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USE OF AGRO-WASTE AS NUTRITIONAL COMPONENT IN NURSERY GROWING MEDIA

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ABSTRACT

Quality seedlings are the key factor for vegetable production. A nursery experiment on cucurbit crops was planned with the objective of investigating the effect of agro-waste component in seedling production. Two agro-wastes i.e. rice husk (Rh) and sugarcane bagasse ash (SBA) along with cocopeat (C), perlite (P) and vermiculite (V) were used. Five media combinations (volume basis) were formed and different physico-chemical properties of media and growth traits of seedling plants were recorded and subjected to statistical analysis. ANOVA revealed significant variation in all media and plant traits. The physico-chemical properties of M_4 media were comparable with the M_5 (C) media. M_4 (6.4%) media had more organic carbon content than other media. Linear correlation (R^2=0.17) was recorded between water holding capacity and bulk density of respective media. Source:sink relation was optimum in M_4 followed by M_2 media. Conclusively, M_4 (SBA:C:P:V in 2:2:1:1 on v/v) media with SBA can be the nutritional component in standard nursery growing media.

Keywords: Nursery, Rice husk, Soilless growing media, Sugarcane bagasse ash, Waste utilization

Quality seedlings are the key factor for vegetable production. A good quality seedling has well developed roots and better source: sink relationship. Healthy seedling has direct relation with yield and quality of produce. The seedling with proportionate foliage and ability to produce new roots is considered as healthy seedling which has no disease, pest or any nutritional deficiencies (Tuzel *et al.,* 2015). Vegetable cultivation, especially protected cultivation, is greatly affected by various soil born diseases (El Sharkawi *et al.,* 2014). Thus, many farmers try to purchase seedlings from certified organization. During past two decades, the researcher tried to substitute peat in soilless growing media for nursery as well as crop production (Kumarasinghe *et al.,* 2015). Now a days, cocopeat + perlite + vermiculite (2:1:1 or 3:1:1) is being used as standard nursery growing media (Gulia *et al.,* 2022). This soilless nursery growing media is devoid of nutrients thus needs fertigation (Bhoomika *et al.,* 2021) or some other organic / agro waste nutrition source which act as self-sustaining component.

Among various agro-wastes, management of rice husk and sugarcane bagasse ash has become a major concern to the humankind (Channa *et al.,* 2021). Rice husk was produced 151.4 MT (757 million tonnes of rice production) around the globe (FAO, 2020). Annually India produces 24 million tons of Rh which was used in different forms in various industries (Prabha *et al*., 2021). While, 20-25% of weight of paddy is received as husk (Lee *et al*., 2023). Punjab was consuming 4.5 lakh tons of Rh as fuel (Anonymous, 2017). Similarly, sugarcane bagasse is most abundant agro-waste on the globe with an annual production of 100 MT in India (Konde *et al.,* 2021). Bagasse ash has been reported to improve soil structure, aeration and have significant effect on soil fauna (Medina *et al.,* 2009).

In India, not much work has been reported on the effect of Rh and SBA with standard nursery growing media. Thus, a study was conducted with objective of investigating the effect of agro-waste as component of standard nursery growing media for vegetable seedling production and to improve nutritional quality of nursery media without adding any inorganic fertilizer.

MATERIALS AND METHODS

The experiments were carried out at Punjab Agricultural University- Krishi Vigyan Kendra, Regional Station, Gurdaspur (Lat. 32°40’ N, Long. 75°40’ E and altitude 241 m amsl) in naturally ventilated polyhouse. Two agro-wastes *viz*., rice husk (Rh) and sugarcane bagasse ash (SBA) were used along with cocopeat (C), perlite (P) and vermiculite (V). Cocopeat was soaked in water for 24 hrs and kept open for shade drying for 8 hrs. Five media combinations (M_1= Rh:P:V in 2:1:1; M_2= Rh:C:P:V in 2:2:1:1; M_3= SBA:P:V in 2:1:1; M_4= SBA:C:P:V in 2:2:1:1; M_5 (C)= C:P:V in 2:1:1) were formed on volume basis. Prior to filling the mixture, it was moistened for consistent filling of 50 cell plug tray (cell size of 5 cm diameter). All the media combinations were replicated thrice for estimation of bulk density (Blake and Hartge, 1986), pH (Thomas, 1996),

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electrical conductivity (Sangwan *et al.,* 2010), Water Holding Capacity (Richard, 1954), available P (Olsen *et al.,* 1954) and organic carbon (Nelson and Sommers, 1982).

