Original Research Article

Effect of Different Seedling Growing Media on Growth, Quality and Vigour of Tomato and Cabbage Seedling and Subsequent Performance in the Main Field

Abstract

This study, conducted during the 2018-20 rabi season at the Experimental Farm, Assam Agricultural University, Jorhat, aimed to determine the influence of various seedling growing media on tomato and cabbage seedlings' growth, quality, and field performance. Four media compositions (M1 (Cocopeat: Vermiculite: Perlite), M2 (Cocopeat: Vermicompost), M3 (Cocopeat: Vermicompost: Microbial consortium), and M4 (Conventional nursery mix of soil, sand, and FYM) were tested, alongside two crops (tomato and cabbage), resulting in eight treatment combinations. These treatments were arranged in a RBD with three replications. The study aimed to identify optimal seedling growing media for enhanced crop performance Tomato seedlings performed best in plug trays using a coconut (50%) and vermicompost (50%) medium (M2), showing higher emergence rates, growth, and yield. Cabbage seedlings excelled with a coconut (50%), vermicompost (50%), and microbial consortium (M3) medium. Both M2 and M3 mediums also demonstrated superior field performance.

Keywords:Tomato, Cabbage,microbial consortium LAI,perlite,vermiculite,yield, cocopeat, vermicompost

Introduction

Tomato (*Solanum lycopersicum*L.) is a member of the Solanaceae family that is grown worldwide (Sharma and Singh, 2015). 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. The focus here lies in carotenoids, particularly lycopene, an unsaturated compound. It's thought to actively contribute to cancer prevention, lowering cardiovascular risk, and slowing cellular aging (Abdel-Monaim, 2012). Lycopene is found in fresh, red-ripe tomatoes as all-trans (79-91%) and cis- (9-21%) isomers. The full potential of atransplanted vegetable can be achieved by establishing an uniform stand of healthy vigorousseedlings. Traditionally tomato seedlings are raised in the open field nursery, which confrontsseveral adverse situations like uneven seed germination, acute seedling competition fornutrient, light and water, attack of soil borne pest and pathogens that lead to variable seedlingstand. For better seedling yields, farmers often employ high-density sowing, which can lead to increased seed expenses and resource wastage. 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.

Cabbage (*Brassica oleracea* L.), biennial but generally grown as annuals, is a vegetable crop, an excellent source of vitamin C, some B vitamins, potassium and calcium. The full potential of a transplanted vegetable can be achieved by establishing an uniform stand of healthy vigorous seedlings.

Traditionally, cabbage seedlings are cultivated in open field nurseries, which come with various challenges such as irregular seed germination, intense competition among seedlings for nutrients, light, and water, and susceptibility to soil-borne pests and diseases. In an attempt to obtain healthier seedlings, farmers frequently resort to high-density sowing, resulting in elevated seed costs and resource inefficiency. 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.

Due to the rising costs of seeds, various vegetable crops such as tomatoes, eggplants, peppers, and cucurbits are now being transplanted after nurturing in protected environments. This approach ensures maximum germination rates and robust plant establishment. While seedling production has long been employed for crops like tomatoes, peppers, cucumbers, and eggplants, it has more recently been adopted for leafy vegetables like cabbage and lettuce (Sterrett, 2001). The success of seedling production is significantly influenced by climatic conditions and the choice of seed sowing media.

During vegetative production, the seedling stage plays a pivotal role in shaping growth, development, early and overall yields, and the number of fruits per plant. Conventional methods of seedling production can impose stress on plants. The growth media used in this stage are crucial for the efficient development of horticultural seedlings in nurseries. An ideal growing medium offers stable anchorage, acts as a nutrient and water reservoir, facilitates oxygen exchange with the roots, and allows gaseous interactions between the roots and the surrounding atmosphere. The choice of growing media significantly impacts seedling quality in the nursery, which, in turn, influences field re-establishment and the ultimate productivity of an orchard (Abad et al., 2002; Baiyeri, 2006; Agbo and Omaliko, 2006).
Plug trays are emerging as suitable seedling raising technology, as tray cavities allow proper nourishment ofseedling through uniform utilization of the light, water and nutrients among all the plants. Again, growing mediacontributed significant role on seed germination, seedling growth and initial seedling performance. In addition to traditional farmyard manure, vegetable cultivators are increasingly turning to alternative growing media for nurturing seedlings of various vegetable crops. Notably, vermicompost, cocopeat, vermiculite, perlite, and microbial consortium have gained popularity. Each of these media offers unique advantages. Cocopeat, for instance, boasts excellent physical properties, with a high total pore space, ample water retention, minimal shrinkage, low bulk density, and gradual biodegradation (Prasad, 1997). Perlite and vermiculite play a critical role in aeration and drainage, effectively storing and gradually releasing significant amounts of water as required. 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).A pre-sowing inoculation of planting material as well as the planting medium with the consortia of beneficialmicroorganisms 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 combined action of these formulated microbes has the potential to foster robust and healthy seedlings while significantly curbing cultivation costs by reducing the need for fertilizers in vegetable production. Comparative research on seedling performance between open-field nurseries and plug trays, as well as the effects of various growth media under greenhouse conditions in Assam, remains limited in the existing literature. This knowledge gap led to the design of the present study. Our investigation aims to assess how different seed sowing media impact the growth, quality, and vitality of cabbage seedlings, and subsequently, how they influence the yield and associated attributes of cabbage plants in the main field.

