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Different growing media effect on seedling quality and field performance of Tomato (*Solanum lycopersicum* L.)

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Abstract
Quality seedling can ensure higher crop yield. The present investigation was carried out at AAU, Jorhat, Assam, India during rabi season of 2018-19 and 2019-20 to access the impact of different growing media on growth, quality and vigour of tomato seedling and subsequent performance in the main field. The treatments consisted of four different nursery media composition *viz*., M1: Cocopeat (60): Vermiculite (20): Perlite (20), M2: Cocopeat (50): vermicompost (50), M3: Cocopeat (50): vermicompost (50): Microbial consortium (6g/ kg media), M4: Conventional nursery (soil: sand: FYM). The effect of different seed sowing media on seedling quality and their performance in the main field was found to be significant. The results revealed that tomato seedlings raised in plug trays with seed sowing media coconut (50): vermicompost (50) *i.e*. M2 recorded higher seedling emergence percentage (98.42), seedling height (15.47 cm), seedling vigour index (2268.54), dry matter accumulation (24.18%), total chlorophyll content (1.61 mg g-1fw). The same seedling raised media showed better performance in the main field, recorded less days to seedling establishment (4.29), higher leaf area index (5.45), membrane stability index (70.71%), relative leaf water content (79.48%), root length (60.53 cm), root dry weight (15.95g), days to 50% flowering (31.71), number of fruits per plant (42.78), individual fruit weight (66.78g), yield per hectare (105.63 t) and B:C ratio of 5.28.

Keywords: Tomato, growing media, chlorophyll content, RLWC, cocopeat, vermicompost, perlite, vermiculite, microbial consortium, yield, B:C ratio

Introduction
Tomato (*Solanum lycopersicum* L.) is a member of the Solanaceae family that is grown world-wide (Sharma and Singh, 2015) [17]. Tomato is one of the most important "protective foods" because of its special nutritive value. Tomato has been recently gaining attention in relation to the prevention of some human diseases. This interest is due to the presence of carotenoids and particularly lycopene, which is an unsaturated alkylic compound, that appears to be an active compound in the prevention of cancer, cardiovascular risk and in slowing down cellular aging (Abdel-Monaim, 2012) [18]. Lycopene is found in fresh, red-ripe tomatoes as all-trans (79-91%) and cis- (9-21%) isomers (Abdel-Fattah and Al-Amri, 2012) [18]. The full potential of a transplanted vegetable can be achieved by establishing an uniform stand of healthy vigorous seedlings. Traditionally tomato seedlings are raised in the open field nursery, which confronts several adverse situations like uneven seed germination, acute seedling competition for nutrient, light and water, attack of soil borne pest and pathogens that lead to variable seedling stand. To get more viable seedlings, farmers usually practice high density sowing that increases seed cost and wastage of resources. With the adoption of hybrid variety, cost of seed has increased manifold and farmers are searching new ways to reduce seedling mortality and to get quality seedling.

In view of the high cost of seeds, some vegetable crops like tomato, brinjal, capsicum and cucurbits are being transplanted after growing nursery under protected conditions to achieve maximum germination count and healthy plant establishment. In the production of seedling ready for planting, climatic conditions as well as seed sowing media have quite significant impacts on seedling development. In vegetative production, seedling stage is an important stage that has influences on growth and development, early yield, total yield and fruit per plant. Seedling production with conventional methods causes stress in plants. Seedlings are grown in different growth media, which plays a vital role in efficient production of horticultural seedlings in nurseries (Sterrett, 2001) [9]. The use of suitable growing media or substrates for sowing of seeds directly affects the germination, development and functional rooting system.

A good growing medium provides sufficient anchorage or support to the plant, serves as reservoir for nutrients and water, allow oxygen diffusion to the roots and permit gaseous exchange between the roots and atmosphere outside the root substrate (Abad *et al*., 2002) [10]. The quality of seedlings is very much influenced by growing media under nursery (Agbo and Omaliko, 2006) [13]. The quality of seedlings obtained from a nursery influences re-establishment in the field and the eventual productivity of an orchard (Baiyeri and Mbah, 2006) [14].