The plug trays were sown with seeds of summer squash cv. Punjab Chappan Kadoo 1, cucumber cv. Punjab Kheera 1, bottle gourd cv. Punjab Bahar and bitter gourd cv. Punjab Kareli 1 procured from Punjab Agricultural University, Ludhiana. The experiment was conducted during the month of February and experiment was arranged in completely randomized design with three replications and each replication had 20 plants. One seed per cell was sown. The trays were irrigated immediately after sowing and daily irrigation was followed during morning hours. The seed germination (days) and 1st leaf initiation (days) were recorded from 2 days after sowing. The morphological data of seedlings were recorded after 27 days of sowing. For seedling height (cm), above ground portion upto tip was measured on scale while for root length (cm), below ground portion upto root tip was measured. Similarly, weight of above ground portion was weighed and assigned as plant weight (g) while below ground weight was considered as root weight (g). The ratio of root:shoot (length) and root:shoot (weight) were also recorded. Five plants per replications were randomly selected and pooled data was subjected to statistical analysis using SPSS version 27. ANOVA and Duncan multiple range test were performed at P<0.05 confidence level. A relation between bulk density and water holding capacity was studied using regression analysis. The correlation between media and crop traits was calculated with the R package corrplot.

RESULTS AND DISCUSSION

Analysis of variance (ANOVA) for all the traits related to growing media (Table 1) showed significant difference at 5% (P<0.05). It depicts that due to change in media combination, there was significant change in all the media traits. Important physico-chemical properties of growing media were illustrated in Table 2. Bulk density was recorded maximum in M_1 (0.262 Mg m^{-3}) media which was statistically *at par* with M_2 (0.255 Mg m^{-3}) media. For soilless or hydroponic crop, the ideal range of bulk density lies between 0.1 to 0.3 Mg m^{-3} (Kampf *et al.,* 1999). Similar range was documented by El Sharkawi *et al.* (2014). The maximum pH was observed in M_1 (7.85) media while lowest in M_5 (C; 6.75) media. Except M_1 media, the pH was normal range (6.75 to 7.15) that makes nutrient available to the plants. Cocopeat has slightly acidic nature, however washing as pre-treatment reduces its pH (Bustamante *et al.,* 2021). Whereas, sugarcane bagasse ash and rich husk have slightly basic, all media (except M_1) combinations had normal range of pH (M_1: 7.85, M_2: 7.15, M_3: 6.95, M_4: 6.85, M_5: 6.75).

The electrical conductivity of media ranged between 0.31 to 0.89 dS m^{-1}. Since cocopeat has high cation exchange capacity (Aswath and Pillai, 2004), the EC of media containing cocopeat remained higher. Comparatively, SBA has higher EC (i.e. CEC) as the time required for mineralization is less as compared to rice husk. Thus, SBA containing media have higher EC. This agrees with the findings made by Bidai *et al.* (2020). The WHC was recorded maximum in M_5 (C) media (349.24%) which was *at par* with M2 (347.60%) media. Cocopeat containing media had higher WHC as compared to other. A'saf *et al.* (2020) also documented significant increase in WHC with use of cocopeat in root rhizosphere and soilless substrates, respectively. A regression analysis revealed linear correlation (R^2=0.17) (Fig. 1) between WHC and bulk density of nursery media. Bulk density of medium was inversely correlated with WHC. Hence, cocopeat significantly reduced bulk density with increase in WHC as compared to other media. Kukal *et al.* (2012) documented parallel results as discussed above.

