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Effect of organic amendments and bio-agents on growth of acid lime (*Citrus aurantifolia* Swingle) cv. Balaji seedlings in the nursery

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Abstract
The present investigation was carried out at AICRP on Fruits, Citrus Research Station, Tirupati, during 2016-2017 to study the Effect of organic amendments and bio-agents on growth of acid lime (*Citrus aurantifolia* Swingle) cv. Balaji seedlings in the nursery. The experiment was conducted in completely randomized design with three replications. The treatments consisted of 21 treatments with different potting media, organic amendments and bio-agents and their effect was studied on three age group acid lime seedlings. The results indicated that the medium combination soil, sand, cocopeat @ 1:1:1 v/v, neem cake (20g) with *AM* F@ 5g had given significantly better results among different combination in 2 months old seedlings. In case of three and four months old acid lime seedlings maximum length of tap root, number of secondary roots per seedling, root dry weight, leaf dry weight, total dry weight per seedlings were recorded in the potting media containing soil + sand + vermicompost + *Arbuscular mycorrhiza* (5g) + neem cake 20g each per bag. However, minimum growth parameters were recorded when soil, sand, FYM @ 1:1:1 v/v was used as potting media in case of 2, 3, 4 months old seedlings.

Keywords: Acid lime, *Arbuscular mycorrhiza fungi*, *Azotobacter*

Introduction
Citrus is one of the largest and most important groups of fruits of tropical and subtropical regions. It is a slow growing plant and is commercially propagated through budding/grafting and seeds. It is the third most important fruit crop after Mango, Banana. It belongs to family Rutaceae. In India, among the fruit crops citrus species covers an area of 10.4% of major fruit crops with an area 268.4Mha, with the production of 2950.4 MT and the productivity of 11.0 MT/ha (Anonymous 2015-16) [1]. A.P is the leading producer of citrus especially sweet orange and acid lime in the country. The acid lime is the second most important fruit crop in citrus group is grown in 38,850 hectares of area with production 5, 82,743 MT (Horticulture.A.P.NIC.in). In India, Andhra Pradesh stands first both in area and production of acid lime.

Organic media play an important role in germination of seeds and for further growth and development of seedling. Among different media used Vermicompost provide simultaneously sufficient levels oxygen and water to the roots, adequate storage of water and nutrients for the plant, balancing of physical, chemical and biological requirements for good plant growth, lightweight and to produce uniform plant growth (Atefe *et al.*, 2012) [2], cocopeat improve moisture retention capacity and increase available nutrient content, infiltration rate, total porosity, and hydraulic conductivity of that soil (Savithri and Khan, 1993) [11], A potting medium is a composition of organic materials formulated to achieve desirable chemical and physical needs required by the crop to attain its potential growth and development. Good container-media management is basic to the production of quality container-grown citrus nursery plants. Farmyard manure has been the main basic source of organic matter for the supply of essential minerals needed by the plants. Azotobacter plays an important role as heterotrophic aerobic bacterium capable of non-symbiotic nitrogen fixation is of wide occurrence in rhizosphere of many plants. There has been rise in the use of Azotobacter as biofertilizer as the ability of it to produce biologically active substances was ascertained, its effect on plants was associated not only with the process of nitrogen fixation and improving nitrogen of plants, but also with the supply of biologically active compounds such as vitamins and gibberellins. The mutualistic association of Arbuscular mycorrhiza (AMF) with roots of most terrestrial plants is well known which could enhance plant growth and alleviate salt

stress. The mycorrhiza fungi increases surface area for nutrient absorption and transport them back to the plant. The 3 nutrients P, Zn, C, N, Cu and S absorbed and translocated to the host and produces hormones like auxin, cytokinins, gibberellins and vitamins. AM fungi acts as accessories to the root hairs in the process of nutrient absorption and mobilization, In view of the potential roles played by the organic manures and bio agents in augmenting plant growth, an attempt is made to utilize these materials in the potting media in different doses and combinations with the objective of boosting the seedling growth of acid lime variety Cv. Balaji.

Materials and Methods

The experiment was conducted at Citrus Research Station, Department of Horticulture, Dr. Y.S.R. Horticultural University, Tirupati, Andhra Pradesh, during the year 2016-17. The experiment was laid out in a Completely Randomized Design (CRD) with three replications and 21 treatments viz., T_1:FYM +Sand +soil (control) @ 1:1:1 v/v, T2: Vermicompost +Sand + Soil@ 1:1:1 v/v, T_3:Cocopeat + Sand + Soil@ 1:1:1 v/v, T_4:T_1 + Neem cake, T_5:T_1 + Neem cake + *Azotobacter*, T_6:T_1 + Neem cake + *Arbuscular mycorrhiza*, T_7:T_1 + Castor cake, T_8:T_1 + Castor cake + *Azotobacter*, T_9:T_1 + Castor cake + *Arbuscular mycorrhiza*, T_{10}:T_2 + Neem cake,T_{11}:T_2 + Neem cake + *Azotobacter*, T_{12}*:T_2 + Neem cake + Arbuscular mycorrhiza*, T_{13}*:T_2 + Castor cake*, T_{14}*:T_2 + Castor cake + Azotobacter*, T_{15}*: T_2 + Castor cake + Arbuscular mycorrhiza*, T_{16}*:T_3 + Neem cake*, T_{17}*:T_3 + Neem cake + Azotobacter*, T_{18}*:T_3 + Neem cake + Arbuscular mycorrhiza*, T_{19}*:T_3 + Castor cake*, T_{20}*:T_3 + Castor cake + Azotobacter*, T_{21}*:T_3 + Castor cake + Arbuscular mycorrhiza.* Hundred seedlings were maintained per treatment and each replication.