Cocopeat has good physical properties, high total pore space, high water content, low shrinkage, low bulk density and slow biodegradation (Prasad, 1997) [6]. Perlite and vermiculite provide aeration and drainage; they can retain and hold substantial amount of water and later release it as needed. Vermicompost contains macro and micronutrients. It also contains humic acids, plant growth promoting substances like auxins, gibberellins and cytokinins. N-fixing and P-solubilizing bacteria, enzymes and vitamins, which increases the availability of plant nutrients resulting in increased growth, higher yield and better-quality produce (Atiyeh *et al*., 2001) [8].

A pre-sowing inoculation of planting material as well as the planting medium with the consortia of beneficial microorganisms is an innovative approach for production of quality and healthy seedlings in horticultural production. A microbial consortium is a carrier-based product containing nitrogen fixing, phosphorus and potassium solubilizing and plant growth promoting microorganisms in a single formulation. The synergistic effect of the formulated microbes can help in providing healthy and vigorous seedlings and considerably reducing the cost of cultivation by reducing fertilizer requirement of vegetables.

The literatures are meagre for comparative study on seedling performance in open nursery and plug tray as well as on different growth media under greenhouse condition in Assam. Based on the fact, the present investigation was designed to study the impact of different seed sowing media on growth, quality and vigour of tomato seedling and subsequently their influence on yield and yield attributing parameters of cabbage in the main field.

Materials and Methods

The field experiments were conducted at the Experimental Farm, Department of Horticulture, Assam Agricultural University, Jorhat, Assam, India during rabi season of 2018-2019 and again repeated in 2019-20. The experimental site AAU, Jorhat is situated at 26.47°N latitude and 94.12°E longitude and at an elevation of 86.8 m above mean sea level. The soil was well drained sandy loam having pH 5.20, organic carbon 0.93% and available N, P and K were 212.21 kg ha-1, 20.34 kg ha-1 and 118.42 kg ha-1 respectively. The treatments consisted of four different nursery media composition *viz*., M1: Cocopeat (60): Vermiculite (20): Perlite (20), M2: Cocopeat (50): vermicompost (50), M3: Cocopeat (50): vermicompost (50): Microbial consortium (6g/ kg media), M4: Conventional nursery (soil: sand: FYM). Design used was Randomized Block Design (RBD) with three replications.

Different seedling attributes namely seedling emergence percentage, days to 2-true leaf stage, seedling height, stem diameter, leaf area, days to transplant, root length, seedling vigour index, total chlorophyll content, seedling fresh weight, seedling dry weight and dry matter accumulation were recorded just before transplanting. The chlorophyll content of leaves was measured by using portable leaf chlorophyll meter. The seedling vigour was calculated by multiplying the germination percentage with seedling dry weight (Abdul-Bakki and Anderson, 1973) [1].

The economics of the treatments was worked out on the basis of benefit: cost (B:C) ratio derived from net return and cost of production as per existing market rate. Healthy seedlings were transplanted in the main field at 3.0 m x 2.7 m plots at 45 cm spacing within and between rows. The field crop received a uniform dose of farmyard manure (20 t ha-1) along with inorganic fertilizers at 130 kg N, 80 kg P2O5 and 80 kg K2O per hectare. Recommended cultural and plant protection measures were followed equally in all the plots as and when required. In the main field the observations were recorded on ten randomly selected plants from each plot. Two years data from different treatments were subjected to statistical analysis. The data for individual year was computed and pooled mean was worked out. The treatment means were compared using least significant difference (LSD) test at 0.05 level of significance. All analyses were performed using INDOSTAT version 8.0 statistical package.

Results and Discussion

Performance of seedlings

The results revealed significant differences among the different seed sowing media (Table 1, 2 & Fig 1 and 2). Growing media M2 [Cocopeat (50): vermicompost (50)] recorded higher seedling emergence percentage (98.42%), seedling height (15.47 cm), stem diameter (3.23 mm), leaf area (8.35 cm3), seedling vigour index (2268.54), seedling fresh weight (1.53 g), seedling dry weight (0.37 g) and total chlorophyll content (1.61 mg g-1 fw).