Variation in available phosphorus and organic carbon content was also found significant (Fig. 2). Maximum (52.1 ppm) available P was found in M_5 (C) media followed by M_2 (49.0 ppm) media. The EC of M_5 (C) media was high and thus it had positive relation with

Table 1. ANOVA for important traits linked with different media combination

Trait	Sum of Square	Mean Sum of Square	F cal
Df	Treatment= 4	Error = 5	Total = 9
Bulk Density (Mg m^{-3})	0.001	0.0001*	16.42
pH	1.54	0.39*	29.69
Electrical conductivity (dS m^{-1})	0.46	0.11*	264.37
Water holding capacity (%)	4049.33	1012.33*	1226.49
Available P (ppm)	2131.07	532.77*	312.83
Organic carbon (%)	4.10	1.02*	60.24

Table 2. Important physico-chemical property of media responsible for plant growth

Media	BD	pH	EC	WHC
M_1	0.262 [c]	7.85 [c]	0.31 [a]	297.86 [a]
M_2	0.255 [bc]	7.15 [b]	0.33 [a]	347.60 [d]
M_3	0.240 [a]	6.95 [ab]	0.58 [c]	312.78 [b]
M_4	0.248 [b]	6.85 [ab]	0.46 [b]	335.15 [c]
M_5 (C)	0.250 [b]	6.75 [a]	0.89 [d]	349.24 [d]
Mean	**0.251**	7.11	0.51	328.52

Note: Values with common superscript alphabets in column were non-significant at 5% level using Duncan multiple range test

available P. Cocopeat has higher EC (Banitalebi *et al.,* 2021) which results in increase in available P where cocopeat was a media component i.e. M_2 and M_5 (C) media. The media containing SBA had lower available P as compared to other media. This was probably due to mineralization process. This was in agreement with Bidai *et al.* (2020) who documented that higher the amount of manure, longer the time for mineralization to release nutrient. With increased pH and decreasing total exchange capacity, there will be decrease in available nutrients (Webber III *et al.,* 2017). Organic carbon content was recorded maximum (6.4%) in M_4 media followed by M_5 (C) (6.1%) and M_3 (6.0%) media. SBA is processed byproduct of sugarcane obtained after milling and burning of bagasse (Xu *et al.,* 2019). SBA is rich source of carbon (Lehmann and Joseph 2009) and has been reported to improve soil fertility, scavenge pollutants and increase crop productivity (Cabrera *et al.,* 2011). While rice husk and cocopeat, though being agro-waste, require decomposition or degradation of biomass components (cellulose, hemicellulose, protein, lignin, etc.) to increase soil organic carbon (Munda *et al.,* 2018).

Two way ANOVA for morphological traits of cucurbit seedlings were presented in Table 3. All the studied traits showed significant variation ($P<0.05$) for crops, media and their interaction. Mean sum of square due to crop was higher than media which depicts that none of the studied crop has similar behavior even though they belong to same family group with different genus (Bisognin, 2002).

Variation in seedling traits of different cucurbits due to media combination was presented in Table 4. Among crops, minimum days for germination were recorded in cucumber (10.78 days) in M_2 which was *at par* with M_4 (11.11 days) media. This could be due to thin seed shell that allows quick imbibition of water and easy way-out for plumule and radicle. Cucumber germination was followed by summer squash and bottle gourd. Maximum days for germination were recorded in bitter gourd in M_1 (18.78 days) media. Similarly, 1st leaf initiation was recorded earliest in cucumber (17.00 days) in M_4 which was at par with M_5 (17.33 days) media. Maximum (21.78) days for 1st leaf initiation were observed in bitter gourd when grown in M_1 media.

