Journal of Advanced Scientific Research

Available online through https://sciensage.info

ISSN
0976-9595
Research Article

GROWTH AND YIELD ATTRIBUTES OF *VIGNA MUNGO* L. WITH RESPONSE TO ORGANIC FERTILIZERS

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Received: 16-05-2022; Accepted: 22-08-2022; Published: 30-09-2022

 https://doi.org/10.55218/JASR.202213803

ABSTRACT

At present, the specialization of organic inputs is very important and the use of locally available inputs is significant. Current experiment was conducted to evaluate the impact of Panchagavya, *Casuarina* needle litter and *Paenibacillus polymyxa* either single or in combined inoculation with each other on growth and yield of *Vigna mungo* under identical experimental condition. The results revealed that seedlings inoculated with Panchagavya + *Casuarina* needle litter powder+ *Paenibacillus polymyxa* recorded higher growth and yield of *Vigna mungo*. It was recorded that 16 % total length, 11.5% collar diameter, 46 %number of leaves and 55.7% increase over control plants. It is recemented that similar studies are needed to find out the impact of combined inoculation of Panchagavya + *Casuarina* needle litter + *Paenibacillus polymyxa* on *Vigna mungo* under field condition.

Keywords: Panchagavya, *Casuarina* needle litter, *Paenibacillus polymyxa*, Growth and Yield, *Vigna mungo.*

1. INTRODUCTION

Organic farming is a preconceived notion of following the principles and logics of living things, in which all the elements, soil, plants, farm, animals, microorganisms, insects and farmers are closely linked to each other [1]. The instant need of the hour is to initiate proper remediation measures for the quality and yield that contributed to agricultural production. At this time, the specialization of organic inputs is very important and the use of locally available inputs is significant [2].

Panchagavya is an organic growth stimulant and is made from five ingredients such as cow dung, cow urine, cow's milk, curd and ghee [3]. It is further enhanced by the addition of toddy, jaggery, coconut water, banana and fertile soil that are mainly used for fermentation. Traditionally in India, Panchagavya used as safeguard of plants from phytopathogens and enhances plant production [4].

Casuarina equisetifolia belongs to the family Casuarinaceae, is an excellent multipurpose tree which has been introduced successfully in India. It was estimated that the huge amount of *Casuarina* needle litter produce each year during its cultivation. The importance of leaf litter is apparent in the finding that *Casuarina* needles contained the highest percentage of N, P, K and Mg in comparison with other tree parts and the second highest content of Ca after that of bark [5]. It was stated that *Casuarina* litter contain high amount of N, P, K, Ca, Mg and other micronutrients, the decomposed litter can be effectively used for field application to improve the growth and sustainable production of agricultural crops mixing with other organic substances [6].

Plant growth promoting rhizobacteria, which colonize plant roots, draw special attention due to their beneficial effects on crops and ecosystems [7]. *Paenibacillus polymyxa* (formerly known as *Bacillus polymyxa*), is famous for its production of antimicrobial lipopeptides polymyxins, which were described as early as the 1940s and demonstrated to have very strong growth inhibitory activity. In nature, the habitat of *Paenibacillus* spp. is mainly soil. Due to their multiple beneficial effects, *Paenibacillus* spp. have implications for agriculture, environmental remediation, and even human and animal health [8].

Pulses are important components of organic farming systems in the India. *Vigna mungo*, the black gram (*Ulundhu* in Tamil) belongs to the family Faboideae and it is the third most important pulse crop of India and extensively grown in southern part of India. In South India, the most popular food of *Idli* and *Dosa* are prepared by mixing rice and black gram flours. The food values of black gram lie in its high and easily digestible protein. Its seed contains approximately 26% protein, 1.2% oil and 62 - 65% carbohydrates on dry weight basis [9].

Connecting the beneficial roles of all above mentioned factors as research view, an experiment was designed to elucidate the impact of Panchagavya, *Casuarina* needle litter and *Paenibacillus polymyxa* either single or in combined inoculation with each other on growth and yield of *Vigna mungo*.