Mature acid lime fruits were harvested manually for the extraction of seeds from the trees in CRS, Tirupati. Seeds were carefully extracted from fully ripened fruits. Extracted seed was washed thoroughly and shade dried for 2 to 3 days. Thoroughly dried seeds were used for sowing on the raised nursery beds. Before sowing the seeds were treated with Diathane M-45@ 3g per kg seed and shade dried for 2 hours. Black polyethylene bags of gauge 100 microns and having dimensions of 6×8 inches were used for filling of potting media. Poly bags were filled with potting media consisted of soil, sand, vermicompost, cocopeat, farm yard manure in different proportions (1:1:1v/v). Uniform, healthy vigorous 2, 3 and 4 months old seedlings were selected and lifted carefully from the nursery beds. The seedlings were washed in the water and the roots were dipped in fungicidal solution containing Copper oxy chloride 3g per liter of water for 5 minutes later transplanted in into poly bags.

In each treatment ten plants were randomly selected from each replication for recording growth parameters at monthly interval starting from 60 days after transplanting to 150 days after transplanting. Observation on length of tap root, number of secondary roots per seedling, root dry weight, leaf dry weight, total dry weight were recorded. The length of top root is recorded with scale, numbers of secondary roots were counted in each seedling, root dry weight ten plants were selected in each replication and seedlings are dried in the open for 3 days and after shade dried seedlings are dried for 48 hr at 60 ^{0}C. Weight of roots was recorded in using simple balance, leaf dry weight was measured by collecting total leaves from each seedling, and leaves were dried at 60 ^{0}C for 48 hr and dry weight was recorded in grams. For recording total dry weight ten seedlings in each replication are shade dried in the open for three days. Shade dried seedlings are oven dried for 48 hr at 60 ^{0}C. Oven dry weight of seedlings was recorded by using simple balance.

Result and discussion

The significantly longest root length (20.79 cm) was recorded with T_{18} [Cocopeat + Sand + Soil + Neem cake (20g) + *Arbuscular mycorrhiza* (5g)] in two months old seedlings (Table 1). The treatment closely followed by T_{12} (19.83 cm) [Vermicompost + Sand + Soil + Neem cake + *Arbuscular mycorrhiza* (5g)]. Similar results have been recorded with the seedlings of three months old where T_{12} gave significantly tallest root lengths (23.58 cm) which was followed by T_{18} [cocopeat+ Sand + Soil + Neem cake (20g) + *Arbuscular mycorrhiza* (5g)] (22.57cm). however with regards to the seedlings of four months old, significantly tallest root lengths (23.16cm) have been recorded with T_{12} closely followed by T_{18} (2.19 cm). In case of 2 months, 3 months and 4 months old seedlings lowest root length were observed in T_1 (soil + sand+ FYM).

From the results the increase in length of the roots in the treatments T_{12} and T_{18} could be attributed to the beneficial roles played by amendments and bio agents added to the media. Vermicompost besides adding major nutrients also adds micronutrients to the soil. It releases the nutrients slowly to the soil their by making them available to the plants for longer periods. It also improved soil organic matter contents. Cocopeat improves water holding capacity of the soil. AMF associated with roots helps in absorption of water and nutrient to the seedlings. Due to combined effect of all the components in the potting media length of seedling roots in T_{12} and T_{18} appears to be taller. Similar findings were also reported by Reddy *et al*. (1996) [9] in acid lime seedlings, Kamble *et al*. (2010) [5] in mango seedlings, Sharma *et al*. (2009) [13] in citrus seedlings, Bhardwaj (2014) [4] in papaya and Rakesh *et al*. (2012) [10] in acid lime.

In case of two months old seedlings highest number secondary roots were observed in T_{18} (18.51) followed by T_{12} (18.1) Similar results have also been recorded with the seedlings of three months old seedling maximum number of secondary seedlings was recorded with T_{12} (21.73) and in four months old seedlings maximum number of secondary roots was observed In T_{12} (22.32) at 150 days in case of 2, 3 and 4 months old seedlings lowest number of leaves was observed in T_1 (Table 2). The increase in number of secondary roots per seedling is attributed to the presence of organic amendments in the media like neem cake, cocopeat and vermicompost bio-agents such as *Arbuscular mycorrhiza*, in the potting media which might have enhanced the water holding capacity, improved physical properties and nutritional content of media. Similar findings were also reported by Patil *et al*. (2013) [7] in rangapur lime, Bhardwaj (2014) [4] in papaya, Sonawane *et al*. (1997b) [12] in grape and Banker *et al*. (2009) [3] in kagzi lime.