Materials and Methods

The field experiments were conducted at the Experimental Farm, Department of Horticulture, Assam AgriculturalUniversity, 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. M_1: Cocopeat (60): Vermiculite (20): Perlite (20), M_2: Cocopeat (50): vermicompost (50), M_3: Cocopeat (50):

vermicompost (50): Microbial consortium(6g/kg media), M_4: Conventional nursery (soil: sand: FYM), two Crops viz. C_1: Tomato (Arka Rakshak), C_2: Cabbage (Rare Ball). Thus, eight treatment combinations viz. M1C1, M2C1, M3C1, M4C1, M1C2, M2C2, M3C2 and M4C2 were laid in Randomized Block Design (RBD) with three replications.Different seedling attributes namely seedling emergencepercentage(SE %), days to 2-true leaf stage (DTLS), seedling height (SH), stemdiameter (SD), leaf area (LA), days to transplant (DT), root length (RL), seedlingvigour index (SVI), seedling fresh weight (SFW), seedling dry weight (SDW) andtotal chlorophyll content (TCC) were recorded just beforetransplanting. The chlorophyll content of leaves wasmeasured by using portable leaf chlorophyll meter. Theseedling vigour was calculated by multiplying thegermination percentage with seedling dry weight (Abdul-Bakki and Anderson, 1973).The economics of the treatments was worked out on the basisof benefit: cost (B:C) ratio derived from net return and cost ofproduction as per existing market rate. Healthy seedlings weretransplanted in the main field at 3.0 m x 2.7 m plots at 45 cmspacing within and between rows. The field crop received auniform dose of farmyard manure (20 t ha^{-}1) along with recommended dose of inorganic fertilizers. Recommended cultural and plant protectionmeasures were followed equally in all the plots as and whenrequired. In the main field the observations were recorded onten randomly selected plants from each plot. Two years datafrom different treatments were subjected to statisticalanalysis. The data for individual year was computed andpooled mean was worked out. The treatment means werecompared using least significant difference (LSD) test at 0.05level of significance. All analyses were performed usingINDOSTAT version 8.0 statistical package

Results and Discussion

PerformanceofTomato seedlings

Theresultsrevealedsignificantdifferencesamongthedifferentseedsowingmedia(Table1,2&Fig1).GrowingmediaM2recordedhigherSE(98.42%),SH (15.47 cm), SD(3.23 mm), LA (8.35 cm3), SVI (2268.54), SFW (1.53 g), SDW (0.37 g) and TCC(1.61mgg-1fw).

Allseedsneedwater,oxygenandrighttemperaturetogerminate. Water to soften the protective seed coat. Oxygenneeded for aerobic respiration so that they can produce energyforgerminationandgrowth.Theembryogetenergybybreaking down its food stores. Warm temperature is needed tospeed up the chemical reaction that take place in seed and alsoto speed up the making of new cell when the seed embryo isgrowing.InsidethegreenhousepropertemperaturewasmaintainedandgrowingmediaM2 having good water holding capacity andmoisture supply as well as sufficient porosity which permitsadequate moisture and gaseous exchange between media andseed which helps better seedling emergence. Similar resultswerealsoobtainedbyZaller(2007);HotaandArulmozhiselvan(2017)

More Seedling height might be due to conducive effect of thismediacompositiononwaterholdingcapacity,porosity,proper aeration and substantial amount of nutrient especiallynitrogen and micronutrients for good plant growth (Chopde*etal*. 1999). Similar result was obtained by Nissi (2018) intomato.AtiyehandCoworkers(2002)pointedoutthatvermicompostcanresultintheleafsurfaceincreasebecauseof having enough nutrition and the absorption capability. Theleaf surface increase because of the microorganism activityandpointedoutthatthemicroorganismwithhavingtheabilityinproducingtheregulatedgrowthmaterialcanresultintheleafsurfaceincrease.SimilarresultwasalsoobtainedbyNissi(2018)intomato.

