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Research Article

Effect of different sources of planting material on growth, yield and quality attributes in cassava (*Manihot esculenta* Crantz.)

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Background: Cassava is an industrial tropical tuber crop and it is used for human and animal consumption: but also used as a raw material for various agro-based industries. Cassava is commercially propagated by using stem cuttings. These stem cuttings are often infected with viral and bacterial diseases which affect yield adversely. With this background, the present experiment was taken up to identify an elite virus free planting material with improved yield and qualitative characters in two promising cultivars of tapioca *viz*., H 226 and CO 2 using tissue cultured plants and different types of setts from field grown plants as planting materials.

Methods: An experiment was carried out to assess the effect of planting materials on the growth, yield and quality of Cassava varieties *viz.,* H 226 and CO 2. The experiment was laid out in a Factorial Randomized Block Design with four treatments in two varieties and three replications. Observations were recorded on various growth, yield and quality attributes of the crop.

Results: Significant results on plant height, stem girth, number of branches and number of leaves are recorded with tissue cultured plants. There is no significant difference among the treatments for starch, HCN and protein contents. There is a significant difference in starch content among the varieties. The variety CO 2 possessed more starch content than H 226.

Conclusion: Among the four treatments (different kinds of planting materials) followed in this study, the treatment T_1 Tissue cultured plants recorded lesser incidence of cassava mosaic virus, more number of fibrous roots, highest values for plant height, stem girth and tuber yield. Among the varieties, CO 2 showed the least incidence of cassava mosaic virus. The CO 2 tissue culture plants could give better yield in the field conditions.

Keywords: *cassava, tissue culture, mosaic disease, yield*

Introduction

Cassava (*Manihot esculenta* Crantz.) is an industrial tropical tuber crop and it is used for human and animal consumption: but also used as a raw material for various agro-based industries. The percentage of carbohydrate production from the unit area of cassava is 40 per cent higher than rice and 25 per cent more than maize (Tonukari, 2004). Cassava tubers are the cheapest source of calories (Tonukari, 2004). Cassava, the third main source of carbohydrates in Africa, provides daily nutrition for over 700 million people on the continent and a vital source of income for subsistence farmers (Szyniszewska, 2020). Africa is a major contributor of cassava tuber production (57%), followed by Asia (25%). Tapioca is being cultivated in 15.70 million hectares of area and production was 158 million tonnes with an average productivity of 10t/ha in the world. In India, presently, cassava is cultivated in an area of 0.163 m ha, with a production of 4.98 m tons and productivity of 30.55 t ha^{-1} (Radhakrishnan et al., 2022). Major cassava production states in India are Kerala, Tamil Nadu and Andhra Pradesh. True seeds of cassava are not used for commercial cultivation due to high seed dormancy and very poor germination. Commercially, farmers are practicing 8-10 cm long cuttings from the mature part of stem and planted in vertical position in specially prepared nursery bed at closer spacing of 5cm. The rooted cuttings cannot be transported from one place to other place because of bare roots. Cassava is highly susceptible to cassava mosaic disease (CMD) and disease spreads through infected setts and subsequently transmitted by white flies (Pugalendhi & Velmurugan, 2020). In many the cases tissue culture techniques are used for large scale propagation of vegetatively propagated crops (Faria and Illg, 1995), to eliminate the virus and other pathogens. With this background, the present experiment was taken up to identify an elite virus free planting material with improved yield and qualitative characters in two promising cultivars of tapioca *viz*., H 226 and CO 2 using tissue cultured plants and different types of setts from field grown plants as planting materials.

Materials and Methods

The present experiment was carried out at College Orchard of Tamil Nadu Agricultural University, Coimbatore. The maximum temperature of the location fluctuated between 25.5ºC and 34.4ºC, with a minimum temperature ranging between 16.5ºC and 23.4ºC. Relative humidity ranged from 30 to 93 per cent. The soil of the experimental field was clay loam in texture and the pH ranged 8.0- 8.5. The experiment was laid out in a factorial randomized block design with a plot size of 4m x 4m and replicated thrice. Following promising varieties of cassava were taken for the experiment.

V_1 **-**H 226 released from ICAR Central Tuber Crop Research Institute, Thiruvananthapuram
V_2 **-** CO 2 released from Tamil Nadu Agricultural University, Coimbatore

The planting materials taken for the study are as follows.

T_1 **-** Tissue cultured plants
T_2 - Two budded setts from tissue cultured grown plants
T_3 - Six budded setts from normal field grown plants and
T_4 -Two budded setts from normally field grown plants.