From the results it is found that maximum leaf dry weights in two months old seedlings (3.88 g) have been recorded with the treatment T_{18} followed by treatment T_{12} (3.49 g) at different intervals of data recorded. However for three months old seedlings highest leaf dry weights from 60 to 150 days after transplanting have been recorded with T_{12} (4.11g) followed by T_{18} (4.06g). With regard to the four months old seedlings also highest leaf dry weights have been recorded with T_{12} (4.51g) followed by T_{18} (4.34 g) and lowest leaf dry weight was observed in T_1 at different intervals of data recorded (Table 3). In the present studies also potting media

supplemented with Mycorrhiza fungi and neem cake, vermicompost and cocopeat would have played an important role in enhancing the growth of citrus seedlings which resulted in production of more number of leaves ultimately leading to the higher leaf dry weights. The similar results were reported by Rakesh *et al*. (2012) [10] in acid lime, Qiang-Sheng Wu *et al*. (2010) [8] in citrus seedlings and Banker *et al*. 2009 [3] in lime seedlings.

Application of cocopeat + Sand + Soil + Neem cake (20g) + *Arbuscular mycorrhiza* (5g) T_{18} had given significantly maximum root dry weight (2.91g) per seedlings after 150 days transplanting seedlings in 2 months old acid lime seedlings [Table-4]. In case of three (3.19g) and four months (3.17g) old seedlings maximum root dry weight was observed in T_{12} and the all three group aged seedlings lowest root dry weight was observed T_1 (Table 4). These results are also supported with those of Thaker and Jasrai. (2002) [14] in banana, Kamble *et al*. (2010) [5] in mango seedlings, Rakesh *et al.* (2012) [10] in acid lime seedlings and Khade and Rodrigues *et al.* (2009) [6] in papaya. For 2 months old acid lime seedlings maximum total dry weight was recorded in T_{18} (7.94g) [Table-5]. In the case of three (8.69g) and four (9.1g) months old seedlings maximum total dry weight was observed in T_{12}. Lowest values were recorded in T_1 in all aged group seedlings (Table 5). The results are in accordance with the findings of Rakesh *et al.* (2012) [10] in acid lime seedlings, Qiang-Sheng Wu *et al*. (2010) [8] in citrus, Patil *et al*. (2013) [7] in Rangapur lime seedlings.

Increase in root length, number of secondary roots, root dry weight, leaf dry weight and total dry weight in T_{12} and T_{18} which contain organic amendments *i.e.*, vermicompost, cocopeat, neem cake could be due to the fact that these materials besides increasing water holding capacity in the soil also are rich in nutrients (major and micronutrients). Amendments releases nutrient slowly for longer periods, and hence the availability of nutrients to the plants might be continuous. Further the role of AMF in boosting the plant growth and well established in many crops and roots with *mycorrhiza* have more surface area to absorb water and nutrients and the main role in plant can't directly use the minute amount of phosphorus contained in the soil. *Mycorrhiza* transforms or solubilizes the phosphorus contained in the soil to the benefit of the plant. In the present study also combination of vermicompost, cocopeat, neem cake with AM must have played vital role in enhancing the seedling growth.

Conclusion

The potting mixture containing soil + sand + cocopeat @ 1:1:1 v/v + *AM* [5g] and neem cake 20g per bag was best potting media for 2 months old seedlings, whereas in case of 3 and 4 months old seedlings best potting mixture was soil + sand + vermicompost @ 1:1:1 v/v + *AM* [5g] and neem cake 20g per bag.

Table 1: Effect of organic amendments and bio-agents on length of tap root (cm) of 2, 3 and 4 months old acid lime seedlings cv. Balaji