Combined application of vermicompost and cocopeat in themedia M2 showed more stem diameter probably due to thesynergisticcombinationsofthesefactorsimprovingthephysical conditions of the media and nutritional factors (Sahni*et al.*, 2008). It may be due to better nutrient availabilityleading to higher production of photosynthetically functionalleavesinthistreatmentfinallyresultinginbettergirthofseedling(Borah*etal*.,1994).Similarresultsw erealsoobtainedbyParasana*etal*.,(2013).

The leaves of seedling raised in this media (M2) also hashigher leaf chlorophyll content due to presence of nitrogen invermicompostwhichmightcertainlyupgradethephotosynthetic rate, dry matter production and their by morefreshand dryweight ofplant(Awasthi *etal*.,1996). The conventional nursery (soil: sand: FYM) seedlings showedbetter result than media M1 i.e Cocopeat (60): Vermiculite(20): Perlite (20) which might be due to availability of N, Pand K from FYM along with water though it is under openfield condition

Table 1: Pooledmean data analysis oftwoyears 2018-20 for the various traits

Treatment	SE (%)	DTLS	SH (cm)	SD (mm)	LA(cm2)	DT
M1	93.67	14.08	8.34	1.92	2.59	29.12
M2	98.42	10.35	15.47	3.23	8.35	21.38
M3	97.34	10.95	14.74	3.06	7.58	22.74
M4	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: Pooledmean data analysis oftwoyears 2018-20 for the various traits

Treatment	RL(cm)	SVI	SFW (g)	SDW (g)	DMA(%)	TCC (mgg-1fw)
M1	5.84	1348.64	0.51	0.09	18.83	0.81
M2	10.25	2268.54	1.53	0.37	24.18	1.61
M3	10.37	2201.28	1.49	0.35	23.74	1.28
M4	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

