world over on the need for promoting environmentally sustainable agriculture practices. Cumin (*Cuminum cyminum* Linn.), is a winter season annual herb in the family Apiaceae. Cumin is grown for its seeds that are used whole or ground. Cumin has medicinal and culinary uses. India is the largest producer, consumer and exporter of cumin in the world. In India, cumin is sown from October until the beginning of December, and harvesting starts in February-March. Cumin is especially sensitive to *Alternaria* blight and *Fusarium* wilt. The most important disease is *Fusarium* wilt, resulting in yield losses up to 80 per cent. *Fusarium* is soil borne and it requires distinct soil temperatures for development of disease as well as fungal spores from previous cumin crop on the same field promotes the wilt disease severity. Presence of beneficial rhizobacteria in the effective root zone of early seedling growth will be helpful in good establishment of cumin crop and better growth.

Traditionally nutrient management in cumin (*Cuminum cyminum* L.) is being done by application of chemical fertilizers. In nutrient management systems, biofertilizers form an alternative low cost and eco-friendly input which can reduce the chemical fertilizer dose by 25%–50% (Pattanayak *et al.,* 2007). Biopriming cumin seeds with plant growth promoting rhizobacteria (*Psedomonas putida* and *Microbacterium paraoxidans*) resulted into higher growth and yield (Shivran *et al.,* 2012). However, meagre information is available on the combined effect of plant growth promoting rhizospheric bacteria on cumin growth and yield. Therefore, an attempt was made to evaluate different strains of native *Bacillus* sp. isolated from cumin fields of Rajasthan (India) for realizing higher growth and yield in cumin.

Materials and methods

The field experiment comprising of absolute control, three strains of *Bacillus* bacterium (*Bacillus subtilis, B. megaterium*, and *Bacillus* sp.), and their combinations was conducted in a randomized block design with three replications at the research farm of ICAR-National Research Centre on Seed Spices, Ajmer (Rajasthan) during winter season of 2016-17 and 2017-18. The soil of the

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experimental site was sandy loam with a pH of 8.9 and having 0.23% organic carbon and 75.2, 32.8 and 233.5 kg ha^{-1} available N, P_2O_5, and K_2O respectively. The seed of cumin (Var. GC-4) was treated with bacterial cultures before sowing through mixing the seeds with talc based bacterial formulations prepared in the laboratory. The bacterial formulations were containing atleast 1×10^8 cfu g^{-1} of carrier material. For this purpose, the bacillus strains were grown in nutrient agar broth for 72 hrs and then mixed (in a ratio of 1:3) with pre-sterilized talc powder having carboxyl methyl cellulose (1%). This formulation was spread on seed then mixed thoroughly and the treated seeds were sown and during first manual weeding plant to plant distance of 10 cm was maintained. Diseases and pests were controlled by use of recommended pesticides. Five plants were selected randomly from each plot and their dry weight was taken after drying in oven at 70ºC till constant weight was obtained. Observations on plant height, branches plant^{-1}, yield attributing characters like umbel plant^{-1}, umbellate umbel^{-1} and seed umbellate^{-1} and yield were recorded. The trend of response of all the treatments under study remained the same during both the years of study. Hence, pooled analysis was carried out as per the procedure of Panse & Sukhamte (1985).

Results and discussion

Application of different strains of plant growth promoting *bacillus* sp. influenced plant height at all growth stages, branches plant^{-1} and dry matter accumulation plant^{-1}. At maturity, application of T_6 (*B. subtilis* + *B. megaterium* + *Bacillus* sp.) gave maximum plant height (33.00 cm) which was at par with T_2 *(B. megaterium)* and T_5 *(B. megaterium*+ *Bacillus* sp.) (Table 1). However, there was not much difference among the different *Bacillus* strains except T_3 (*Bacillus* sp.) and control. Similarly, the dry matter accumulation (5.26 g plant^{-1}) was recorded highest with T_6 (*B. subtilis* + *B. megaterium* + *Bacillus* sp.) followed by T_1 (*B. subtilis*) and lowest was recorded with T_3 (Bacillus sp.) which was at par with control (Table 1). Although, there was significant difference recorded for number of secondary branches plant^{-1} which ranged from 23.33 to 30.00 for various treatments, the number of primary branches plant^{-1} was found non-signifcant (Table 1). Slightly early maturity and early 50 % flowering was recorded in control and maximum days (84.0 DAS) to 50 % flowering was observed with T_5 and similar trend was observed for days to maturity (Table 1). In case of number of umbels plant^{-1}, the best treatment was T_6 (*B. subtilis* + *B. megaterium* + *Bacillus* sp.) which was at par with T_4 (*B. subtilis* + *B. megaterium*) and lowest was recorded with control (Table 2). Similarly, maximum number of seeds umbellate^{-1} (8.30) was recorded with T_4 (*B. subtilis* + *B. megaterium*) followed by T_6 (*B. subtilis* + *B. megaterium* + *Bacillus* sp.). However, there was non-significant difference recorded for number of umbellates umbel^{-1}. The maximum cumin seed yield (451.60 kg ha^{-1}) was observed with T_6 (*B. subtilis* + *B. megaterium* + *Bacillus* sp.) and minimum yield was recorded with control (Table 2). However the maximum essential oil content (4.05 %) was found in cumin seeds obtained from treatment T_4 (*B. subtilis* + *B. megaterium*) followed by T_3 (*Bacillus* sp.) and the minimum essential oil content (3.28 %) was recorded with T_5- *Bacillus megaterium* + *Bacillus*. sp. (Table 2).

