International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(5): 997-1002

Received: 22-06-2020
Accepted: 24-08-2020

T Krishnakumar
Scientist, Division of Crop Utilization, ICAR-CTCRI, Trivandrum, Kerala, Thiruvananthapuram, Kerala, India

MS Sajeev
Division of Crop Utilization, ICAR-Central Tuber Crops Research Institute (CTCRI), Sreekariyam, Thiruvananthapuram, Kerala, India

G Suja
Division of Crop Production, ICAR-Central Tuber Crops Research Institute (CTCRI), Sreekariyam, Thiruvananthapuram, Kerala, India

Corresponding Author:
T Krishnakumar
Scientist, Division of Crop Utilization, ICAR-CTCRI, Trivandrum, Kerala, Thiruvananthapuram, Kerala, India

Effect of planting methods and varieties on performance of modified TNAU cassava harvester

T Krishnakumar, MS Sajeev and G Suja

DOI: https://doi.org/10.22271/chemi.2020.v8.i5n.10427

Abstract
Cassava is one of the most important tropical tuber crops that ensure food and nutritional security in the developing countries. In India, cassava is cultivated mainly in the southern states *viz*., Tamil Nadu, Kerala and Andhra Pradesh. Harvesting is one of the major difficult and labour intensive operations in cassava cultivation. In India, cassava is mostly harvested manually by hand. This study was attempted to evaluate the performance of tractor operated Tamil Nadu Agricultural University (TNAU) cassava harvester with two industrial varieties (H-165 and Mulluvadi) and two commercial planting system (Mound and Ridge) using six treatments in a randomized complete block design (RCBD). Based on the field performance trial, the shank length and width of digging blade were modified and then their dimensions were optimized for better performance. Among the selected treatments, it was found that a minimum damage of 4.12% was observed for H-165 variety under manual harvesting and a maximum damage of 9.05% for Mulluvadi variety in mound planting system under mechanized harvesting was noticed. The tuber spread length was highly correlated with the per centage damage (%) of cassava tubers. Thus, the tuber spread length is an important agronomical parameter to be considered while selecting the variety for mechanization of cassava harvesting. This study also confirmed that the ridge planting system is highly suitable for operating mechanized harvester as compared to mound planting system.

Keywords: Cassava, industrial varieties, ridge planting, mound planting, harvesting, damage loss

Introduction
Cassava (*Manihot esculenta* Crantz) is one of the major tuber crops, locally called as tapioca and cultivated in tropical and subtropical regions of the world. It is the third largest source of carbohydrates after rice and wheat for people all over the world and the starch content of cassava tubers varies according to varieties (Krishnakumar *et al.* 2019) [7]. In India, it is cultivated about 0.20 million hectares with a total production of 8.13 million tonnes and a productivity of 22.3 metric tonnes per hectare (Krishnakumar *et al.* 2020) [8]. Tamil Nadu stands first in the production and processing of tapioca into starch and sago. In Kerala and North-Eastern States, tapioca is consumed directly by the people whereas in Tamil Nadu more than 80% production of tapioca tubers is being processed into sago and starch (Krishnakumar and Sajeev, 2017) [6]. The dried cassava tubers consist of about 80 to 90 per cent (%) carbohydrate, out of that starch which ranges from 78 to 90% on dry basis. It is also considered as a good source for minerals such as calcium, iron, magnesium and phosphorus and has higher calorific value compared to other tubers such as yam, potato and sweet potato. Native cassava starch is mainly used for production of sago, monosodium glutamate (MSG), glucose and bakery products, whereas modified cassava starch is used for textile, glue, paper, plywood and the pharmaceutical industries (Sheriff *et al.* 2005).
The cultivation of cassava is currently facing a labour shortage, topographic constrains and non-availability of appropriate machineries for replacing labour. In cassava cultivation, labour requirement is invasive during planting, weeding, fertilization and earthing up besides harvesting. Harvesting is one of the major difficult and labour intensive operations in cassava cultivation. This is because cassava is highly perishable and prone to deteriorate after harvest within 48 hrs due to surface damage and post-harvest physiological deterioration (PPD). Thus enough moisture to be maintained at the time of harvest in order to reduce the damage of fresh cassava tubers. The cassava crop is ready for harvest after 10 to 12 months after planting.