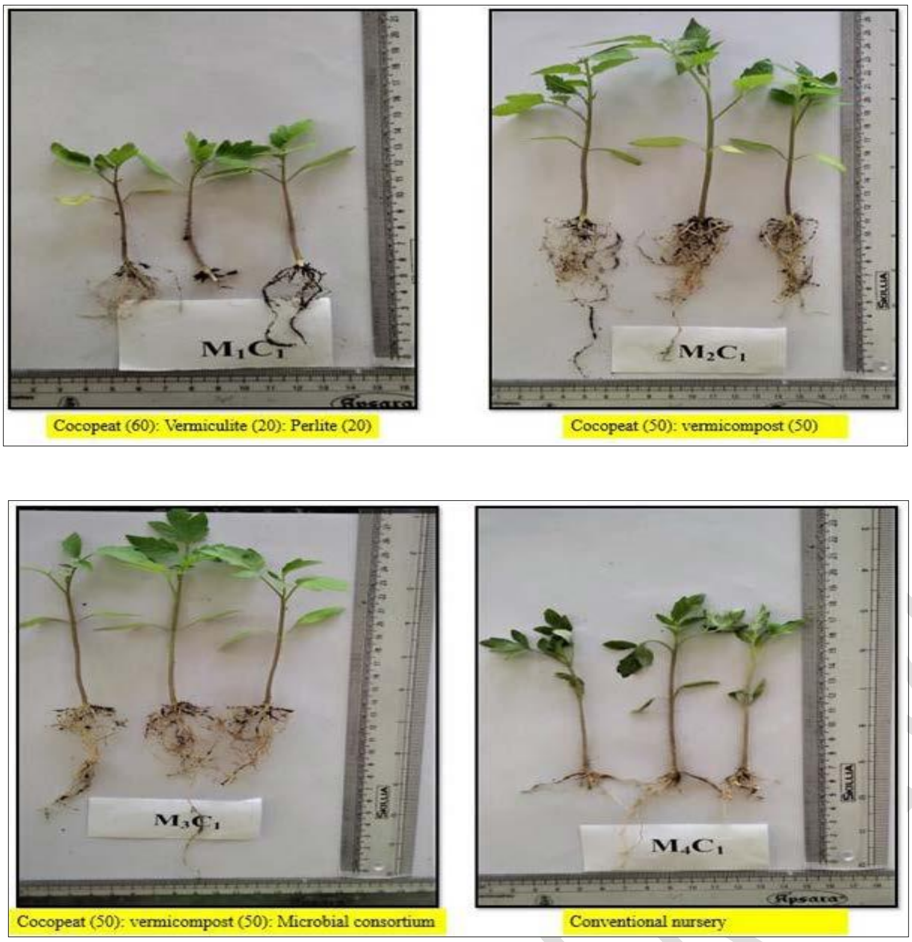

Fig1: Seedlinggrowthunderdifferentgrowingmedia

Performanceof Cabbage seedlings

Theresultsrevealedsignificantdifferencesamongthedifferent seed sowing media (Table 3, 4& Fig 2). GrowingmediaM3recorded higher SE(92.67%), SD (3.12 mm), LA (9.15 cm^3), RL (12.01 cm), SVI (2358.43), SFW (1.72 g), SDW (0.38 g) and TCC(0.99mgg^{-1}fw).Higherseedlingemergence percent might be due to media M3having good waterholding capacity and moisture supply as wellas sufficientporositywhichpermitsadequatemoistureandgaseousexchange between media and seed which helps better seedlingemergence.Moreover,undergreenhouseconditionpropertemperaturewasmaintainedwhichhelpsin emergenceofseedling. Similar result was also obtained by Zaller (2007).Leaf area increased because of microbial activity. Microbialconsortium contained azotobacter, azospirillum and phosphatesolubilizingbacteriaandvermicompostalsocontainbeneficialmicroorganismswhichhavingtheab ilityinproducing the regulated growth material, which results in leafarea increase. Similar result was obtained by Subbaiah *et al.*(2018) in brinjal. More stem diameter might be due tobetter nutrient availability leading to immense production ofphotosyntheticallyfunctionalleavesinthistreatment(M3)andfinallyresultingin bettergirth ofseedling.

Microorganismspresentinvermicompostandmicrobialconsortiumsynthesizeplantgrowthhormonem ainlyauxin, gibberellinandcytokinin.Themaximumrootgrowthmightbe due more availability of auxin in this growing media (M3).TheobtainedresultsareagreedinsomewhatwithNgaatendwe*etal*. (2015).Higher vigour index was found media (M3) might be due toincreasedgerminationandseedlingheightwhichhavecontributed to greater vigour index. The results of study are inclose agreement with the findings of Prajapati *et al.* (2017)andParasana*et al.*(2013).

Table 3: Seedling emergence (%), days to 2-True leaf stage, seedling height and stem diameter (Pooled mean of two years 2018-19 and 2019-20)

Treatment	SE (%)	DTLS	SH (cm)	SD (mm)	LA (cm^2)
M1	83.56	12.72	7.08	2.01	4.68
M2	90.45	10.59	10.90	3.02	8.87
M3	92.67	10.21	10.35	3.12	9.15
M4	91.78	13.66	9.15	2.56	8.04
S.Ed(±)	2.38	0.39	0.59	0.07	0.77
CD(0.05)	5.95	0.87	1.26	0.21	1.46

Table 4: Days to transplant, Root length, Seedling vigour index, Seedling fresh weight, Seedling dry weight and Total Chlorophyll content(Pooledmeanoftwoyears 2018-20)

Treatment	DT	RL (cm)	SVI	SFW (g)	SDW (g)	TCC(mgg^{-1}fw)
M1	27.19	5.68	1264.61	0.72	0.14	0.80
M2	22.62	8.82	2175.26	1.64	0.36	0.93
M3	22.54	12.01	2358.43	1.72	0.38	0.99
M4	29.57	4.51	1384.83	1.18	0.23	0.78
S.Ed(±)	1.65	1.23	42.68	0.06	0.03	0.03
CD(0.05)	4.10	3.46	101.50	0.15	0.07	0.06