Seedling height at the time of transplanting in different crops ranged in between 7.93 (cucumber) to 13.73 cm (bitter gourd). Among various media combinations, maximum plant height was achieved in M_4 media while lowest in M_5 (C) media in all the studied crops. The plant weight ranged from 0.87 (bitter gourd) to 1.29 g (bottle gourd). All the crops grown in M_4 media combination recorded maximum plant weight except M_2 media in bottle gourd. The root trait plays a vital role in seedling growth and its establishment in main

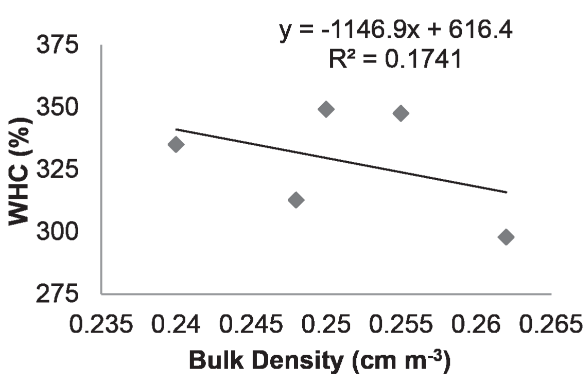


Fig. 1. Relationship between bulk density and water holding capacity of nursery media

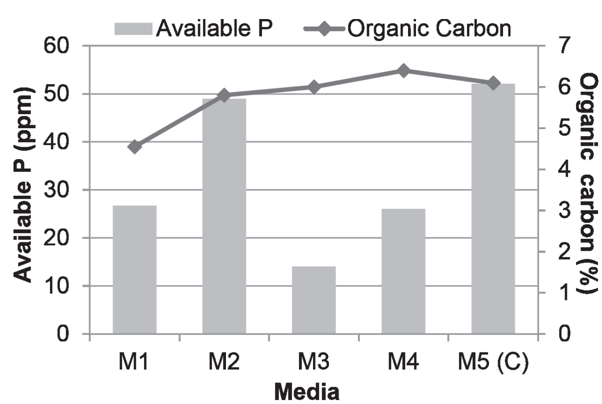


Fig. 2. Available P (ppm) and organic carbon (%) content in different nursery media combinations