Treatment	2 months old				3 months old				4 months old			
	DAT 60	DAT 90	DAT 120	DAT 150	DAT 60	DAT 90	DAT 120	DAT 150	DAT 60	DAT 90	DAT 120	DAT 150
T_1 FYM +Sand +soil (control)	5.64	7.60	9.61	11.86	6.93	8.79	11.06	15.21	7.17	9.05	11.61	16.68
T_2 Vermicompost +Sand + Soil	5.88	7.95	9.87	12.66	7.11	9.04	11.24	18.54	8.15	9.41	11.79	18.04
T_3 Cocopeat + Sand + Soil	6.30	8.25	10.64	13.89	7.09	8.99	11.17	17.54	7.56	9.36	11.71	17.21
T_4 T_1 + Neem cake	6.71	9.02	12.10	15.09	8.21	11.10	13.74	17.87	8.84	10.27	12.94	18.81
T_5 T_1 + Neem cake + *Azotobacter*	6.55	8.63	11.23	14.63	9.12	11.98	13.95	18.73	10.03	11.74	14.72	20.28
T_6 T_1 + Neem cake + *Arbuscular mycorrhiza*	7.75	9.61	12.97	17.39	10.06	12.14	15.15	22.24	11.12	13.06	15.17	21.93
T_7 T_1 + Castor cake	6.42	7.95	10.78	13.66	9.17	10.31	12.74	17.84	9.32	10.23	12.30	19.17
T_8 T_1 + Castor cake + *Azotobacter*	6.58	9.30	11.84	14.83	8.97	11.23	13.25	18.76	9.38	11.08	13.08	20.59
T_9 T_1 + Castor cake + *Arbuscular mycorrhiza*	7.07	10.82	13.37	16.59	9.18	11.11	14.01	18.89	9.80	11.46	14.18	20.71
T_{10} T_2 + Neem cake	6.29	8.26	11.13	14.07	7.90	9.91	11.96	16.67	8.73	10.67	13.37	18.63
T_{11} T_2 + Neem cake + *Azotobacter*	6.88	9.72	12.23	16.42	8.21	10.95	12.95	17.68	9.06	10.33	13.46	18.30
T_{12} T_2 + Neem cake + *Arbuscular mycorrhiza*	8.21	11.29	15.03	19.83	10.29	12.29	15.38	23.58	11.47	14.27	16.70	23.16
T_{13} T_2 + Castor cake	5.99	9.21	11.56	14.26	7.90	10.13	12.68	17.83	8.73	10.51	11.88	18.79
T_{14} T_2 + Castor cake + *Azotobacter*	6.93	10.43	13.13	15.64	9.24	11.12	13.31	18.08	10.18	10.48	13.17	18.48
T_{15} T_2 + Castor cake + *Arbuscular mycorrhiza*	7.99	11.00	14.72	17.03	9.60	11.13	13.07	20.47	9.10	10.44	12.52	19.22
T_{16} T_3 + Neem cake	6.58	8.92	10.83	14.31	7.38	11.26	12.58	17.37	7.92	10.27	12.29	17.93
T_{17} T_3 + Neem cake + *Azotobacter*	7.32	10.37	12.94	17.23	8.60	10.95	12.74	19.07	9.29	10.81	13.35	20.25
T_{18} T_3 + Neem cake + *Arbuscular mycorrhiza*	8.83	12.18	16.44	20.79	9.27	12.63	15.12	22.57	11.40	13.52	16.18	22.19
T_{19} T_3 + Castor cake	6.33	8.80	11.28	15.63	8.03	10.12	12.14	18.20	8.80	9.53	11.65	18.46
T_{20} T_3 + Castor cake + *Azotobacter*	7.20	10.05	13.37	16.73	8.91	11.12	14.73	19.78	9.63	11.45	14.08	20.93
T_{21} T_3 + Castor cake + *Arbuscular mycorrhiza*	8.07	11.56	14.81	18.88	9.10	11.77	14.95	22.08	9.72	11.62	14.11	21.20
Mean	6.93	9.57	12.38	15.78	8.58	10.86	13.23	19.00	9.30	10.93	13.35	19.57
SE(m) ±	0.35	0.40	0.52	0.68	0.34	0.24	0.43	0.48	0.76	0.29	0.46	0.62
C.D. (5%)	1.00	1.15	1.49	1.97	0.99	0.71	1.23	1.39	2.18	0.85	1.33	1.77