All seeds need water, oxygen and right temperature to germinate. Water to soften the protective seed coat. Oxygen needed for aerobic respiration so that they can produce energy for germination and growth. The embryo get energy by breaking down its food stores. Warm temperature is needed to speed up the chemical reaction that take place in seed and also to speed up the making of new cell when the seed embryo is growing. Inside the greenhouse proper temperature was maintained and growing media M2 [Cocopeat (50): vermicompost (50)] having good water holding capacity and moisture supply as well as sufficient porosity which permits adequate moisture and gaseous exchange between media and seed which helps better seedling emergence. Similar results were also obtained by Zaller (2007) [18]; Hota and Arulmozhiselvan (2017) [19].

More Seedling height might be due to conducive effect of this media composition on water holding capacity, porosity, proper aeration and substantial amount of nutrient especially nitrogen and micronutrients for good plant growth (Chopde *et al*. 1999) [7]. Similar result was obtained by Nissi (2018) [20] in tomato.

Paul and Metzger (2005) [12] observed that 20% vermicompost (by volume) as growth media in plug tray emerged as best in seedling attributes of tomato (plant height 9.40 cm; leaf area 39.99 cm2; dry weight 0.18 g) and brinjal (plant height 9.0 cm; leaf area 84.07 cm^2; dry weight 0.35 g). Quality seedlings in plug tray container in presence of vermicompost could be due to good physical structure and favourable growing media that utilized the space, moisture and nutrients properly and encouraged healthy and vigorous seedling growth (Singh *et al*., 2007; Alex *et al*., 2007) [15, 16].

Atiyeh and Coworkers (2002) [11] pointed out that vermicompost can result in the leaf surface increase because of having enough nutrition and the absorption capability. The leaf surface increase because of the microorganism activity and pointed out that the microorganism with having the ability in producing the regulated growth material can result in the leaf surface increase. Similar result was also obtained by Nissi (2018) [20] in tomato.

Combined application of vermicompost and cocopeat in the media M2 showed more stem diameter probably due to the synergistic combinations of these factors improving the physical conditions of the media and nutritional factors (Sahni *et al*., 2008) [21]. It may be due to better nutrient availability leading to higher production of photosynthetically functional leaves in this treatment finally resulting in better girth of seedling (Borah *et al*., 1994) [3]. Similar results were also obtained by Parasana *et al*., (2013) [22] and Patel *et al* (2019) [23].

The microorganisms present in vermicompost and microbial consortium synthesize plant growth hormone mainly auxin, gibberellin and cytokinin. The maximum root growth might be due to more availability of auxin in this growing media (M3). Moreover, cocopeat helped the media to acquire good physical and chemical properties by decreasing compactness and increasing porosity of the media which helped in better root growth. Moreover, vermicompost is reported as having bioactive principles considered to be beneficial for root growth, root initiation, germination and growth of the plant (Bachman and Metzger, 2008) [24], as also having a balanced composition of nutrients (Zaller, 2007) [18]. Similar result was also obtained by Nissi (2018) [20] in tomato.

For chlorophyll formation nitrogen and magnesium is needed by plant. Increase in these two nutrient uptakes resulted in increasing chlorophyll content in M2 media grown seedlings which contains Cocopeat (50): vermicompost (50).

The leaves of seedling raised in this media (M2) also has higher leaf chlorophyll content due to presence of nitrogen in vermicompost which might certainly upgrade the photosynthetic rate, dry matter production and their by more fresh and dry weight of plant (Awasthi *et al*., 1996) [5].

The fresh weight and dry weight of seedling were found significantly maximum under the media Cocopeat (50): vermicompost (50) *i.e* M2 compared to other treatments. This seems to be the effect of better mobilization of water and nutrients transported at higher rate which might have promoted more production of photosynthetic products and translocated them to various plant parts which might have resulted in better growth of the seedlings and hence, more fresh and dry weight (Anjanawe *et al*, 2013 and Nissi, 2018) [25, 20].