2. MATERIAL AND METHODS

2.1. Preparation of Panchagavya

Panchagavya was prepared as per the method outlined by Selvaraj *et al*. [10]. Panchagavya contained fresh cow dung (7 kg), cow urine (10 L), cow milk (3 L), curd (2 L), water (10 L), tender coconut water (3 L), jaggery (3 kg) and well ripened banana (12 nos.). Cow dung and ghee were mixed in a 50 L plastic container and stirred thoroughly both in morning and evening hours and kept aside for 3 days. After 3 days, cow urine and water were added to the mixture and kept for 15 days mixing twice every day. After 15 days, the rest of the ingredients were added. The Panchagavya was ready in 30 days after proper sieving through fine cloth.

2.2. *Casuarina* needle litter

Casuarina equisetifolia needle litter was collected from the base of trees at already existing plantation in Thuvariman (9.949° N latitude and 78.065° E longitude) of Madurai district, Tamil Nadu.

2.3. Procurement of *Paenibacillus polymyxa*

The pure cultures of *Paenibacillus polymyxa* with a population load of 10^8 Colony Forming Units were obtained from the Department of Microbiology, Thiagarajar College (9.901° N latitude and 78.151° E longitude), Madurai, Tamil Nadu. The cultures were sub-cultured in respective medium to prepare peat soil based cultures for further studies.

2.4. Experimental site and design

Experiment was conducted at Post Graduate and Research Department of Botany, Thiagarajar College, Madurai. The experiment was set-up in a completely randomized block design with 8 treatments involving Panchagavya, *Casuarina* needle litter powder and *Paenibacillus polymyxa* individually or in various combinations, and uninoculated plants were kept as control. Each treatment consisted of 25 seedlings. Totally 200 seedlings were used for data collection. All the plants were kept under identical nursery condition and data were collected 60 days after inoculation.

2.5. Details of treatments

The treatments consist, T_0 - control (without fertilizer), T_1 - Panchagavya (15 ml), T_2 - *Casuarina* needle litter powder (15 gm), T_3 - *Paenibacillus polymyxa* (15 ml), T_4 - Panchagavya (7.5 ml) + *Casuarina* needle litter powder (7.5 gm), T_5 - Panchagavya (7.5 ml) + *Paenibacillus polymyxa* (7.5 ml), T_6 - *Casuarina* needle litter powder (7.5 gm) + *Paenibacillus polymyxa* (7.5 ml) and T_7 - Panchagavya (5 ml) + *Casuarina* needle litter powder (5 gm) + *Paenibacillus polymyxa* (5 ml). These treatments were replicated by three times in Randomized Block Design.

2.6. Procurement of *Vigna mungo* seeds

Certified seeds of the *Vigna mungo* were obtained from Department of Seed Science, Agricultural College and Research Institute, Madurai. The seeds were selected with uniform size; they were stored in polythene bag, containing the sterile soil samples. Seeds were soaked with water. Then the seeds were sowed on seed beds.

2.7. Raising seedling for experiment

The seed beds were made by mixing garden soil, red soil and sandy loam soil in the ratio of 2:2:1. Seeds were sown in separate bed uniformly at a depth of 2-3 cm. A regular watering, weeding and plant protection measures were carried out when required.

2.8. Estimation of growth and yield parameters

Sixty days after inoculation, from each treatment, a total of 12 plants were randomly selected and studied for the following morphological parameters viz., height of the plant (in cm), number of leaves per plant, leaf area (cm) root length (cm), shoots length (cm), total length of the plant (in cm) and germination rate (%) were observed and recorded. Yield attributes such as number of pods per plant, pod length (cm) and fresh weight of seed (g) were also recorded.

2.9. Estimation of biomass

The plants were carefully uprooted without disturbing the root system and washed in the running tap water. Excess of water was wiped out by placing them between the folds of blotting paper. The plants were cut at collar region, dried separately at 70° C in paper bags in hot air oven and biomass estimation (root and shoot dry weight) was carried out using top pan electronic balance.