DAT- Days After Treatment

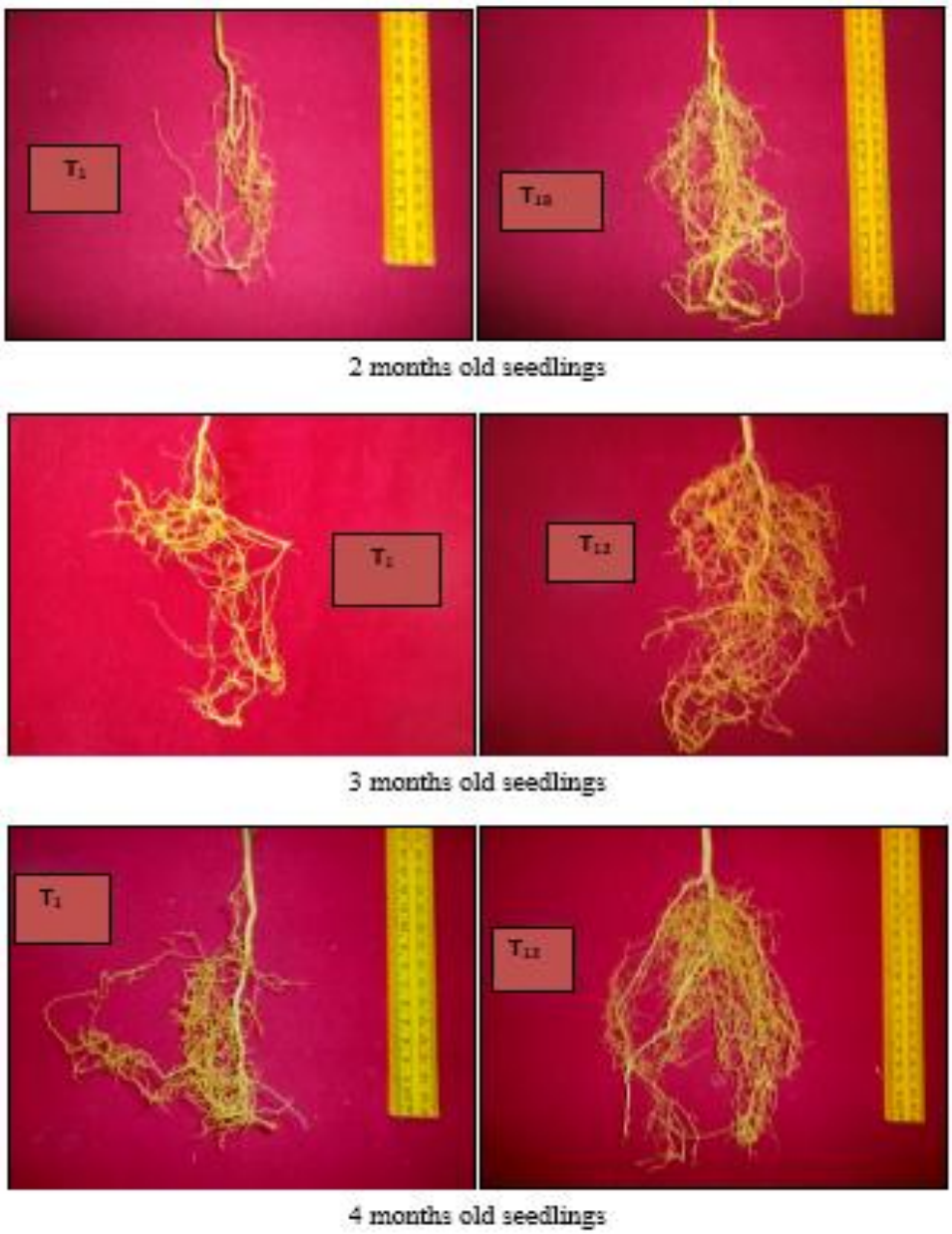

Fig 1: Effect of organic amendments and bio agents on root growth (root length and number of secondary roots) of 2,3,4 months oldacid lime seedings Cv. Balaji.

Table 2: Effect of organic amendments and bio-agents on number of secondary roots of 2, 3 and 4 months old acid lime seedlings cv. Balaji

Treatment	2 months old				3 months old				4 months old			
	DAT 60	DAT 90	DAT 120	DAT 150	DAT 60	DAT 90	DAT 120	DAT 150	DAT 60	DAT 90	DAT 120	DAT 150
T_1 FYM +Sand +soil (control)	3.05	5.09	7.66	9.80	3.41	5.79	9.21	11.77	3.56	7.19	10.32	12.43
T_2 Vermicompost +Sand + Soil	3.26	5.89	8.81	10.79	3.56	6.65	9.41	11.95	4.26	7.41	10.49	13.62
T_3 Cocopeat + Sand + Soil	3.66	6.46	9.12	12.63	3.75	6.81	9.57	13.81	3.74	7.4	10.45	13.52
T_4 T_1 + Neem cake	4.33	7.79	10.95	13.89	5.16	8.21	11.07	14.26	5.48	8.39	11.63	14.55
T_5 T_1 + Neem cake + *Azotobacter*	4.63	8.15	11.07	14.21	4.83	7.95	11.79	14.80	5.37	8.48	13.10	14.36
T_6 T_1 + Neem cake + *Arbuscular mycorrhiza*	5.41	9.82	13.36	17.38	6.93	11.05	16.24	19.50	8.19	13	17.31	21.44
T_7 T_1 + Castor cake	4.12	7.66	10.87	13.97	4.91	10.42	12.53	15.75	5.41	10.42	13.42	15.60
T_8 T_1 + Castor cake + *Azotobacter*	5.41	8.32	12.70	16.21	5.13	8.95	12.23	15.85	5.47	9.56	11.45	16.41
T_9 T_1 + Castor cake + *Arbuscular mycorrhiza*	6.30	10.47	14.32	17.62	5.89	8.97	13.77	16.74	7.26	11.47	15.48	14.86
T_{10} T_2 + Neem cake	4.36	7.86	11.80	14.87	6.22	9.14	12.95	16.29	6.47	10.52	13.46	17.30
T_{11} T_2 + Neem cake + *Azotobacter*	4.87	8.38	11.52	16.23	5.25	8.52	12.68	16.50	6.27	10.41	14.39	17.6
T_{12} T_2 + Neem cake + *Arbuscular mycorrhiza*	6.71	10.80	14.63	18.21	8.19	12.37	17.41	21.73	9.09	14.1	18.22	22.32
T_{13} T_2 + Castor cake	4.90	8.34	11.45	14.30	6.54	9.58	12.58	17.23	7.50	10.39	13.45	18.86
T_{14} T_2 + Castor cake + *Azotobacter*	5.31	9.29	11.37	14.82	5.76	8.68	11.83	14.89	6.17	9.5	12.467	16.38
T_{15} T_2 + Castor cake + *Arbuscular mycorrhiza*	6.18	9.82	13.20	16.79	6.85	10.83	14.75	18.28	7.53	11.46	15.49	18.36
T_{16} T_3 + Neem cake	4.61	7.46	11.13	14.60	4.87	7.98	11.44	15.26	5.65	9.49	14.36	18.84
T_{17} T_3 + Neem cake + *Azotobacter*	5.36	8.58	12.69	15.77	6.07	9.66	14.05	16.92	7.28	11.36	14.45	18.19