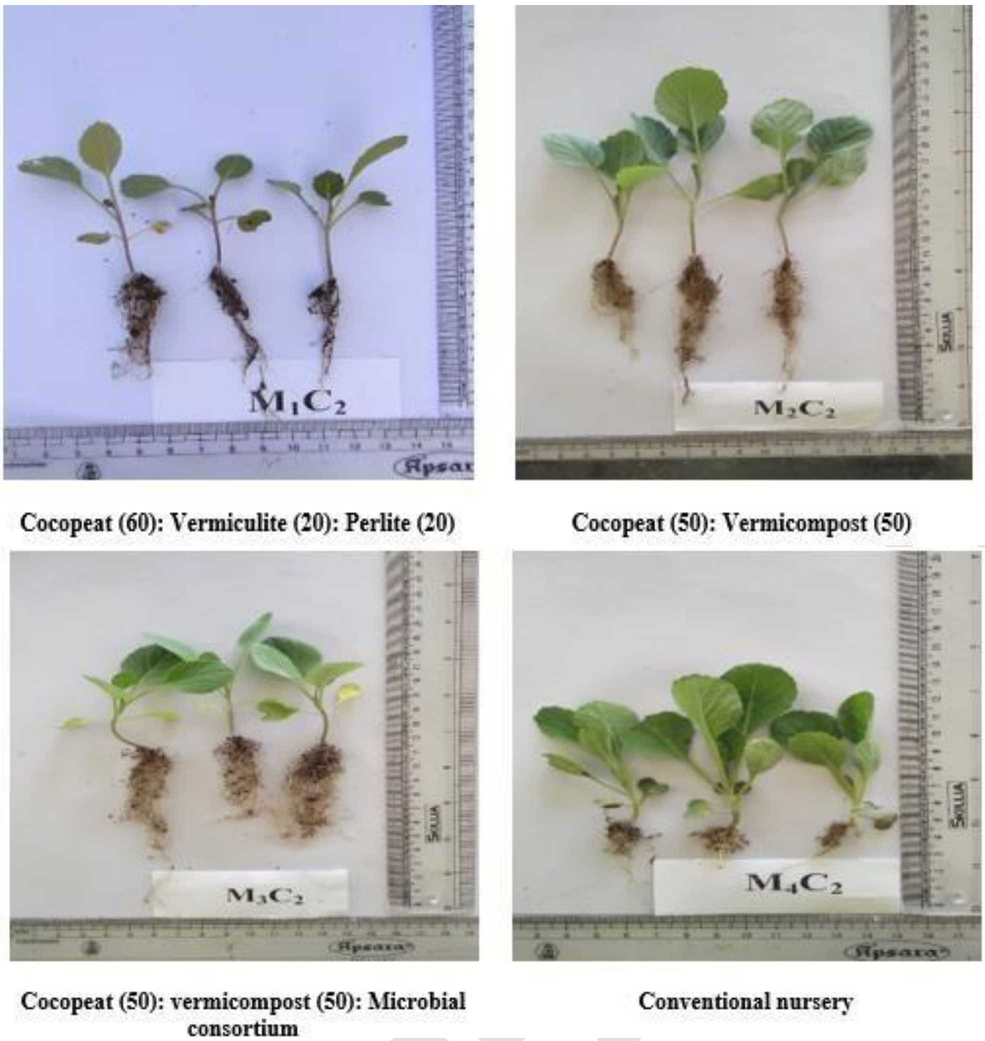

Fig 2: Seedlinggrowth underdifferent growingmedia

Performanceof Tomato seedlinginthemainfield

The seedling raised media M2 under greenhouse condition showed better performanceinthemainfield,recordedlessdays(4.29)toSE,morePH(70.43,95.30and118.50cm) after 30, 60 and 90 DT, higher LAI (5.45), higher RL (60.53 cm), less days requiredforDF(31.71),50%fruitset(46.89)andharvesting (93.69 days), higher individual fruit weight (66.78g), higher fruit yield per plant (2.85 kg) and higher yield perhectare(105.63t)and B:C ratio(5.28) (Table: 5,6,7 & 8).

Successful establishment of a seedling in the main field is thefirstcriticalstepforcropproduction.Earlyestablishmentmight be due to more root length which quickly absorb waterand nutrients and high seedling vigour index. This active rootsystem allows more uniform and faster growth, with little orno transplant shock. Increase in number of leaves might bemainlyduetocorrespondingincreaseinplantheight(Govind and Chandra, 1993) and also may be due to better nutrientavailabilityleadingtoimmenseproductionofphotosynthetically functional leaves in these treatments (Patel *et al*,2019). LAI is an important parameter in plant ecology.Because it tells how much foliage is there, it is a measure ofthe photosynthetic active area. More LAI might be due moreleafnumberintheplant.Rootsarelifelineofaplant,takingup air (O2), water and nutrient from soil and moving them uptotheleaves.Morerootlengthmightbeduetomorephotosynthates transferred to the root because leaf area indexis more in this this treatment and more leaf area index morephotosynthesis *i.e*more food production for plant. The morefruit weight might be due to production of a greater number ofleaves. More leaf area index was also found in this treatmentM2duetowhichphotosynthesisincreasedandfinallyincreased the fruit weight. Similar result was given by Jett *etal*.,(1995) inbroccoli.