2.10. Statistical analysis

The data were statistically analysed by analysis of variance (ANOVA) and treatment means were separated using Duncan's multiple range test ($p<0.05$) [11].

3. RESULTS AND DISCUSSION

The data obtained from the periodical field observations pertaining to growth, yield attributing characters and biochemical were tabulated and then statistically computed. The interpretations of the results have been made based on the appropriate mean data in the tables.

3.1. Growth parameters

3.1.1. Seedling survival percentage

By the present experiment, it was observed that the seedlings survival percentage for all the treatments was above 90%. Maximum seedling survival percentage was observed in triple inoculation (T_7), followed by dual inoculated plants (T_5) and single inoculated plants (T_1). It was 6.2% increase by triple inoculation, 5.2% increase by dual inoculation and 3.2% increase by single inoculation. Within the dual inoculants, T_6 combination performed poorly in survival percentage (2.1% increase over the control). Similarly, among the single inoculated plants, T_2 inoculated plants showed poor seedling survival rate (2.1% increase over the control) (Table 1).

3.1.2. Number of leaves and leaf area index (cm)

Statistical analysis shows that higher number of leaves (28) was found in seedlings treated with T_7 plants; this was 46.4% increase over control. In contrast, lowest number of leaves (18) was found in T_2 and T_3 plants. Maximum leaf area index (8.5 cm) was found in T_6 seedlings; this was 34.1% increase over control. Meanwhile, within the treated plants, minimum leaf area index (7.0) was found in T_2 plants (Table 1).

Table 1: Impact of organic fertilizers on growth of *Vigna mungo*

Treatments	Germination Percentage	No. of Leaves	Leaf Area Index (cm)	Shoot Length (cm)	Root Length (cm)	Total Length (cm)	Collar Diameter (mm)
T_0	90^a	15^a	5.6^a	30.5^a	9.7^a	40.2^a	2.3^a
T_1	93^b (3.2%)	22^c (31.8%)	7.8^d (28.2%)	33.3^b (8.4%)	11.8^b (17.7%)	45.1^b (10.86%)	2.5^b (8%)
T_2	93_b (3.2%)	18^b (16.6%)	7.0^b (20%)	33.8^b (9.7%)	11.6^b (16.3%)	45.4^b (11.46%)	2.4^b (4.1%)
T_3	92^b (2.1%)	18^b (16.6%)	7.3^c (23.2%)	34.5^c (11%)	12.3^c (21.1%)	46.8^c (14.16%)	2.4^b (4.1%)
T_4	94^{bc} (4.2%)	22^c (31.8%)	7.8^d (28.2%)	32.7^b (6.7%)	12.0^c (19.1%)	44.7^b (10.66%)	2.6^c (11.5%)
T_5	95^{bc} (5.2%)	25^d (40%)	8.4^e (33.3%)	33.9^c (10%)	10.8^{ab} (10.1%)	44.7^b (10.6%)	2.4^b (4.1%)
T_6	92^b (2.1%)	25^d (40%)	8.5^e (34.1%)	34.8^c (12.3%)	11.3^b (14.1%)	46.1^c (12.86%)	2.5^b (8%)
T_7	96^c (6.2%)	28^e (46.4%)	8.3^e (32.5%)	35.7^d (14.5%)	12.3^c (21.1%)	48.0^d (16.2%)	2.6^c (11.5%)

Values in parenthesis are percentage increase over control

Means followed by common letter(s) in the same column are not significantly different at 5% level by DMRT.

Treatments: T_0 - control (without fertilizer), T_1 - Panchagavya (15 ml), T_2 - Casuarina needle litter powder (15 gm), T_3 - Paenibacillus polymyxa (15 ml), T_4 - Panchagavya (7.5 ml) + Casuarina needle litter powder (7.5 gm), T_5 - Panchagavya (7.5 ml) + Paenibacillus polymyxa (7.5 ml), T_6 - Casuarina needle litter powder (7.5 gm) + Paenibacillus polymyxa (7.5 ml) and T_7 - Panchagavya (5 ml) + Casuarina needle litter powder (5 gm) + Paenibacillus polymyxa (5 ml).