The minimum fresh weight and dry weight might be due the media combination of Cocopeat (60): Vermiculite (20): Perlite (20) *i.e* M1 where primary nutrients (NPK) are not there for proper growth and development. In this media only water availability is good but along with water, plants also need nutrients.

The conventional nursery (soil: sand: FYM) seedlings showed better result than media M1 i.e Cocopeat (60): Vermiculite (20): Perlite (20) which might be due to availability of N, P and K from FYM along with water though it is under open field condition.

Table 1: Seedling emergence (%), days to 2-True leaf stage, seedling height, stem diameter and days to transplant (Pooled mean of two years 2018-19 and 2019-20)

Treatment	Seedling emergence (%)	Days to 2-True leaf stage	Seedling height (cm)	Stem diameter (mm)	Leaf area (cm2)	Days to transplant
M1: Cocopeat (60): Vermiculite (20): Perlite (20)	93.67	14.08	8.34	1.92	2.59	29.12
M2: Cocopeat (50): vermicompost (50)	98.42	10.35	15.47	3.23	8.35	21.38
M3: Cocopeat (50): vermicompost (50): Microbial consortium (6g/ kg media)	97.34	10.95	14.74	3.06	7.58	22.74
M4: Conventional nursery (soil: sand: FYM)	94.17	16.83	11.68	2.23	2.89	28.90
S.Ed (±)	1.22	1.27	2.12	0.13	0.98	1.48
CD (0.05)	3.04	3.15	4.95	0.31	2.32	3.17

Table 2: Root length, Seedling vigour index, Seedling fresh weight, Seedling dry weight, Dry matter accumulation and Total Chlorophyll content (Pooled mean of two years 2018-19 and 2019-20)

Treatment	Root length (cm)	Seedling vigour index	Seedling fresh weight (g)	Seedling dry weight (g)	Dry matter accumulation (%)	Total Chlorophyll content (mg g-1 fw)
M1: Cocopeat (60): Vermiculite (20): Perlite (20)	5.84	1348.64	0.51	0.09	18.83	0.81
M2: Cocopeat (50): vermicompost (50)	10.25	2268.54	1.53	0.37	24.18	1.61
M3: Cocopeat (50): vermicompost (50): Microbial consortium (6g/ kg media)	10.37	2201.28	1.49	0.35	23.74	1.28
M4: Conventional nursery (soil: sand: FYM)	5.89	1518.91	0.56	0.10	17.83	0.73
S.Ed (±)	1.32	25.54	0.04	0.02	1.91	0.04
CD (0.05)	3.01	61.29	0.09	0.04	4.41	0.09

Table 3: Days to establishment, Plant height at 30, 60 and 90 days after transplanting, leaf number, leaf area, leaf area index and specific leaf weight (Pooled mean of two years 2018-19 and 2019-20)

Treatment	Days to establishment	Plant height (cm) at 30 DAT	Plant height (cm) at 60 DAT	Plant height (cm) at 90 DAT	Leaf numbers	Leaf area index (LAI)	Specific leaf weight (mg cm-2)
M1: Cocopeat Vermiculite (20):(20) (60): Perlite	5.83	51.68	85.23	100.78	30.84	3.29	8.29
M2: Cocopeat Vermicompost (50)(50):	4.29	70.43	95.30	118.50	41.56	5.45	18.22
M3: Cocopeat vermicompost (50):(50): Microbial consortium (6g/kg media)	4.41	60.70	93.94	114.74	38.77	5.20	19.59
M4: Conventional nursery (soil: sand: FYM)	6.21	55.37	89.86	103.34	35.08	4.67	13.45
S.Ed (±)	0.77	6.16	2.39	4.75	2.37	0.33	2.82
CD (0.05)	1.69	13.61	5.99	9.90	5.37	0.65	5.67