Table 5: Days to establishment, Plant height at 30, 60 and 90 days after transplanting, leaf number, leaf area, leaf area index and specific leafweight(Pooledmean oftwoyears 2018-19 and2019-20)

Treatment	Days toestablishment	Plant height (cm)at30DAT	Plant height (cm)at60DAT	Plant height (cm)at90DAT	Leaf numbers	Leafareaindex (LAI)	Specific leaf weight(mg cm-2)
M1	5.83	51.68	85.23	100.78	30.84	3.29	8.29
M2	4.29	70.43	95.30	118.50	41.56	5.45	18.22
M3	4.41	60.70	93.94	114.74	38.77	5.20	19.59
M4	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 6: Membrane stability index, relative leaf water content, root length, root dry weight, days to 50% flowering, days to 50% fruit set and no.offlowerclusterper plant (Pooled mean oftwoyears2018-19and 2019-20)

Treatment	Membrane stability index(%)	Relative leafwatercontent (%)	Rootlength (cm)	Root dryweight(g)	Days to50 % flowering	Days to50% fruit set
M1	62.73	77.24	38.45	12.38	35.67	56.22
M2	70.71	79.48	60.53	15.95	31.71	46.89
M3	66.91	77.20	54.77	15.95	32.80	46.92
M4	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 7: No. of fruits per cluster, Head weight, head diameter, head compactness, head yield and B:C ratio (Pooled mean of two years 2018-19and 2019-20)

Treatment	No. of flowerclusterperplant	No. offruitspercluster	Days tofirst harvest	Individual fruitweight (g)	Fruityieldper plant(kg)	Totalyield (tha-1)
M1	9.65	5.12	109.51	59.77	2.04	75.29
M2	10.78	6.37	93.69	66.78	2.85	105.63
M3	10.83	6.15	99.29	65.57	2.73	101.01
M4	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 8: Productioneconomicsof tomato(Pooledmeanoftwoyears2018-19and2019-20)

Treatment	Gross expenditure (Rs.ha-1)	Gross return(Rs. ha-1)	Net return(Rs.ha-1)	B:C ratio
M1	261446	1129350	867904	3.32
M2	252398	1584450	1332052	5.28
M3	252554	1515150	1262596	4.99
M4	239762	1195950	956188	3.98

Fig3: TomatoFruitclusterunderdifferenttreatments

Performance of Cabbage seedling inthemainfield

The seedling raised media M3 [Cocopeat (50): vermicompost(50):Microbialconsortium]undergreenhouseconditionshowed better performance in the main field, recorded lessdaystoseedlingestablishment(3.34),moreplantheight(21.84 cm) after 30 days of transplanting, higher leaf areaindex (12.16), higher root length (22.07 cm), higher no. ofwrapping leaves (37.45), less days required to head initiation(41.64) and harvesting (62 days), higher head weight (1.58kg),higherheaddiameter(15.91cm),headcompactness(4.09) and higher head yield per hectare (77.42 t) and B:Cratio(3.88). (Table 9, 10and 11)

Table 9: Days to establishment, Plant height at 30 and 60 days after transplanting, leaf number, leaf area and leaf area index (Pooled mean oftwoyears2018-19 and 2019-20)

Treatment	Days toestablishment	Plant height (cm)at30 DAT	Plant height (cm)at60 DAT	Leafnumbers	Leaf area index(LAI)
M1	4.29	17.00	26.27	38.03	8.89
M2	3.36	21.35	29.73	48.03	10.39
M3	3.34	21.84	29.27	49.18	12.16
M4	5.41	17.69	26.68	39.52	9.31
S.Ed(±)	0.54	0.65	0.71	4.68	0.86
CD(0.05)	1.17	1.40	1.61	10.68	1.84

Table 10: Root length, root dry weight, no. of non-wrapping and wrapping leaves, days to head initiation and days to harvesting (Pooled mean oftwoyears2018-19 and 2019-20)

Treatment	Root length(cm)	Root dryweight(g)	No. of non-wrappingleaves	No. of wrappingleaves	Days to headinitiation	Days toharvesting
M1	17.28	12.83	10.01	28.02	43.41	67.23
M2	20.29	15.25	11.48	36.55	41.89	62.77
M3	22.07	16.20	11.73	37.45	41.64	62.00
M4	17.02	12.21	10.13	29.39	42.73	65.89
S.Ed(±)	0.61	0.82	0.68	0.53	0.77	2.21
CD(0.05)	1.33	1.83	1.53	1.15	1.58	5.16

Cocopeat (60): Vermiculite (20): Perlite (20)

Cocopeat (50): Vermicompost (50)

