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Pummelo (*Citrus maxima* L) seedlings growth as influenced by bio-fertilizers and organic amendments

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Abstract

Experiment was conducted in poly-house at College of Horticulture, Bengaluru to study the effect of Bio fertilizers and organic amendments on growth and establishment of pummelo under nursery condition during 2019-20. The nursery were established in potting mixture; sand, soil and farm yard manure in the ratio of 2:1:1 (Sand: Soil: FYM;) taken in polythene bags of size 12 cm x 24 cm. Applied with bio-fertilizers such as *Azospirillum* spp., Phosphorus solubilizing bacteria (PSB), *Pseudomonas fluorescens*, @ 6 g per plant (single / dual / combinations 6 g only) plus Vesicular Arbuscular Mycorrhiza (VAM), soil based bio-fertilizers @ 6 g per plant. A total of nine treatments were tested in four replications. The results at the end of 120 days showed that the inoculation of consortium of three bio-fertilizers; *Azospirillum*, spp. *Phosphorus solubilizing bacteria* and VAM had produced significantly highest seedling height (36.32 cm), seedling girth (4.67 mm), number of leaves (23.10 no.), leaf area (28.25 cm²), fresh and dry Weight of shoot (17.47 and 7.16g respectively) in T₃ treatment. The maximum fresh and dry weight of root (10.02 and 5.07 g), number of primary and secondary roots (37.95), length of primary root (35.95 cm) and root volume (10.34 cm³) was recorded the treatment *Azospirillum*, *Phosphate solubilizing bacteria* and *Pseudomonas fluorescens* and VAM at the end of 120 days in nursery.

Keywords: Pummelo CV. Devanahalli seedlings, Bio-fertilizers and organic amendments on growth and establishment

Introduction

Pummelo (*Citrus maxima* or *citrus grandis*,) is the largest fruit among Citrus fruits. It has thick rind and locally it is known as Chakotha, Chakotara etc. In India this fruit is commercially grown on a very limited scale but the trees are found in North Eastern states, North Western Himalayan region, Eastern Uttar Pradesh, Bihar, Karnataka and Kerala. It is used in religious programmes in the country. In Manipur it is also used for religious purposes. In Bihar and eastern UP, this fruit is essential for Chhatpooja. Every house of this area has a pummelo tree in their kitchen garden. Pummelo grown in the far northeastern states of India, and some southern regions of Karnataka and Kerala. The states mainly Assam, Manipur and Tripura cultivate the fruit up to 1,500 meters MSL. It is commercially grown in parts of Karnataka. This is also found in Kanyakumari region of Tamil Nadu and lower hills of Uttarakhand, Himachal, Bihar and West Bengal. In the world, presently pummelo is grown in many eastern countries including China, Japan, India, Fiji, Malaysia, Vietnam and Thailand. It is also now grown in the Caribbean and in the United States, in California and Florida. Vietnam, Thailand, China, USA are main producer of pummelo. The area of pummelo is increasing due to health benefits. (Sankar *et al.* 2014) [9]. However, pummelo development area is still very limited. Pummelo production is still low in 2014 and 2015 reached 141,296 tons and 111,753 tons respectively or around 5% of national citrus production reported by (Susanto *et al.* 2018) [11]. Bio-fertilizers are used in live formulation of beneficial microorganism which on application to seed, root or soil mobilizes the availability of nutrients particularly by their biological activity help build up the lost micro flora and in turn improve the soil health (Pathak *et al.*, 2018) [8]. Bio-fertilizer is a substance used to increase the fertility of the soil, it contains microorganisms which help the soil to gain its nutrient back and make the soil available for cultivation (Malik Asif *et al.* 2008) [4].

Azospirillum is a non-symbiotic micro aerophilic bacterium commonly found in association with roots of horticultural crops nitrogen fixation capacity and tolerance to high soil temperature. The phosphate solubilizes containing bacteria or fungi may convert insoluble form of phosphate to soluble form by producing organic acids. In general about 15 – 25% of insoluble phosphate can be solubilized (Sankara Rao Karri et al. 2012) [9].

Materials and Methods

The present investigation entitled “Effect of bio-fertilizers and organic amendments of growth and establishment of pummelo seedlings under nursery condition, (*Citrus maxim* CV. Devanahalli)” The experiment was conducted under poly-house condition at Regional Horticultural Research and Extension Centre (RHREC), University of Horticultural sciences campus, GKVK, post Bengaluru, during the year 2019–20. The experimental was laid out in completely randomized design with four replications. The experiment comprised of nine treatments with the combinations of effect of biofertilizers and organic amendments on growth and establishment of Pummelo under nursery condition. Pummelo seeds were collected from pummelo plot of RHREC. Seedlings were raised in polythene bags of (12 x 24) cm with 4 holes punched on the polythene bags from bottom to top to facilitate proper drainage. Then the seeds were sown into the media polybags containing mixtures of Soil, FYM and Sand (2:1:1) and treated with bio-fertilizers combinations such as *Azospirillum* spp., Phosphorus solubilizing bacteria (PSB), *Pseudomonas fluorescens* (PF) and *Vesicular Arbuscular Mycorrhiza* (VAM) @ 6 g per seedling (all together) per treatment. These polythene bags were kept under poly-house, at 30 days interval liquid organic manures panchagavya, jeevamrutha, beejamrutha and bio digester @ 5, 10, 10 and 10 per cent respectively were applied through foliar application and observations were recorded at 30, 60, 90 and 120 days after germination.