Table 4: Membrane stability index, relative leaf water content, root length, root dry weight, days to 50% flowering, days to 50% fruit set and no. of flower cluster per plant (Pooled mean of two years 2018-19 and 2019-20)

Treatment	Membrane stability index (%)	Relative leaf water content (%)	Root length (cm)	Root dry weight (g)	Days to 50% flowering	Days to 50% fruit set
M1: Cocopeat (60): Vermiculite (20): Perlite (20)	62.73	77.24	38.45	12.38	35.67	56.22
M2: Cocopeat (50): vermicompost (50)	70.71	79.48	60.53	15.95	31.71	46.89
M3: Cocopeat (50): vermicompost (50): Microbial consortium (6g/ kg media)	66.91	77.20	54.77	15.95	32.80	46.92
M4: Conventional Nursery (soil: sand: FYM)	57.59	78.78	40.10	11.46	37.26	50.55
S.Ed (±)	2.39	0.86	4.25	1.12	0.83	2.83
CD (0.05)	4.06	1.17	7.76	2.70	1.78	6.37

Table 5: No. of fruits per cluster, Head weight, head diameter, head compactness, head yield and B:C ratio (Pooled mean of two years 2018-19 and 2019-20)

Treatment	No. of flower cluster per plant	No. of fruits per cluster	Days to first harvest	Individual fruit weight (g)	Fruit yield per plant (kg)	Total yield (t ha-1)
M1: Cocopeat (60): Vermiculite (20): Perlite (20)	9.65	5.12	109.51	59.77	2.04	75.29
M2: Cocopeat (50): vermicompost (50)	10.78	6.37	93.69	66.78	2.85	105.63
M3: Cocopeat (50): vermicompost (50): Microbial consortium (6g/ kg media)	10.83	6.15	99.29	65.57	2.73	101.01
M4: Conventional nursery (soil: sand: FYM)	10.22	5.32	107.06	58.71	2.15	79.73
S.Ed (±)	0.24	0.13	2.58	0.87	0.15	1.89
CD (0.05)	0.45	0.24	5.35	1.91	0.55	4.72

Table 6: Production economics of tomato (Pooled mean of two years 2018-19 and 2019-20)

Treatment	Gross expenditure (Rs. ha-1)	Gross return (Rs. ha-1)	Net return (Rs. ha-1)	B:C ratio
M1: Cocopeat (60): Vermiculite (20): Perlite (20)	261446	1129350	867904	3.32
M2: Cocopeat (50): vermicompost (50)	252398	1584450	1332052	5.28
M3: Cocopeat (50): vermicompost (50): Microbial consortium (6g/ kg media)	252554	1515150	1262596	4.99
M4: Conventional nursery (soil: sand: FYM)	239762	1195950	956188	3.98