The setts with different nodes were planted, irrigated daily and kept under shade net for 25 days in the nursery and then they were transplanted the main field. In the case of tissue culture plants were kept under shade net for secondary hardening. Two months old plants were planted in the main field. Well decomposed farm yard manure was applied at the rate of 25t/ha as a basal dose before final ploughing and basal dose of 45:80:120 kg/ha N, P_2O_5 and K_2O was applied. Then the tissue cultured plants and setts were planted at a spacing of 90 x 75 cm at the ridges. The growth characters *viz.*, plant height, stem girth, number of branches, and number of leaves were recorded on 270^{th} day after transplanting. Cassava mosaic disease incidence was counted from infected plants in a plot. The cassava mosaic incidence was calculated by the formula 'CMD incidence (%) =(No of plants infected/ Total no. of plants $plot^{-1}$) x 100'.

The yield contributing parameters *viz.*, tuber yield per plot, number of tubers per plant, tuber yield per plant, length and girth of tuber are recorded during harvest. The harvesting was done on fifth April, 2022. Similarly, the quality attributing traits *viz*., starch content (Hernández-Carmona et al., 2017), protein content of tubers were estimated as per standard procedures (Lowry et al., 1951). The HCN content in the flesh of the tubers was estimated at harvesting stage, from the tuber the samples were taken and by the method described by Indira & Sinha (1969). The benefit cost ratio was worked out in terms of total expenditure. The observations recorded on various attributes were statistically analysed by the method recommended by Panse & Sukhatme (1985).

Results

The treatment T_1 (tissue cultured plants) has recorded maximum plant height, stem girth, number of branches and number of leaves. Among the two varieties, H 226 (V_1) has recorded the highest plant height and the variety CO 2 (V_2) has recorded the higher stem girth, number of branches and number of leaves. The interaction between treatment and varieties were significant. Tissue cultured plants (T_1) of cv. H 226 (V_1) recorded the highest plant height and tissue cultured plants of variety CO 2 recorded higher stem girth, number of branches and number of leaves (Table 1,2,3,4).

Table 1. Effect of planting materials on plant height (cm) in cassava

Treatments	90 DAT			180 DAT			270 DAT		
	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
T_1	62	55	57	143	127	135	215	199	207
T_2	40	47	44	124	118	121	193	191	192
T_3	59	40	51	132	125	128	205	198	202
T_4	39	32	36	126	118	122	193	192	192
Mean	50	44	47	131	122	127	202	195	198
	V	T	VxT	V	T	VxT	V	T	VxT
S.E(d)	4.6	6.5	9.2	0.6	0.8	1.2	1.2	1.7	2.4
CD (5%)	**9.9**	**14.0**	**19.8**	**1.3**	**1.8**	**2.5**	**2.6**	**3.7**	**5.3**

Table 2. Effect of planting materials on stem girth (cm) in cassava treatments

	90DAT			180DAT			270DAT		
	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
T_1	3.9	4.7	4.3	9.0	9.7	9.4	11.1	13.2	12.1
T_2	3.9	3.8	3.8	7.5	7.1	7.3	9.4	11.0	10.2
T_3	3.8	4.1	3.9	8.0	8.3	8.1	10.4	11.7	11.1
T_4	3.5	3.7	3.6	7.3	7.1	7.2	9.1	10.9	10.0
Mean	3.8	4.0	4.9	8.0	8.0	8.0	8.0	9.4	8.7
	V	T	VxT	V	T	VxT	V	T	VxT
S.Ed	0.18	0.26	0.36	0.07	0.10	0.15	0.17	0.24	0.35
CD (5%)	**0.39**	**0.55**	**0.79**	**0.16**	**0.23**	**0.32**	**0.37**	**0.53**	**0.75**

Table 3. Effect of planting materials on the total number of branches in cassava

Treatments	90DAT			180DAT			270DAT		
	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
T_1	2.80	3.26	3.03	3.26	4.43	3.84	7.16	9.96	8.56
T_2	1.60	2.90	2.25	2.56	3.83	3.19	5.76	8.46	7.11
T_3	2.30	3.23	2.76	3.16	4.40	3.78	6.73	9.96	8.34
T_4	1.50	2.10	1.80	2.46	3.50	2.98	5.70	8.40	7.05
Mean	2.05	2.87	2.46	2.86	4.04	3.45	6.33	9.19	7.76
	V	T	VxT	V	T	VxT	V	T	VxT
S.Ed	0.15	0.22	0.31	0.10	0.15	0.21	0.14	0.21	0.29
CD (5%)	**0.33**	**0.47**	**0.67**	**0.22**	**0.32**	**0.45**	**0.31**	**0.45**	**0.63**