Cocopeat (50): Vermicompost (50): Microbial consortium

Conventional nursery

Fig 4 : Cabbage at head initiation stage under different treatments

Table 11: Headweight,headdiameter,headcompactness, headyieldandB:Cratio(Pooledmean oftwoyears2018-19and2019-20)

Treatment	Head weight(kg)	Headdiameter(cm)	Headcompactness	Head yield(t ha^{-1})	B:C ratio
M1	1.21	13.08	6.12	59.29	2.54
M2	1.51	14.87	5.13	73.99	3.67
M3	1.58	15.91	4.09	77.42	3.88
M4	1.31	13.01	6.85	64.43	3.55
S.Ed(±)	0.12	0.47	0.49	0.96	-
CD(0.05)	0.26	1.04	1.07	2.08	-

Cocopeat (60): Vermiculite (20): Perlite (20)

Cocopeat (50): Vermicompost (50)

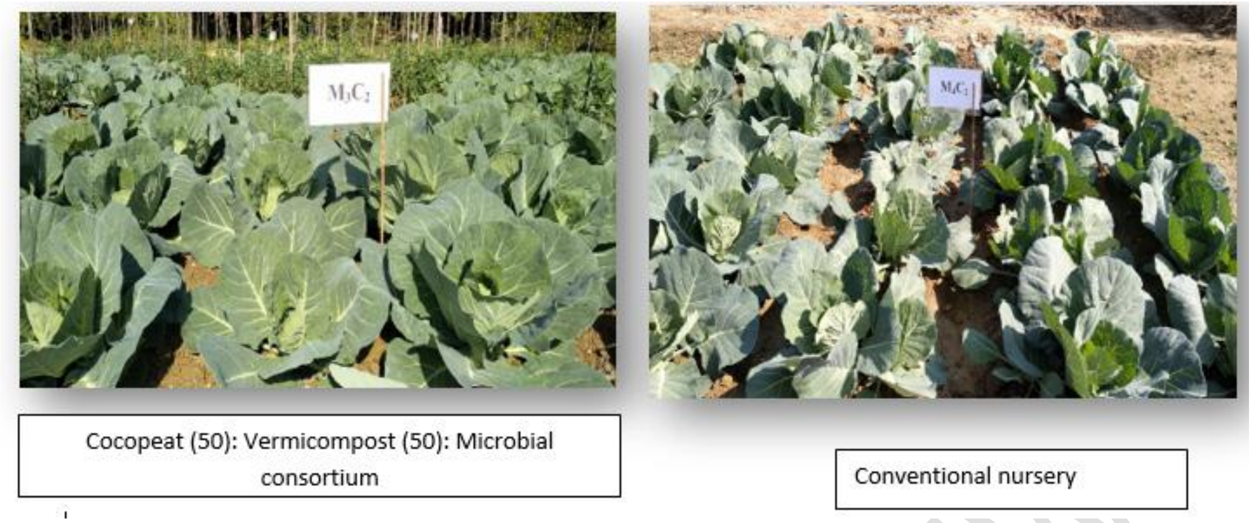

Fig 5 : Cabbage at vegetative stage under different treatment

Conclusion

The result of the present investigation revealed that seedling raising in cocopeat (50): vermicompost (50) i.e media M2 and cocopeat (50): vermicompost (50): Microbial consortium i.e media M3 in greenhouse are an efficient and superior alternative to traditional open field seedling raising (M4 : conventional nursery) for tomato and cabbage. These method offers great potential for healthy and vigorous seedlings production in tomato and cabbage which finally shows better performance in the main field in terms of yield and yield attributing characters.

Reference:

Abdel-Monaim, M.F. Induced systemic resistance in tomato plants against Fusarium wilt diseases. Inter. Res. J. Microbiol.2012;**3**: 14–23.

Abad M, Noguera P, Puchades R, Maquieira A, NogueraV. Physico-chemical and chemical properties of somecoconut dusts for use as a peat substitute for containerizedornamental plants. Biores. Technol. 2002;82:241-245.

Agbo CV, Omaliko CM. Initiation and growth of shoots of*Gongronema latifolia* Benth stem cutting in differentrooting media. Afri. J Biotech. 2006;5:425-428.

Atiyeh RM, Lee S, Edwards CA, Arancon NQ, MetzgerJD.Theinfluenceofhumicacidderivedfromearthworm-processedorganicwastesonplantgrowth.Biores.Technol. 2002;84:7-14

Atiyeh RM, Edwards CA, Subler S, Metzger JD. Pig manure vermicompost as a component of a horticultural bedding plant medium: effect on physicochemical properties andplant growth. Biores. Tech. 2001;78(1):11-20.