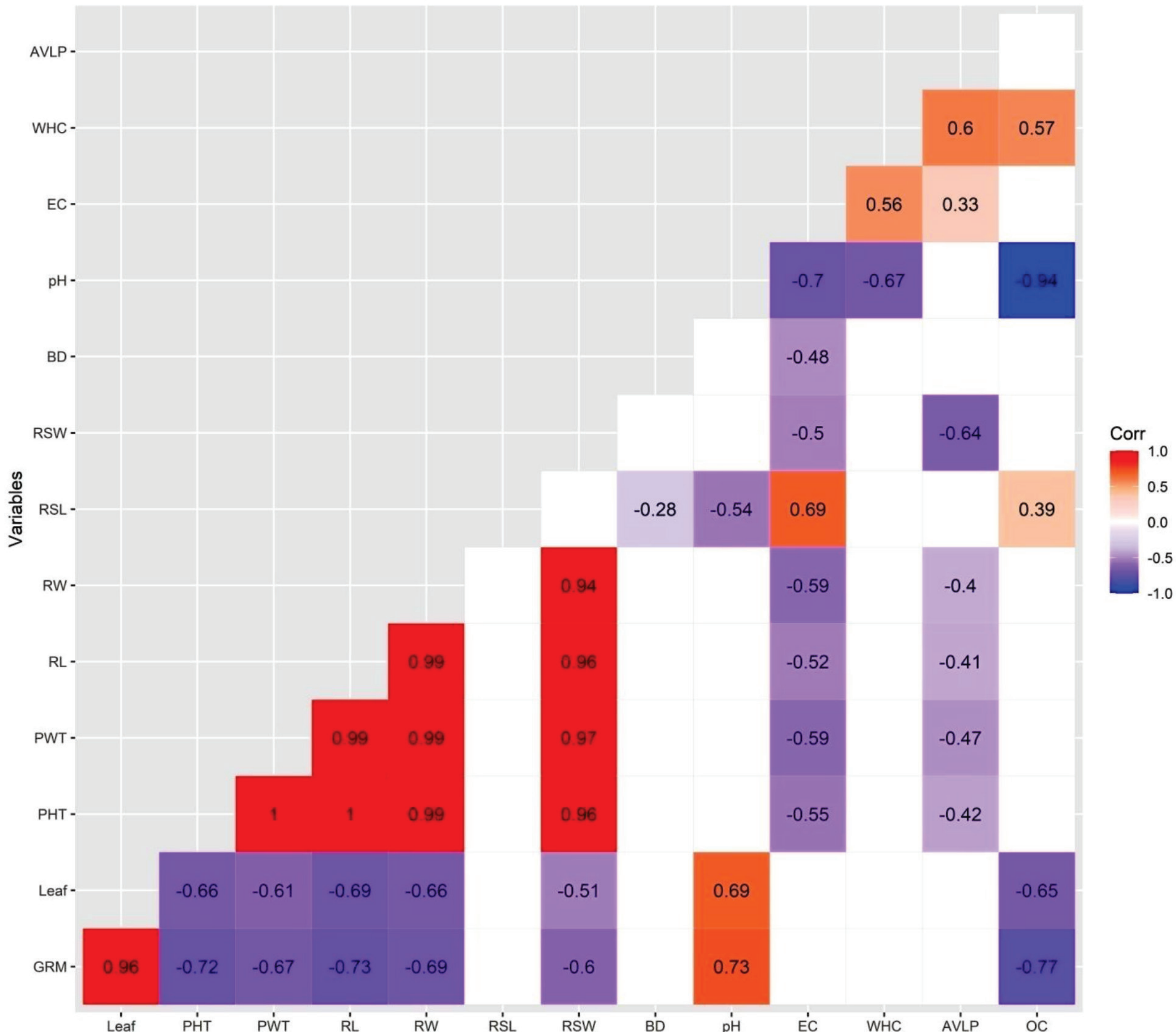
Table 3. Two way ANOVA for morphological/seedling traits of cucurbit crops

Trait	Mean sum of square		
	Crop	Media	Crop × Media
DF	3	4	12
Germination (Days)	96.17*	6.39*	0.86*
1st leaf initiation (Days)	18.17*	7.72*	1.16*
Plant height (cm)	48.08*	5.80*	0.16*
Plant weight (g)	0.30*	0.02*	0.00*
Root length (cm)	6.78*	2.32*	0.16*
Root weight (g)	0.05*	0.01*	0.00*
Root:shoot (Length)	0.29*	0.00*	0.00*
Root:shoot biomass	0.02*	0.00*	0.00*

Table 4. Effect of media combination on morphological seedling traits of different cucurbits