T_{18} T_3 + Neem cake + *Arbuscular mycorrhiza*	7.20	11.67	15.14	18.51	8.50	12.62	16.54	19.81	8.59	13.27	17.59	21.91
T_{19} T_3 + Castor cake	4.97	8.60	11.68	14.46	5.82	9.76	12.77	16.23	6.4	10.45	13.43	17.45
T_{20} T_3 + Castor cake + *Azotobacter*	5.34	8.92	12.12	15.49	6.07	9.22	11.69	16.82	6.27	8.51	12.70	18.94
T_{21} T_3 + Castor cake + *Arbuscular mycorrhiza*	6.42	10.58	13.65	17.37	6.98	11.14	14.70	18.91	7.57	11.57	15.72	19.28
Mean	5.07	8.57	11.87	15.14	5.75	9.25	12.82	16.35	6.36	10.20	13.78	17.25
SE(m) ±	0.31	0.53	0.40	0.57	0.34	0.44	0.42	0.31	0.51	0.50	0.40	0.23
C.D. (5%)	0.90	1.52	1.14	1.63	0.283	1.26	1.22	0.91	1.47	1.45	1.15	0.67

Table 3: Effect of organic amendments and bio-agents on leaf dry weight (g) of 2, 3 and 4 months old acid lime seedlings cv. Balaji

Treatment	2 months old				3 months old				4 months old			
	DAT 60	DAT 90	DAT 120	DAT 150	DAT 60	DAT 90	DAT 120	DAT 150	DAT 60	DA 90	DAT 120	DAT 150
T_1 FYM +Sand +soil (control)	0.24	0.53	1.29	1.54	0.25	0.59	1.40	1.83	0.28	0.69	1.46	1.97
T_2 Vermicompost +Sand + Soil	0.24	0.60	1.50	1.85	0.28	0.68	1.43	2.31	0.31	0.76	1.52	2.40
T_3 Cocopeat + Sand + Soil	0.25	0.65	1.34	2.14	0.26	0.68	1.75	2.06	0.30	0.72	1.48	1.98
T_4 T_1 + Neem cake	0.26	0.93	1.81	2.37	0.32	1.07	1.91	2.62	0.38	1.14	1.99	2.79
T_5 T_1 + Neem cake + *Azotobacter*	0.36	1.30	2.19	3.19	0.41	1.24	1.99	2.94	0.46	1.35	2.11	3.05
T_6 T_1 + Neem cake + *Arbuscular mycorrhiza*	0.41	1.20	2.27	3.27	0.60	1.69	2.75	3.92	0.67	2.03	3.32	4.33
T_7 T_1 + Castor cake	0.26	1.01	1.86	2.60	0.39	1.19	2.07	2.50	0.41	1.28	2.11	2.85
T_8 T_1 + Castor cake + *Azotobacter*	0.31	1.25	2.20	3.13	0.43	1.29	2.38	3.03	0.51	1.31	2.43	3.46
T_9 T_1 + Castor cake + *Arbuscular mycorrhiza*	0.30	1.19	2.10	2.85	0.45	0.87	1.65	2.53	0.50	0.99	1.74	2.69
T_{10} T_2 + Neem cake	0.27	0.79	1.43	2.38	0.44	1.26	2.01	2.85	0.49	1.34	2.19	3.24
T_{11} T_2 + Neem cake + *Azotobacter*	0.40	1.38	2.47	3.23	0.47	1.29	2.12	3.07	0.45	1.25	1.94	3.19
T_{12} T_2 + Neem cake + *Arbuscular mycorrhiza*	0.45	1.45	2.79	3.49	0.62	1.85	3.45	4.11	0.71	2.16	3.41	4.51
T_{13} T_2 + Castor cake	0.26	1.05	1.85	2.80	0.49	1.22	2.25	3.15	0.58	1.41	2.41	3.42
T_{14} T_2 + Castor cake + *Azotobacter*	0.29	1.22	2.09	2.93	0.45	1.42	2.35	3.11	0.46	1.52	2.97	3.33
T_{15} T_2 + Castor cake + *Arbuscular mycorrhiza*	0.31	1.15	2.28	3.08	0.61	1.75	2.63	3.78	0.65	1.63	2.82	4.17
T_{16} T_3 + Neem cake	0.28	1.13	2.02	2.85	0.43	1.24	2.30	3.35	0.45	1.43	2.38	3.33
T_{17} T_3 + Neem cake + *Azotobacter*	0.30	1.03	2.12	3.18	0.53	1.35	2.52	3.58	0.57	1.44	2.62	3.67
T_{18} T_3 + Neem cake + *Arbuscular mycorrhiza*	0.51	1.52	2.82	3.88	0.58	1.47	2.59	4.06	0.67	1.96	2.83	4.34
T_{19} T_3 + Castor cake	0.27	1.06	1.52	2.31	0.51	1.43	2.42	3.22	0.49	1.48	2.42	3.41
T_{20} T_3 + Castor cake + *Azotobacter*	0.30	1.04	1.91	2.56	0.58	1.51	2.38	3.49	0.62	1.71	2.74	3.98
T_{21} T_3 + Castor cake + *Arbuscular mycorrhiza*	0.26	0.98	1.68	2.89	0.61	1.79	3.18	3.98	0.68	1.75	2.85	4.06
Mean	0.31	1.07	1.98	2.79	0.46	1.28	2.26	3.12	0.51	1.40	2.37	3.34
SE(m) ±	0.02	0.07	0.14	0.18	0.02	0.11	0.15	0.18	0.01	0.11	0.13	0.11
C.D. (5%)	0.08	0.22	0.42	0.53	0.08	0.33	0.43	0.53	0.04	0.33	0.38	0.33