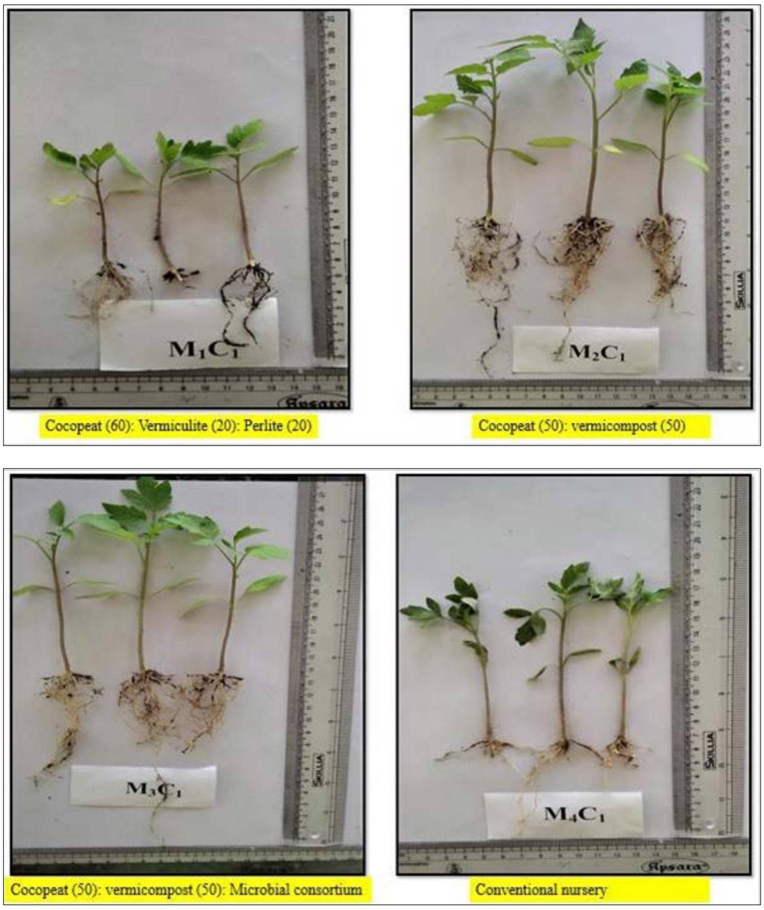

Fig 1: Seedling growth under different growing media

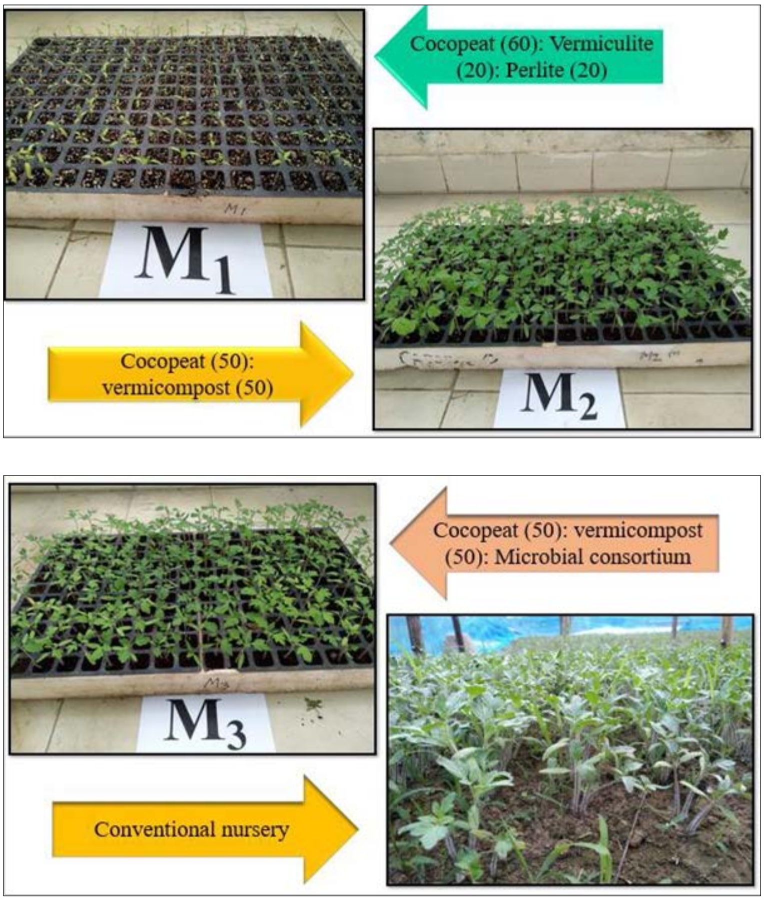

Fig 2: Seedling growth under different growing media

Performance of seedling in the main field

The seedling raised media M2 [Cocopeat (50): vermicompost (50)] under greenhouse condition showed better performance in the main field, recorded less days (4.29) to seedling establishment, more plant height (70.43, 95.30 and 118.50 cm) after 30, 60 and 90 days of transplanting, higher leaf area index (5.45), higher root length (60.53 cm), less days required for 50% flowering (31.71), 50% fruit set (46.89) and harvesting (93.69 days), higher individual fruit weight (66.78 g), higher fruit yield per plant (2.85 kg) and higher yield per hectare (105.63 t) and B:C ratio (5.28).