Crop	Media	Germination (days)	1st leaf initiation (days)	Plant height (cm)	Plant weight (g)	Root length (cm)	Root weight (g)	Root:shoot (length)	Root:shoot biomass
Summer squash	M_1	16.30 ^{ij}	20.97 ^{h}	9.07 ^{ef}	1.08 ^{g}	5.93 ^{bcd}	0.21 ^{gh}	0.66 ^{ef}	0.19 ^{ijk}
	M_2	14.33 ^{ef}	19.00 ^{d}	9.73 ^{g}	1.11 ^{h}	5.83 ^{abc}	0.22 ^{i}	0.60 ^{d}	0.20 ^{jkl}
	M_3	15.56 ^{h}	20.22 ^{f}	9.57 ^{g}	1.08 ^{g}	5.97 ^{bcd}	0.22 ^{hi}	0.63 ^{de}	0.20 ^{jkl}
	M_4	14.00 ^{e}	18.67 ^{d}	10.33 ^{h}	1.14 ^{i}	6.23 ^{def}	0.24 ^{j}	0.60 ^{d}	0.21 ^{l}
	M_5 (C)	15.27 ^{gh}	20.27 ^{f}	8.83 ^{de}	0.99 ^{de}	5.60 ^{a}	0.19 ^{f}	0.63 ^{de}	0.19 ^{ijk}
Mean		15.09	19.82	9.51	1.08	5.91	0.22	0.62	0.20
Cucumber	M_1	11.56 ^{c}	18.22 ^{c}	8.23 ^{b}	0.90 ^{b}	6.67 ^{h}	0.15 ^{de}	0.81 ^{ij}	0.16 ^{de}
	M_2	10.78 ^{a}	17.78 ^{b}	8.60 ^{cd}	0.93 ^{b}	7.24 ^{ij}	0.16 ^{e}	0.84 ^{j}	0.17 ^{def}
	M_3	12.18 ^{d}	18.67 ^{d}	8.47 ^{bc}	0.96 ^{c}	7.07 ^{i}	0.15 ^{de}	0.84 ^{j}	0.16 ^{d}
	M_4	11.11 ^{ab}	17.00 ^{a}	9.17 ^{f}	1.02 ^{f}	7.57 ^{k}	0.18 ^{f}	0.83 ^{ij}	0.18 ^{efgh}
	M_5 (C)	11.22 ^{bc}	17.33 ^{a}	7.93 ^{a}	0.91 ^{b}	6.30 ^{efg}	0.13 ^{c}	0.79 ^{i}	0.14 ^{c}
Mean		11.37	17.80	8.48	0.94	6.97	0.15	0.82	0.16
Bottle Gourd	M_1	17.20 ^{l}	20.70 ^{g}	10.17 ^{h}	1.25 ^{k}	7.18 ^{ij}	0.23 ^{i}	0.71 ^{h}	0.18 ^{fghi}
	M_2	15.00 ^{g}	18.86 ^{d}	11.17 ^{j}	1.29 ^{l}	7.50 ^{jk}	0.25 ^{j}	0.67 ^{fg}	0.19 ^{hij}
	M_3	15.27 ^{gh}	20.86 ^{h}	10.70 ^{i}	1.21 ^{j}	7.42 ^{jk}	0.22 ^{i}	0.69 ^{gh}	0.18 ^{ghi}
	M_4	14.45 ^{f}	17.88 ^{b}	11.77 ^{k}	1.27 ^{kl}	8.01 ^{l}	0.26 ^{k}	0.68 ^{fgh}	0.21 ^{kl}
	M_5 (C)	16.00 ^{i}	19.44 ^{e}	9.57 ^{g}	1.19 ^{j}	6.60 ^{gh}	0.20 ^{g}	0.69 ^{fgh}	0.17 ^{defg}
Mean		15.58	19.55	10.67	1.24	7.34	0.23	0.69	0.19
Bitter Gourd	M_1	18.78 ^{m}	21.78 ^{i}	12.23 ^{l}	0.90 ^{b}	5.53 ^{a}	0.11 ^{b}	0.45 ^{a}	0.12 ^{b}
	M_2	17.33 ^{l}	20.28 ^{f}	13.07 ^{m}	0.97 ^{cd}	6.47 ^{fgh}	0.13 ^{c}	0.50 ^{bc}	0.13 ^{c}
	M_3	16.78 ^{k}	19.52 ^{e}	12.87 ^{m}	0.98 ^{cd}	6.03 ^{cde}	0.11 ^{b}	0.47 ^{ab}	0.11 ^{ab}
	M_4	16.66 ^{jk}	19.69 ^{e}	13.73 ^{n}	1.01 ^{ef}	7.03 ^{i}	0.14 ^{d}	0.51 ^{c}	0.14 ^{c}
	M_5 (C)	17.47 ^{l}	20.41 ^{fg}	11.37 ^{j}	0.87 ^{a}	5.70 ^{ab}	0.09 ^{a}	0.50 ^{bc}	0.10 ^{a}
Mean		17.40	20.36	12.65	0.95	6.15	0.12	0.49	0.12
Range		10.78-18.78	17.00-21.78	7.93-13.73	0.87-1.29	5.53-8.01	0.09-0.26	0.45-0.84	0.10-0.21
Overall Mean		14.86	19.38	10.33	1.05	6.59	0.18	0.65	0.17

Note: Values with similar superscript alphabets in column were non-significant at 5% level using Duncan multiple range test.