Table 4: Effect of organic amendments and bio-agents on root dry weight (g) of 2, 3 and 4 months old acid lime seedlings cv. Balaji

Treatment	2 months old				3 months old				4 months old			
	DAT 60	DAT 90	DAT 120	DAT 150	DAT 60	DAT 90	DAT 120	DAT 150	DAT 60	DAT 90	DAT 120	DAT 150
T_1 FYM +Sand +soil (control)	0.24	0.42	0.65	1.06	0.53	0.91	1.16	1.42	0.66	1.05	1.29	1.59
T_2 Vermicompost +Sand + Soil	0.24	0.63	0.90	1.14	0.58	0.97	1.26	1.58	0.61	1.09	1.43	1.64
T_3 Cocopeat + Sand + Soil	0.25	0.57	0.77	1.22	0.56	0.94	1.21	1.50	0.64	1.15	1.37	1.68
T_4 T_1 + Neem cake	0.31	0.64	0.93	1.28	0.60	1.18	1.49	1.85	0.68	1.32	1.83	2.21
T_5 T_1 + Neem cake + *Azotobacter*	0.39	0.80	1.10	1.39	0.69	1.22	1.82	2.21	0.74	1.48	2.06	2.37
T_6 T_1 + Neem cake + *Arbuscular mycorrhiza*	0.87	1.72	2.28	2.53	0.72	1.62	2.11	2.57	0.94	1.82	2.32	2.87
T_7 T_1 + Castor cake	0.37	0.59	0.76	1.25	0.58	1.24	1.64	1.80	0.69	1.35	1.69	1.99
T_8 T_1 + Castor cake + *Azotobacter*	0.39	0.77	0.96	1.34	0.65	1.15	1.72	2.18	0.74	1.44	1.83	2.25
T_9 T_1 + Castor cake + *Arbuscular mycorrhiza*	0.75	1.38	1.97	2.36	0.75	1.38	1.97	2.36	0.78	1.70	2.10	2.43
T_{10} T_2 + Neem cake	0.70	1.22	1.65	2.05	0.67	1.16	1.56	2.14	0.77	1.36	1.74	2.18
T_{11} T_2 + Neem cake + *Azotobacter*	0.67	1.16	1.56	2.14	0.70	1.22	1.65	2.05	0.85	1.45	1.83	2.18
T_{12} T_2 + Neem cake + *Arbuscular mycorrhiza*	0.80	1.49	2.26	2.64	0.90	1.76	2.47	3.19	0.98	1.88	2.93	3.17
T_{13} T_2 + Castor cake	0.67	1.07	1.53	1.91	0.67	1.07	1.53	1.91	0.78	1.35	1.73	2.08
T_{14} T_2 + Castor cake + *Azotobacter*	0.66	1.24	1.65	1.97	0.66	1.24	1.65	1.97	0.80	1.53	1.85	2.24
T_{15} T_2 + Castor cake + *Arbuscular mycorrhiza*	0.78	1.46	1.88	2.49	0.80	1.49	2.26	2.64	0.95	1.84	2.04	2.67
T_{16} T_3 + Neem cake	0.60	1.17	1.52	1.92	0.71	1.13	1.43	1.93	0.84	1.23	1.60	1.90
T_{17} T_3 + Neem cake + *Azotobacter*	0.71	1.13	1.43	2.26	0.66	1.19	1.44	1.78	0.75	1.36	1.42	1.75
T_{18} T_3 + Neem cake + *Arbuscular mycorrhiza*	0.90	1.76	2.47	2.91	0.87	1.72	2.28	2.76	0.84	1.92	2.40	2.94
T_{19} T_3 + Castor cake	0.48	0.88	1.12	1.64	0.60	1.17	1.52	1.92	0.73	1.38	1.75	2.11
T_{20} T_3 + Castor cake + *Azotobacter*	0.66	1.19	1.44	1.78	0.63	1.20	1.75	2.26	0.79	1.67	1.98	2.48
T_{21} T_3 + Castor cake + *Arbuscular mycorrhiza*	0.63	1.20	1.75	2.26	0.78	1.46	1.88	2.49	0.89	1.75	2.17	2.67
Mean	0.57	1.07	1.46	1.88	0.68	1.26	1.70	2.12	0.78	1.48	1.87	2.26
SE(m) ±	0.05	0.10	0.13	0.14	0.06	0.11	0.14	0.12	0.10	0.10	0.13	0.1
C.D. (5%)	0.15	0.30	0.37	0.42	0.19	0.31	0.40	0.35	N/A	0.31	0.37	0.28