Successful establishment of a seedling in the main field is the first critical step for crop production. Early establishment might be due to more root length which quickly absorb water and nutrients and high seedling vigour index. This active root system allows more uniform and faster growth, with little or no transplant shock. Increase in number of leaves might be mainly due to corresponding increase in plant height (Govind and Chandra, 1993) [2] and also may be due to better nutrient availability leading to immense production of photo synthetically functional leaves in these treatments (Patel *et al*, 2019) [23]. LAI is an important parameter in plant ecology. Because it tells how much foliage is there, it is a measure of the photosynthetic active area. More LAI might be due more leaf number in the plant. Roots are lifeline of a plant, taking up air (O2), water and nutrient from soil and moving them up to the leaves. More root length might be due to more photosynthates transferred to the root because leaf area index is more in this this treatment and more leaf area index more photosynthesis *i.e* more food production for plant. The more fruit weight might be due to production of a greater number of leaves. More leaf area index was also found in this treatment M2 due to which photosynthesis increased and finally increased the fruit weight. Similar result was given by Jett *et al*., (1995) [4] in broccoli.

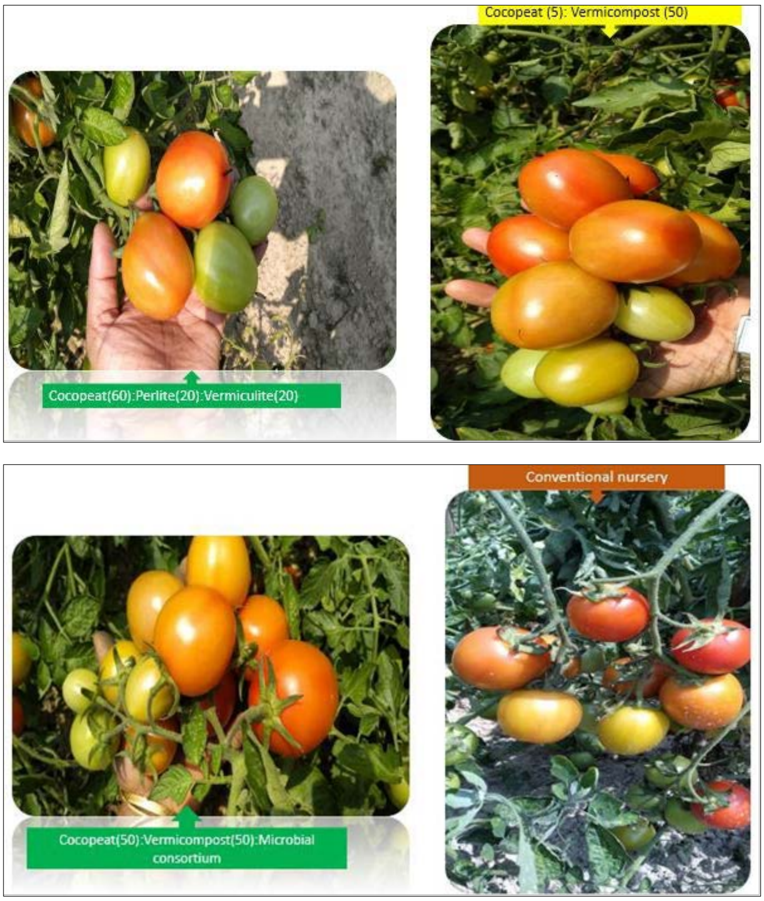

Fig 3: Tomato Fruit cluster under different treatments

Conclusion

The result of the present investigation revealed that seedling raising in cocopeat (50): vermicompost (50) *i.e* media M2 under greenhouse condition is an efficient and superior alternative to traditional open field seedling raising (M4: conventional nursery) for tomato. These method offers great potential for healthy and vigorous seedlings production in tomato which finally shows better performance in the main field in terms of yield and yield attributing characters.

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