3.1.3. Shoot length and root length (cm)

The seedlings treated with triple inoculation (T_7) recorded maximum shoot length (35.7cm) and root length (12.3cm). This was 14.5% and 21.1% increase over control respectively. In dual inoculation, T_6 plants recorded maximum shoot length (34.8 cm) and in single inoculation T_3 recorded maximum shoot length (34.5 cm). In dual inoculation T_4 plants (12.0 cm) and in single inoculation T_3 (12.0 cm) recorded maximum root length (Table 1).

3.1.4. Collar diameter (mm)

In case of collar diameter, T_7 plants showed maximum collar diameter (2.6mm); this was 11.5% increase over control and it was followed by T_4 and T_1 plants (2.6 mm and 2.5 mm collar respectively). Least collar diameter was found in T_2 and T_3 treatments (2.3 mm) (Table 1).

3.1.5. Biomass (g/plant)

The data pertaining to dry matter accumulation of root, stem, leaf, fruit and total biomass were presented in Table 2. T_7 plants resulted in substantial increase in total plant biomass (1.13 g/plant) over the control or dual or single inoculation. This maximum biomass was 55.7% increase over control. Within the dual inoculations, T_6 plants performed better in total plant biomass stimulation (0.93 g/plant). This was 46.2% increase over control. In case of single inoculation, the plants of T_1 (0.85 g/plant) induced 41.1% increase in total biomass over the control (Table 2).

3.2. Yield parameters

Regarding the yield attributes, the seedlings inoculated with Panchagavya + *Casuarina* needle litter + *Paenibacillus polymyxa* (T_7) recorded maximum number of pods/plant, pod length, seeds/pod and seed yield. They were recorded as 9.07, 7.65 cm, 8.00 and 1.74 g respectively. Among the single inoculated plants, the seedlings treated with Panchagavya (T_1) exposed significant yield parameters (Table 3).

In our experiments, use of Panchagavya significantly promoted the rate of growth and yield of black gram. The same results were observed by Srimathi *et al*. [12] in *Jatropha curcas* and *Pongamia pinnata*. Similar findings were also reported by Dhasarathan *et al*. [13] in the seed germination ability of *Abelmoschus esculentus* by soaking the seed in Panchagavya. Growth hormones and bacteria associated with Panchagavya were reported to enhance seed germination and growth. This may be due to the beneficial microorganisms from Panchagavya and their establishment in the soil improved the sustainability of growth and yield. The findings of present study was also corroborated with the observations made on the number of leaves produced, leaf area and the number of root nodules formed in the pulses such as in the pulses *Vigna radiata*, *Vigna mungo*, *Arachis hypogea*, *Cyamopsis tetragonoloba*, *Lablab purpureus*, *Cicer arietinum* and the cereal *Oryza sativa* [14].

Table 2: Impact of organic fertilizers on biomass of *Vigna mungo*

Treatments	Leaf dry weight (g/plant)	Stem dry weight (g/plant)	Root dry weight (g/plant)	Fruit dry weight (g/plant)	Total dry weight (g/plant)
T_0	0.12^a	0.19^a	0.09^a	0.10^a	0.5^a
T_1	0.15^b (20.0%)	0.28^d (32.1%)	0.19^c (52.6%)	0.23^c (56.5%)	0.85^d (41.1%)
T_2	0.14^b (14.2%)	0.23^c (17.4%)	0.18^c (50.0%)	0.19^b (47.3%)	0.74^b (32.4%)
T_3	0.14^b (14.2%)	0.24^c (20.8%)	0.16^b (43.7%)	0.18^b (44.4%)	0.72^b (30.5%)
T_4	0.13^{ab} (7.7%)	0.21^b (9.5%)	0.15^b (40.0%)	0.29^d (65.5%)	0.78^b (35.8%)
T_5	0.14^b (14.2%)	0.31^e (38.7%)	0.17^c (47%)	0.30^d (66.6%)	0.92^e (45.6%)
T_6	0.15^c (20.0%)	0.32^e (40.6%)	0.18^c (50.0%)	0.28^d (64.2%)	0.93^e (46.2%)
T_7	0.16^d (25.0%)	0.39^f (51.2%)	0.21^d (57%)	0.37^d (72.9%)	1.13^f (55.7%)

Values in parenthesis are percentage increase over control

Means followed by common letter(s) in the same column are not significantly different at 5% level by DMRT.