Table 5: Effect of organic amendments and bio-agents on total dry weight (g) of 2, 3 and 4 months old acid lime seedlings cv. Balaji

Treatment	2 months old				3 months old				4 months old			
	DAT 60	DAT 90	DAT 120	DAT 150	DAT 60	DAT 90	DAT 120	DAT 150	DAT 60	DAT 90	DAT 120	DAT 150
T_1 FYM +Sand +soil (control)	1.80	2.28	2.72	3.84	1.85	2.58	3.14	4.51	2.16	3.30	3.72	5.11
T_2 Vermicompost +Sand + Soil	1.91	2.56	3.58	4.83	1.94	2.87	3.52	4.74	2.39	3.37	3.75	5.36
T_3 Cocopeat + Sand + Soil	1.86	2.42	3.35	4.40	1.90	2.70	3.34	4.62	2.24	3.32	3.73	5.18
T_4 T_1 + Neem cake	2.12	2.79	4.15	5.19	2.17	3.45	4.11	5.21	2.47	3.96	4.44	6.10
T_5 T_1 + Neem cake + *Azotobacter*	2.07	2.95	3.93	5.37	2.16	3.43	4.41	6.27	2.26	3.95	4.43	6.63
T_6 T_1 + Neem cake + *Arbuscular mycorrhiza*	2.65	3.52	4.89	6.84	3.23	4.46	6.35	7.88	3.66	5.22	6.11	8.07
T_7 T_1 + Castor cake	2.34	3.19	3.96	4.98	2.47	4.21	5.29	6.09	2.71	4.34	5.24	5.97
T_8 T_1 + Castor cake + *Azotobacter*	2.22	2.85	3.86	5.71	2.31	3.85	5.19	6.87	2.54	4.67	5.39	6.82
T_9 T_1 + Castor cake + *Arbuscular mycorrhiza*	2.40	3.15	4.55	5.98	2.74	4.90	6.05	6.95	3.06	5.40	6.14	7.06
T_{10} T_2 + Neem cake	2.12	2.75	4.15	5.80	2.41	4.15	5.13	6.22	2.95	4.53	5.09	6.58
T_{11} T_2 + Neem cake + *Azotobacter*	2.37	2.96	4.45	6.20	2.48	4.26	4.85	6.34	2.66	4.23	4.84	6.76
T_{12} T_2 + Neem cake + *Arbuscular mycorrhiza*	2.80	3.82	6.13	7.80	3.47	5.47	6.76	8.69	3.78	6.22	7.46	9.21
T_{13} T_2 + Castor cake	2.33	2.99	4.50	5.62	2.33	4.53	5.84	6.31	2.84	5.12	5.74	6.8
T_{14} T_2 + Castor cake + *Azotobacter*	2.62	3.17	4.71	6.12	2.47	4.73	5.82	6.92	3.31	5.02	5.80	7.10
T_{15} T_2 + Castor cake + *Arbuscular mycorrhiza*	2.57	3.87	5.01	6.77	2.82	4.83	6.12	7.71	3.42	5.63	6.62	8.34
T_{16} T_3 + Neem cake	2.29	2.93	4.21	5.83	2.29	4.16	5.08	6.04	2.65	4.38	4.97	6.15
T_{17} T_3 + Neem cake + *Azotobacter*	2.38	3.26	4.59	6.05	2.47	4.71	5.89	6.83	2.82	5.28	6.18	7.48
T_{18} T_3 + Neem cake + *Arbuscular mycorrhiza*	3.15	4.35	6.26	7.94	3.31	5.35	6.48	8.16	3.52	6.09	6.84	8.75
T_{19} T_3 + Castor cake	2.27	3.16	4.64	6.02	2.27	3.82	4.90	6.95	2.83	4.99	5.72	7.1
T_{20} T_3 + Castor cake + *Azotobacter*	2.42	3.54	4.57	6.24	2.65	4.97	5.88	7.06	3.06	5.14	6.16	7.65
T_{21} T_3 + Castor cake + *Arbuscular mycorrhiza*	2.46	3.83	5.47	6.05	2.66	5.21	6.29	7.79	3.26	5.64	6.65	8.34
Mean	2.34	3.16	4.46	5.88	2.50	4.22	5.26	6.58	2.88	4.75	5.48	6.98
SE(m) ±	0.15	0.22	0.32	0.30	0.15	0.168	0.14	0.20	0.12	0.11	0.17	0.19
C.D. (5%)	0.44	0.64	0.93	0.88	0.43	0.48	0.22	0.57	0.36	0.34	0.49	0.54

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