Table 4. Effect of planting materials on the number of leaves per plant in cassava

Treatments	90DAT			180DAT			270DAT		
	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
T_1	36.0	42.1	39.0	102.0	125.2	113.6	69.2	70.2	69.7
T_2	29.3	31.0	30.1	87.9	109.0	98.4	45.8	59.4	52.6
T_3	34.1	39.3	36.7	99.2	119.3	109.3	59.3	69.5	64.4
T_4	28.1	29.9	29.0	83.6	99.9	91.7	43.5	58.3	50.9
Mean	31.8	35.6	33.7	93.2	113.4	103.3	54.4	64.4	59.4
	V	T	VxT	V	T	VxT	V	T	VxT
S.Ed	2.17	3.07	4.34	1.56	2.79	3.45	2.1	3.01	4.12
CD (5%)	**4.66**	**6.59**	**9.33**	**3.54**	**5.98**	**8.72**	**4.2**	**5.99**	**9.10**

V_1 - H 226, V_2 - CO 2, DAT- Days after transplanting
T_1- Tissue cultured plants
T_2- Two budded setts from tissue cultured plants
T_3- Six budded setts from field grown plants
T_4- Two budded setts from field grown plants

The treatment T_3 (Six budded setts from field grown plants) recorded the highest CMD incidence and the least CMD incidence was recorded by T_1 (tissue cultured plants). Among the varieties, H 226 (V_1) recorded the higher CMD incidence and CO 2 (V_2) recorded the lesser CMD incidence (Table 5).

Table 5. Effect of planting materials on CMD incidence (%) in cassava

Treatments	90DAT			180DAT			270DAT		
	V_1	**V_2**	**Mean**	**V_1**	**V_2**	**Mean**	**V_1**	**V_2**	**Mean**
T_1	1.10	0.00	0.55	2.20	0.90	1.55	3.00	1.00	2.00
T_2	21.33	1.01	11.17	22.43	2.50	12.46	23.30	3.33	13.31
T_3	45.50	10.45	27.97	55.20	15.50	35.35	78.33	22.33	50.33
T_4	44.90	10.33	27.61	49.90	15.22	32.56	77.93	22.01	49.97
Mean	18.20	5.44	16.82	33.43	8.53	20.48	45.64	12.16	28.90
	V	T	VxT	V	T	VxT	V	T	VxT
S.Ed	0.19	0.22	0.31	0.44	0.52	0.64	1.01	1.18	1.40
CD (5%)	**0.45**	**0.51**	**0.63**	**0.90**	**1.10**	**1.21**	**1.30**	**1.65**	**2.01**

V_1 - H 226, V_2 - CO 2
T_1- Tissue cultured plants
T_2- Two budded setts from tissue cultured plants
T_3- Six budded setts from field grown plants
T_4- Two budded setts from field grown plants
DAT- Days after transplanting

The treatments T_1 (tissue cultured plants) registered significantly more number of tubers per plant followed by T_3 (Six budded setts from field grown plants). The significant difference was higher in CO 2 (V_2) which was followed by H 226 (V_1). As far as the interaction effect, CO 2 (V_2) along with T_1 (Tissue cultured plants) produced the maximum number of tubers per plant (Table 6).

Table 6. Effect of planting material on tuber yield of cassava

Treatments	No. of tubers plant^{-1}			Tuber yield plant^{-1}			Tuber yield plot^{-1}(kg)			Tuber yield (t ha^{-1})		
	V_1	**V_2**	**Mean**	**V_1**	**V_2**	**Mean**	**V_1**	**V_2**	**Mean**	**V_1**	**V_2**	**Mean**
T_1	7.7	10.7	9.2	5.2	6.0	5.6	70.2	87.8	79.0	43.8	54.9	49.3
T_2	5.5	6.7	6.1	3.8	4.9	4.3	58.8	79.1	68.9	36.7	49.4	43.0
T_3	7.3	9.7	8.5	4.9	5.5	5.2	67.2	83.1	75.1	42.0	51.9	46.9
T_4	5.3	6.3	5.8	3.4	4.1	3.7	54.7	74.9	64.8	34.2	46.8	40.5
Mean	6.4	8.3	7.4	3.5	5.1	5.3	62.7	81.2	71.9	39.2	50.7	44.9
	V	T	VxT	V	T	VxT	V	T	VxT	V	T	VxT
S.Ed	0.30	0.42	0.60	0.25	0.34	0.50	0.08	0.17	0.19	0.19	0.32	0.28
CD (5%)	**0.64**	**0.91**	**1.28**	**0.52**	**0.70**	**0.94**	**0.20**	**0.24**	**0.31**	**0.35**	**0.47**	**0.72**