Abdul Baki, A. A. and Anderson, J. D. Vigour determination in soybean seed by multiple criteria. Crop. Sci; 1973 **13**: 630-633.

Baiyeri KP, Mbah BN. Effects of soilless and soil-basednursery media on seedling emergence, growth andresponse to water stress of African Breadfruit (*TreculiaAfricana* Decne). Afri. J Biotech. 2006;5(15):1405-1410.

Chopde N, Patil BN, Paagr PC, Gawande R. Effect ofdifferentpotmixturesongerminationandgrowthofcustard apple (*Annona squamosa* L.). J Soils and Crops.1999;9(1):69-71.

Govind S, Chandra R. Standardization of suitable pottingmedia for raising seedlings of khashi mandarin. Indian JHort.1993;50(3):224-227.

Prasad, M. Physical, chemical and biological properties of coir dust. Acta Horti. 1997; **450**: 21-29.

Hota, Surabhi, and K. Arulmozhiselvan. Standardizationof soilless growth media under capillary rise irrigationprinciplefornurseryraisingoftomato(*Lycopersicum esculentum*) seedlings by nutriseed pack; c2017. p. 101-103.

Nissi E, Sarra A. A measure of well-being across theItalianurbanareas:AnintegratedDEA-entropyapproach.SocialIndicatorsResearch.2018Apr;136(3):1183-209

SahniV,ShafielooA,StarobinskyAA.Twonewdiagnosticsofdarkenergy.PhysicalReviewD.2008Nov3;78(10):103502

Borah AS, Nath A, Ray AK, Bhat R, Maheswarappa HP,Subramanian P, *et al*. Effect of seed size, rooting mediumandfertilizersonthegrowthofseedlingsofsilkcotton (*Ceiba pentandra*Linn.). Ind. J Forestry. 1994;17(4):293-300.

NgaatendweM,ErnestM,MosesM,TuariraM,Ngenzile M. Tanyaradzwa ZL. Use ofVermicompost as SupplementtoPineBarkforSeedlingProductioninNurseries.World J Agri. Res.2015;3(4):123-128.

ParasanaJS,LeuaHN,RayNR.Effectofdifferentgrowing medias mixture on the germination and seedlinggrowth of mango (Mangifera indica) cultivars under nethouseconditions.TheBioscan.2013;8(3):897-900.

Awasthi RP, Godara RK, Kaith NS. Interaction effect ofvamycorrhizaeand*Azotobacter*inoculationonpeachseedlings.Ind.JHort.1996;53(1):8-13.

Singh SP, Sharma SC. A survey on cluster based routing protocols in wireless sensor networks. Procedia computer science. 2015 Jan 1; 45:687-95.

SubbaiahKV,ReddyRVSK,RajuGS,KarunasreeE,Sekhar V, Nirmala TV, *et al*. Effect of Different Levels ofarkamicrobialconsortiumonseedgerminationandsurvival rate in Brinjal cv. Dommeru Local. Int. J Cur.Microbiol.Appl. Sci.2018;7(6):2821-2825.

ParasanaJS,LeuaHN,RayNR.Effectofdifferentgrowingmedia'smixturesongerminationandseedlinggrowth of mango (*Mangifera indica* L.) cultivars under nethouseconditions. The Bioscan.2013;8(3):897-900.

PrajapatiDG,SatodiyaBN,DesaiAB,NagarPK.Influence of storage period and growing media on seedgerminationandgrowthofacidlimeseedlings(*Citrusaurantifolia*Swingle) cv. Kagzi. J. Pharmacognosy andPhytochem.2017;6(4):1641-1645.

Patel M, Kumar R, Kishor K, Mlsna T, Pittman Jr CU,MohanD.Pharmaceuticalsofemergingconcerninaquaticsystems:chemistry,occurrence,effects,andrem ovalmethods.Chemicalreviews.2019Mar4;119(6):3510-673.

JettWL,RonaldD,Morse,CharlesDellRO.Plantdensity effects on single head broccoli production. Hort.Sci.1995;30(1):50-52.

Sterrett SB. Compost as Horticultural Substrates for Vegetable Transplant Production. In: Compost Utilization in Horticultural Crooping Systems, StoVella, P.J. and B.A. Kahn (Eds.). Lewis Publication, Boca Raton, FL, 2001, 227-240.

ZallerJG.Vermicompostasasubstituteforpeatinpottingmedia:Effectsongermination,biomassallocation,yieldsandfruitqualityofthreetomatovarieties.ScientiaHorticulturae.2007Mar26;112(2):191-9.

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