During early crop growth stages the higher growth parameters of cumin with application of *B. megaterium* and *B. subtilis* might be due to release of nutrients from soil which promoted higher growth for a longer period which promoted higher crop growth. These results corroborate with those reported by Mishra *et al.*, (2016 & 2017) in fennel and coriander in which native *Bacillus* sp. were applied through seed treatment as potential plant growth promoting rhizobacteria. The potential of eight thermotolerant bacteria (seven *Bacillus* spp. and one actinobacterium *Kocuria* sp.) and two cyanobacteria (*Anabaena laxa* and *Calothrix elenkinii*) as plant growth promoting (PGP) agents was evaluated with seed spices – coriander, cumin and fennel, under controlled conditions in potting mix fortified with microbial cultures. Among the bacterial strains, T_4 (*Bacillus pumilus*) was most promising in terms of growth promotion in cumin crop (Kumar *et al.*, 2013). Different bioformulation treatments could affect days to 50% flowering and days to maturity over untreated control. The different strains of bacillus were comparable for all growth attributes except number of primary branches plant^{-1}. The bioformulation treatments significantly improved yield attributes and yield of cumin over control. Shivran *et al*., (2012) reported that the cumin crop seed yield increased by 18.29, 41.15, 50.50 and 55.88 per cent with untreated control, bioformulation FK 14 (*Pseudomonas pituda*), FL 18 (*Microbacterium paraoxidens*) and FK 14 + FL18, respectively over local control. The results of the experiment indicated that plant height increased significantly with bioformulation *Pseudomonas pituda* + *Microbacterium paraoxidens* over control and was comparable with *Pseudomonas pituda*, or *Microbacterium paraoxidens* alone, however, FK 14 and FL 18 could not bring significant improvement over control. Mehta *et al.,* (2012) reported that application of biofertilizer alone as well as in combination with sheep manure, vermicompost

Table 1. Effect of microbial inoculants on cumin plant biometric data at maturity.

Treatment	Plant height (cm)	Dry matter accumulation (g plant^{-1})	No. of Primary branches plant^{-1}	No. of Secondary branches plant^{-1}	Days to 50 % flowering	Days to maturity
T1- *Bacillus subtilis*	31.50	4.89	9.33	26.33	83.00	132.50
T2-*B. megaterium*	32.50	4.12	8.66	30.0	82.50	131.50
T3 -*Bacillus* sp.	28.00	3.74	10.33	25.33	83.00	128.50
T4 - *B. subtilis* + *B. megaterium*	29.40	4.85	8.66	24.0	83.50	131.30
T5 - *B. megaterium* + *Bacillus* sp	32.60	4.25	9.33	28.0	84.00	132.30
T6- *B. subtilis* + *B. megaterium* + *Bacillus* sp.	33.00	5.26	10.66	27.33	82.20	128.70
T7-control	27.00	3.80	9.00	23.33	80.50	127.50
CD	2.80	0.55	NS	2.30	2.70	3.50

Table 2. Effect of microbial inoculants on yield and quality of cumin seed.

Treatment	No. of umbels plant^{-1}	No. of umbellets umbel^{-1}	No. of seed umbellete^{-1}	Seed yield (kg ha^{-1})	Essential oil (%)
T1- *Bacillus subtilis*	23.33	5.65	6.60	414.70	3.61
T2-*B. megaterium*	21.65	5.82	7.00	433.00	3.33
T3 -*Bacillus* sp.	24.50	6 .00	7.00	418.60	3.86
T4 - *B. subtilis* + *B. megaterium*	26.80	6.35	8.30	435.50	4.05
T5 - *B. megaterium* + *Bacillus* sp	20.40	5.62	6.60	388.00	3.28
T6- *B. subtilis* + *B. megaterium* + *Bacillus* sp.	27.00	5.28	7.40	451.60	3.82
T7-control	20.40	5.7 0	6.60	353.70	3.59
CD	2.68	NS	1.10	63.40	0.27

and recommended doses of fertilizer resulted in higher growth, yield attributes and yield over absolute control. The association of biofertilizers with all sources of nutrients proved beneficial and resulted in higher growth and yield. Application of recommended doses of fertilizer with seed inoculation by biofertilizer proved to be superior for realizing higher net return and benefit : cost ratio.

The direct mechanism of plant growth promoting rhizobacteria include the increase in bio available phosphorus for plant uptake, biological nitrogen fixation, production of plant hormones like auxins, cytokinins and gibberellins and decrease of ethylene level. The indirect mechanism used by plant growth promoting rhizobacteria include the biotic protection against pathogenic bacteria, reduction of iron available to phytopathogens in the rhizosphere, synthesis of fungal cell wall lysing enzymes and competition with detrimental microorganisms. The *B. megaterium* and *B. subtilis* employed in present experiment have plant growth promoting characters due to their phosphorus solubilizing capacity as well as production of plant hormones like auxins.

Conclusion

It may be concluded that the application of native plant growth promoting rhizobacteria (PGPR) of *Bacillus* strains are helpful in increasing the seed yield as well essential oil content in the cumin seeds. The co-inoculation of different PGPR isolates are able to enhance the P-availability significantly as well as may compete with pathogenic microflora in the semi-arid soil commonly found in cumin growing areas of Rajasthan in India. The application of *Bacillus* sp. as microbial inoculants will not only help in increasing the nutrient use efficiency but also reduce the chemical phosphatic fertilizer dependence in cumin cultivation.

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