Treatments :T_0 - control (without fertilizer), T_1 - Panchagavya (15 ml), T_2 - Casuarina needle litter powder (15 gm), T_3 - Paenibacillus polymyxa (15 ml), T_4 - Panchagavya (7.5 ml) + Casuarina needle litter powder (7.5 gm), T_5 - Panchagavya (7.5 ml) + Paenibacillus polymyxa (7.5 ml), T_6 - Casuarina needle litter powder (7.5 gm) + Paenibacillus polymyxa (7.5 ml) and T_7 - Panchagavya (5 ml) + Casuarina needle litter powder (5 gm) + Paenibacillus polymyxa (5 ml).

Table 3: Impact of organic fertilizers on yield of *Vigna mungo*

Treatments	Number of pods/plant	Pod length (cm)	Number of seeds/pod	Seed yield/plant (g)
T_0	5.32[a]	4.45[a]	4.32[a]	1.18[a]
T_1	7.58[c]	5.83[b]	6.12[c]	1.56[b]
T_2	6.25[b]	5.14[b]	5.25[b]	1.25[a]
T_3	6.55[b]	5.22[b]	5.55[b]	1.26[a]
T_4	7.04[c]	6.08[c]	6.41[c]	1.42[b]
T_5	8.10[d]	6.67[c]	7.14[d]	1.49[b]
T_6	8.50[d]	7.11[d]	7.50[d]	1.73[c]
T_7	9.07[e]	7.65[d]	8.00[e]	1.74[c]

Means followed by common letter(s) in the same column are not significantly different at 5% level by DMRT.
Treatments :T_0 - control (without fertilizer), T_1 - Panchagavya (15 ml), T_2 - Casuarina needle litter powder (15 gm), T_3 - Paenibacillus polymyxa (15 ml), T_4 - Panchagavya (7.5 ml) + Casuarina needle litter powder (7.5 gm), T_5 - Panchagavya (7.5 ml) + Paenibacillus polymyxa (7.5 ml), T_6 - Casuarina needle litter powder (7.5 gm) + Paenibacillus polymyxa (7.5 ml) and T_7 - Panchagavya (5 ml) + Casuarina needle litter powder (5gm) + Paenibacillus polymyxa (5 ml).

Similarly, it was reported that during decomposition, the *Casuarina* litter significantly increases the soil organic carbon, nitrogen and mineral nutrients and enhancing the ability of plants to expose higher growth and yield [15]. The findings of present investigation also highlighted the seedlings inoculated by Panchagavya and *Casuarina* needle litter along with *Paenibacillus polymyxa* showed maximum growth and yield attributes of *Vigna mungo*. In early studies with *P. polymyxa*, many researchers explored whether *P. polymyxa* promotes plant growth on cucumber [16], pepper [17] and sesame [18]. The mode of action of PGPR-mediated plant growth promotion, including that mediated by *P. polymyxa*, has been investigated and found that direct plant growth promotion via bacterial secretion of mimic phytohormones and bacterial nitrogen fixation and indirect plant growth promotion via PGPR suppression of plant pathogens that cause plant diseases [19].

4. CONCLUSION

It was concluded that seedlings inoculated with Panchagavya + *Casuarina* needle litter + *Paenibacillus polymyxa* recorded higher values for growth and yield parameters of *Vigna mungo* in nursery condition. Further studies are needed to find out the impact of combined inoculation of Panchagavya + *Casuarina* needle litter + *Paenibacillus polymyxa* on growth and yield of *Vigna mungo* under field condition.

Conflict of interest

The authors have declared that there is no conflict of interest.

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