V_1 - H 226, V_2 - CO 2
T_1- Tissue cultured plants
T_2- Two budded setts from tissue cultured plants
T_3- Six budded setts from field grown plants
T_4- Two budded setts from field grown plants

The treatment T_1 (Tissue cultured plants) registered significantly higher tuber yield followed by T_3 (Six budded setts from field grown plants). Among the two varieties, CO 2 (V_2) gave maximum yield and H 226 recorded lowest value. Within the interaction effect, CO 2 (V_2) along with T_1 (Tissue cultured plants) gave the maximum tuber yield. The lowest tuber yield was recorded in H 226 (V_1) along with T_4 (Two budded setts from field grown plants).

Table 7. Effect of planting material on tuber characters of cassava

Treatments	Tuber length (cm)			Tuber girth (cm)		
	V_1	**V_2**	**Mean**	**V_1**	**V_2**	**Mean**
T_1	38.3	35.4	36.9	17.6	20.2	18.9
T_2	36.1	34.0	35.1	16.3	18.2	17.3
T_3	37.1	34.2	35.7	17.1	19.4	18.2
T_4	34.4	33.2	33.8	15.4	17.4	16.4
Mean	36.5	34.2	35.3	16.6	18.8	17.7
	V	T	VxT	V	T	VxT
S.Ed	0.19	0.27	0.39	0.18	0.26	0.36
CD (5%)	**0.42**	**0.59**	**0.84**	**0.39**	**0.55**	**0.79**

Among the treatments, T_1 (Tissue cultured plants) recorded the maximum tuber length and tuber girth followed by T_3 (Six budded setts from field grown plants) than the other two treatments. H 226 (V_1) recorded the maximum tuber length followed by CO 2 (V_2). The interaction between treatments and cultivars was statistically significant. The maximum tuber length was recorded in T_1 (Tissue cultured plants) along with H 226 (V_1). The shortest tuber length was recorded in CO 2 (V_2) combined with T_4 (Two budded setts from field grown plants). The higher tuber girth was recorded in CO 2 (V_2) which was followed by H 226 (V_1). The variety CO 2 (V_2) combined with T_1 (Tissue cultured plants) recorded the highest tuber girth and the least tuber girth was recorded in H 226(V_1) along with T_4 (Two budded setts from field grown plants) (Table 7).

Table 8. Effect of planting material on tuber quality characters of cassava

Treatments	**Starch content (%)**			**Protein content (%)**			**HCN content (μg g^{-1})**		
	V_1	**V_2**	**Mean**	**V_1**	**V_2**	**Mean**	**V_1**	**V_2**	**Mean**
T_1	29.8	34.1	31.9	21.1	26.1	23.6	22.5	10.1	16.3
T_2	28.3	33.3	30.8	20.0	26.0	23.0	21.9	10.0	15.9
T_3	29.1	34.1	31.6	20.1	25.9	23.0	22.7	10.0	16.4
T_4	27.7	32.9	30.3	20.1	25.8	23.0	21.9	10.0	15.9
Mean	28.7	33.6	31.2	20.3	25.9	23.1	22.3	10.0	16.1
	V	T	VxT	V	T	VxT	V	T	VxT
S.Ed	0.20	0.28	0.40	0.04	0.03	0.07	0.12	0.19	0.21
CD (5%)	**0.43**	**NS**	**0.86**	**0.08**	**NS**	**0.14**	**0.45**	**NS**	**0.63**

V_1 - H 226, V_2 - CO 2
T_1- Tissue cultured plants
T_2- Two budded setts from tissue cultured plants
T_3- Six budded setts from field grown plants
T_4- Two budded setts from field grown plants

There is no significant difference among the treatments for starch, HCN and protein contents. Among the varieties, CO 2 (V_2) recorded higher starch and protein contents followed by H 226 (V_1). But there is a significant difference among the varieties, H 226 (V_1) recorded higher HCN content followed by CO 2 (V_2) (Table 8).