Results and Discussion

The evaluation of bio-fertilizers and organic amendments on growth and establishment of pummelo CV. Devanahalli seedlings under nursery condition showed nitrogen fixer, phosphate solubilize, bio-control agent and phosphorous mobilize in the form of *Azospirillum* spp., *Pseudomonas striata*, *Pseudomonas fluorescens*, VAM and liquid organic amendments respectively had increased the growth parameters. The growth and establishment was significantly superior over un-inoculated control.

The results in Table 1 (Fig. 1) showed positive influence on the maximum seedling height (36.32 cm), seedling girth (4.67 mm), number of leaves (23.10), leaf area (28.25 cm²), fresh and dry weight of shoot (17.47 and 7.16 g respectively) were recorded by combination of *Azospirillum* spp. +

Phosphorus solubilizing bacteria (PSB) + *Vesicular Arbuscular Mycorrhiza* (VAM). (2 g each) in T₃ treatment, while the minimum seedling height, seedling girth, number of leaves, leaf area, fresh and dry weight of shoot was recorded in T₁ treatment control i.e., water spray at 120 days after germination.

The results in Table 2 (Fig. 2) revealed that the maximum fresh and dry weight of root (10.02 and 5.07 g respectively), number of primary and secondary root (37.95), length of primary root (35.95 cm) and root volume (10.34 cm³) were recorded with treated *Azospirillum* spp. + PSB + PF + VAM (1.5 g each) in T₅ treatment at 120 days after germination and minimum fresh and dry weight of root, number of primary and secondary root, length of primary root and root volume was recorded in T₁ treatment control i.e., water spray at 120 days after germination.

The evaluation of bio-fertilizers on growth and establishment of mango grafts var. Alphonso under poly-house condition showed that the biofertilizers, nitrogen fixer, phosphate solubilize, bio control agent and phosphorous mobilize in the form of *Azospirillum* spp., *Pseudomonas striata*, *Pseudomonas fluorescens* and VAM respectively had increased the growth parameters. The growth and establishment was significantly superior as reported by Shankarappa et al. 2018. In case of three and four months old acid lime seedlings (*Citrus aurantifolia* Swingle) cv. Balaji, the maximum plant height, number of leaves, stem girth, were recorded in the potting media containing soil + sand + vermicompost + *Arbuscular mycorrhiza* (5g) + neem cake 20g each per bag. *Azotobacter chroococcum* (A), *Bacillus megatherium* var *phosphaticum* (B), mixture of 50% (A) and 50% (B) (v/v) and algae extraction. The growth vigor parameters in number of leaves and plant height content were estimated in Orange Seedlings (Omayya et al. 2011) [6]. Bio-fertilizers which increases (PSB) level in the rootzone that stimulated more root initiation, more nutrient uptake and root cell elongation, thus resulting into increased taproot length resulted in increasing dry weight. The results are in conformity with the findings of (Anjanawe et al. 2013) [1] in papaya and (Panchal et al. 2015) [7] in khirni. *Azotobacter* with GA3 (1:1 + 5g/kg + GA3 100 ppm increase seedling height, number of leaves per seedling, girth of stem (Mohini Parmar et al. 2019) [5] in acid lime. GA3 150 ppm + NAA 150 ppm has recorded the maximum seedling height, seedling diameter, number of leaves, leaf area, fresh and dry weight of seedlings, number of primary and secondary roots, Length of primary root, root volume and fresh and dry weight of root of pummelo seedlings reported by (Harsha et al. 2017) [3]. The combination of *Azospirillum* and phosphate solubilize bacteria for Banana cv. Grand Nine, recorded the highest growth parameters plant height, plant girth, number of leaves, leaf area leaf area index by reported (Ganapathi and Dharmatti, 2018) [2].

Table 1: Effect of bio-fertilizers and organic amendments on growth of plant height, seedling girth, number of leaves, leaf area and fresh and dry weight of shoot of pummelo CV. Devanahalli seedlings at 120 DAG.