Note: GRM: Germination; Leaf: 1st leaf initiation; PHT: Plant height; PWT: Plant weight; RL: Root length; RW: Root weight; RSL: Root:Shoot (length); RSW: Root:Shoot biomass; BD: Bulk density; pH: pH; EC: Electrical conductivity; WHC: Water holding capacity; AVLP: Available P; OC: Organic Carbon

Fig. 3. Heatmap pairwise Pearson's correlation coefficient ($p < 0.05$) between media and crop traits. Non-significant correlation was represented by white color. A significant positive correlation was denoted by red color whereas blue color shows significant negative correlation. The color intensity depicts relative proportion of correlation.

field. Root length has direct probable relation with high nutrient uptake (Soethe *et al.,* 2006). The root length was recorded maximum in bottle gourd (M_4 media: 8.01 cm) whereas minimum was observed in bitter gourd (M_1 media: 5.53 cm). Generally, root weight was highly influenced by the nutrient concentration in soil or growing media (Mutale-Joan *et al.,* 2020). Maximum root length and root weight were recorded in M_4 media in all the crops (Table 4) which depicts that sufficient nutrient was present as compared to other media combinations. The root: shoot ratio i.e. length and biomass has been reported for seedling survival (Mokany *et al.,* 2006). In all the studied crops and media combinations, maximum root:shoot ratio was recorded in M_4 media and it was *at par* with highest value in those particular crops. Probably more the root:shoot ratio, higher will be source:sink relation that results in higher rate of seedling establishment in main field. Better source:sink relationship proportionally decreases transpiration and increase photosynthesis rate (Blanke, 2007).

To study correlation between seedling and media traits, Pearson's correlation coefficients were calculated (Fig. 3). The heatmap correlation matrix was used to visualize correlation between different variables (Fey *et al.,* 2021). Germination (days) has significant positive correlation with 1st leaf initiation (0.96) while among media traits, pH had positive correlation whereas organic carbon had negative correlation with germination of seeds. 1st leaf initiation observed to have significant negative correlation with all the plant traits except root:shoot ratio (length). It shows that least days for germination and 1st leaf initiation will increase plant height, plant weight, root length, root weight and root:shoot biomass. These results were in accordance with Bhardwaj (2014). Plant biomass contributing traits i.e. plant height, plant weight, root length and root weight have been recorded to have significant positive correlation with each other while negative correlation with EC and available P.

Generally, high EC restricts plant growth. The study also found that with increase in available P, there was rise in EC. Similar results were concluded by Bidai *et al.* (2020). Among media traits, bulb density was recorded to have significant negative correlation with EC. Zhao *et al.* (2009) documented that bulk density was decreased with the application of straw while there was increase in EC. Similarly, pH of media has significant negative correlation with EC (Aini *et al.,* 2014), WHC (Roehrdanz *et al.,* 2019) and organic carbon. The available P has significant positive correlation with WHC. It suggests that higher the media particle available for available P, higher will be the WHC (Kiran *et al.,* 2021).

To summarize, the use of agro-waste in normal nursery growing medium had a considerable impact on the physicochemical properties of the media. Sugarcane bagasse ash reduced bulk density and electrical conductivity in growing media while stabilizing pH. SBA-containing media had the highest concentration of organic carbon. Important plant characters were significantly greater in M_4 (Sugarcane bagasse ash: cocopeat: perlite: vermiculite in 2:2:1:1) media containing SBA. As a result, agro-waste, such as sugarcane bagasse ash, can be used as a nutritious component in vegetable nursery growing media for raising healthy vegetable seedlings.

Authors' contribution

Conceptualization and designing of the research work (SP, YS); Execution of field/lab experiments and data collection (SP, YS); Analysis of data and interpretation (SP); Preparation of manuscript (SP).

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