Table 9. Economic of planting material in cassava

Sl. No.	**Parameters**	**V_1**				**V_2**			
		T_1	**T_2**	**T_3**	**T_4**	**T_1**	**T_2**	**T_3**	**T_4**
1.	Gross cost of production (Rs. ha^{-1})	44129	41023	43290	39925	50632	49578	49974	49120
2.	Yield of produce (t ha^{-1})	43.8	36.7	42.0	46.8	54.9	49.4	51.9	46.8
3.	Selling price (Rs. t^{-1})	4500	4500	4500	4500	4500	4500	4500	4500
4.	Gross income (Rs. ha^{-1})	197100	165150	189000	210600	247050	222300	233550	210600
5.	Gross net income (Rs. ha^{-1})	152971	124127	145710	170675	196418	172722	183576	161480
6.	Gross benefit - cost ratio	3.5	3.0	3.4	4.3	3.9	3.5	3.7	3.3

V_1 - H 226, V_2 - CO 2
T_1- Tissue cultured plants
T_2- Two budded setts from tissue cultured plants
T_3- Six budded setts from field grown plants
T_4- Two budded setts from field grown plants

The economics worked out for different treatments showed that T_1 (Tissue cultured plants) was found to be economically superior in term of benefit cost ratio followed by T_3 (Six budded setts from field grown plants) (Table 9).

Discussion

In the present study, there was a difference between the two varieties with respect to growth and development among different sizes of setts after planting. Similar findings were reported by Pugalendhi et al. (2021). Pugalendhi and Velmurugan (2020) reported that chip bud consists of one to two nodal cuttings planted in protrays recorded the minimum number of days required for sprouting, maximum sprouting percentage, highest length and number of roots in Cassava. In the present study, tissue cultured plants and six budded setts recorded more vigour in growth with respect of plant height, stem girth and number of leaves. Yield of tubers in cassava is highly variable and is influenced by many factors. The present study indicated that the improvement in plant height, stem girth, number of leaves and length and girth of stem caused increase in tuber yield. This is attributed to the dense foliage which provided the maximum photosynthetic area for the synthesis of assimilates. Similar results were also obtained by Beck (1960). The tuber yield depends largely on the increase of tuber girth which act as a physiological may sink as observed in sweet potatoes by Lowe & Wilson (1975). A positive effect was observed between yield and length and girth of tuber in the present study and is line with that of studies conducted by Magoon et al. (1972) Muthukrishnan et al. (1973) and Pugalendhi et al. (2021). The tuber length/ girth ratio was higher in tissue culture plants and longer setts. Such an inter relationship of girth, weight and length of tubers suggests that the tuber length and girth are the most important traits that could be used as reliable selection indices for high yield as evidenced from this study. In the present study, the plants raised from tissue cultured plantlets recorded significantly higher tuber yield. This is because that the tissue culture plants are observed to be established more quickly, grow more vigorously and produce higher yields. A similar observation was also recorded by Manivasagam et al. (2006). The number of tuberous roots was also more in tissue culture plants while it was less in other treatments because of lower production of fibrous roots. The tissue culture plants recorded the highest yield followed by longer setts. The leaves and petioles had a positive association with the yield of tubers in the normal longer setts also. A similar view was expressed by Estevao et al. (1972). These findings have revealed that the longer the setts also used for planting, the greater the yield expected from them. This was confirmed by Loria (1962), Krochmal (1966), Silva (1971), Mohankumar and Mandal (1971) and Pugalendhi et al. (2021). Since tapioca tubers are used as raw material for many industries, the starch content is an important factor to be reckoned with while assessing the suitability of the tubers for this purpose (Geetha et al., 2021). The increase in starch content was due to the increased production of photosynthates as observed by Sinha and Nair (1968), Geddes et al. (1965), Singh & Mandal (1970) and Resenthal (1972). In the present study, the HCN content was observed in the flesh of the tuber at the harvesting stage. Similar observation was recorded by Moh and Alan (1972) and Muthuswamy et al. (1974). In the present study, among the treatments, all the varieties, the HCN content was below the toxicity level of 50-100mg kg^{-1} as postulated by Cock et al. (1979).

Conclusion

Among the four treatments (different kinds of planting materials) followed in this study, the treatment T_1 Tissue cultured plants recorded a significantly higher number of tuberous roots and ultimately enhanced amount of tuber production. This is mainly due to the quick establishment, vigorous growth and virus free features of tissue culture plantlets. The cassava cv. CO 2 planting materials raised from tissue culture protocols had recorded the lowest incidence of cassava mosaic disease with higher tuber yield.

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Author contributions

Sundaramoorthy Nanthakumar : Designed and conducted experiments and manuscript writing. Krithika: Conducted experiment, data collection and analysis. Muthusamy Prabhu: Manuscript editing. Govindasamy Ashok Kumar: Statistical analysis.

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Conflict of interest

The author declares no conflict of interest. The manuscript has not been submitted for publication in any other journal.

Ethics approval

Not applicable

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