Treatments	Seedling height (cm)	Seedling girth (mm)	Number of leaves	Leaf area (cm ²)	Fresh weight of shoot (g)	Dry weight of shoot (g)
T ₁ - Water Spray (control)	27.82	4.01	17.95	29.48	11.69	4.05
T ₂ - <i>Azospirillum</i> spp. + <i>Phosphorus solubilizing bacteria</i> (PSB) + <i>Pseudomonas fluorescens</i> (PF). (2 g each)	29.92	4.26	19.15	30.98	12.35	4.50
T ₃ - <i>Azospirillum</i> spp. + <i>Phosphorus solubilizing bacteria</i> (PSB) + <i>Vesicular Arbuscular Mycorrhiza</i> (VAM). (2 g each)	36.32	4.67	23.10	32.53	17.47	7.16
T ₄ - <i>Azospirillum</i> spp. + <i>Pseudomonas fluorescens</i> + <i>Vesicular Arbuscular Mycorrhiza</i> (VAM). (2 g each)	33.82	4.44	21.85	29.18	16.40	6.11

T ₅ - <i>Azospirillum</i> spp. + <i>Phosphorus solubilizing bacteria</i> (PSB) + <i>Pseudomonas fluorescens</i> (PF) + <i>Vesicular Arbuscular Mycorrhiza</i> (VAM). (1.5 g each)	32.35	4.25	20.40	26.46	15.38	5.47
T ₆ - Panchagavya Spray @ 5% after germination	30.45	4.22	19.60	28.75	14.65	4.82
T ₇ - Jeevamrutha Spray @ 10% after germination	30.20	4.15	19.55	28.94	15.19	5.20
T ₈ - Beejamrutha Spray @ 10% after germination	30.97	4.23	19.25	27.94	15.71	5.60
T ₉ - Biodigested liquid Spray @ 10% after germination	28.62	4.11	18.65	30.78	13.82	4.57
S.Em±	0.41	0.03	0.32	1.17	0.37	0.18
CD @ 5%	1.20	0.11	0.94	3.39	1.10	0.54

DAG.* Days after germination

Table 2: Effect of bio-fertilizers and organic amendments on root parameters of pummelo CV. Devanahalli seedlings at 120 DAG.

Treatments	Fresh weight of root (g)	Dry weight of root (g)	Number of primary and secondary roots	length of primary root (cm)	Root volume (cm ³)
T ₁ - Water Spray (control)	7.75	2.89	30.50	27.07	6.94
T ₂ - <i>Azospirillum</i> spp. + <i>Phosphorus solubilizing bacteria</i> (PSB) + <i>Pseudomonas fluorescens</i> (PF). (2 g each)	9.00	3.68	34.10	32.25	7.95
T ₃ - <i>Azospirillum</i> spp. + <i>Phosphorus solubilizing bacteria</i> (PSB) + <i>Vesicular Arbuscular Mycorrhiza</i> (VAM). (2 g each)	9.73	4.02	34.65	33.49	8.43
T ₄ - <i>Azospirillum</i> spp. + <i>Pseudomonas fluorescens</i> + <i>Vesicular Arbuscular Mycorrhiza</i> (VAM). (2 g each)	8.65	3.12	36.35	34.37	9.14
T ₅ - <i>Azospirillum</i> spp. + <i>Phosphorus solubilizing bacteria</i> (PSB) + <i>Pseudomonas fluorescens</i> (PF) + <i>Vesicular Arbuscular Mycorrhiza</i> (VAM). (1.5 g each)	10.02	5.07	37.95	35.95	10.34
T ₆ - Panchagavya Spray @ 5% after germination	8.19	3.46	32.35	31.52	8.94
T ₇ - Jeevamrutha Spray @ 10% after germination	8.80	3.68	31.45	30.45	8.34
T ₈ - Beejamrutha Spray @ 10% after germination	8.30	3.67	33.60	31.45	8.33
T ₉ - Biodigested liquid Spray @ 10% after germination	8.49	3.40	32.15	29.87	8.63
S.Em±	0.18	0.15	0.29	0.33	0.23
CD @ 5%	0.55	0.44	0.85	0.98	0.67

DAG.* Days after germination

T₁= Water Spray (control), T₂= *Azospirillum* spp. + PSB + PF (2 g each), T₃= *Azospirillum* spp. + PSB + VAM (2 g each), T₄= *Azospirillum* spp. + PF + VAM (2 g each), T₅= *Azospirillum* spp. + PSB+ PF + VAM (1.5 g each), T₆=Panchagavya Spray @ 5% after germination, T₇ = Jeevamrutha Spray @ 5% after germination, T₈ = Beejamrutha Spray @ 5% after germination, T₉= Biodigested liquid Spray @ 5% after germination

Fig.1 Effect of bio-fertilizers and organic amendments on growth of plant height, seedling girth, number of leaves, leaf area and fresh and dry weight of shoot of pummelo CV. Devanahalli seedlings at 120 DAG.

Fig 2: Effect of bio-fertilizers and organic amendments on fresh and dry weight of root, number of primary and secondary root, length of primary root and root volume of pummelo CV. Devanahalli seedlings at 120 DAG.

Conclusion

The treatment of *Azospirillum* spp. + PSB + VAM (2 g each) in poly bags to Pommelo seedlings recorded maximum plant height, seedling girth, number of leaves, fresh and dry weight of shoot and with combination of four bio-fertilizers recorded maximum fresh and dry weight of root, number of primary and secondary root, length of primary root and root volume at 120 days after germination.

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