Harvesting in right time is very important as delay may result in tuber rot leading to drastic quality loss of tubers.

In manual method, harvesting of cassava is carried out by hand, lifting the lower part of stem and pulling the tubers out of the ground, removing soil and separating the tubers, collecting the tubers and loading the tubers for transport. The upper parts of the stems with the leaves are removed before harvest. This method of harvesting is quite strenuous and slow. Sometimes, cutting the soil by spade leads to substantial damage in the form of cuts, bruises or complete breakage of root and the damaged roots are far more susceptible to infection by fungus and bacteria. In general, the force needed to pull out a cassava plant exceeds human strength. The farmers harvest the cassava plant after a shower or if possible, after irrigating the field to wet and soften the soil. Harvesting requires the maximum labour in tuber crops cultivation for about 30% of the cassava production costs (Amponsah *et al.* 2017) [2]. The best efficiency of manual harvesting is achieved when cassava plants are coppiced before harvesting. The average manual cassava harvesting rate is about 0.17 $ha.day^{-1}$ (Amponsah *et al.* 2014) [3]. Also, cassava uprooting force requirement, to a greater extent is influenced by root tuber yield, root depth and number of root tubers per plant, especially under upland mound land preparation method (Amponsah *et al.* 2017) [2] and it ranged between 30 and 80 kg force.

In semi-manual method, cassava harvesting is done by using lever type tools *viz*., first order type and second order that have been developed at CTCRI which function on the lever principles. Using these tools, it requires only 14-15 mandays to harvest one hectare of cassava whereas 30-34 mandays requires for traditional manual operation. These harvesting tools have been found simple in operation and efficient in performance. The average force exerted on the handle of the lever is about 18 to 30 kg for uprooting a cassava plant whereas the average direct pull required to uproot the cassava plant from the soil is 70 to 80 kg (Amponsah *et al.* 2017) [2].

Cassava is cultivated by using cassava stem or setts of 15-20 cm length which is planted vertically at a spacing of 90 x 90 cm. Different methods of land preparation such as ridge, mound and flat methods could be followed depending upon the soil type and conditions (Ekanayake *et al.* 1997) [4]. Mount method is suitable for sloppy areas whereas ridge method is highly suitable for plain land under irrigated condition. Mechanical harvesting of cassava involves the use of a harvesting implement integrally hitched to a tractor to uproot the cassava tubers. Although cassava productivity is high in India, the production costs are also very high and the labour costs alone accounts to 85% of total production cost (Amponsah *et al.* 2014) [3]. At present the production of cassava is facing a shortage of agricultural labour and also appropriate machinery for replacing labour. In this regard, Tamil Nadu Agricultural University (TNAU), Coimbatore has developed a tractor drawn cassava harvester, which can save time up to 10% in single row and 25% can save time in two rows for ridge type planting methods with a spacing of 90 x 90 cm. The labour saving is reduced 36% for single row and 55% for two rows. The harvester is powered by 50 hp tractor. The capacity of the harvester is 0.5-0.7 ha/day in single row and 0.7-1.0 ha/day in double row conditions (Anon, 2016) [1]. With the commercial cultivation of cassava in India, mechanized harvesting of cassava become an urgent necessity and the harvester developed by Tamil Nadu Agricultural University (TNAU) has to be evaluated and further improved to find its suitability for different cassava varieties and cassava planting system. Thus, this study has been focused to evaluate, modify and further test the tractor drawn TNAU cassava harvester in the mound and ridge system of planting for industrial varieties (H-165 and Mulluvadi) of cassava.

Materials and Methods

Selection of cassava varieties

Two varieties of cassava *viz*., H-165 and Mulluvadi (MVD) were selected as they were most important industrial varieties cultivated in Tamil Nadu.

Study area

The study was carried out at the ICAR-Central Tuber Crops Research Institute (CTCRI) research farm, Kerala, India. Soil at ICAR-CTCRI (latitude: 8° 32" N; longitude: 76° 65" E, altitude: 50 m above sea level) fall under the sandy clay texture (Soil Survey Organisation, 2007). The site experiences a typical humid tropical climate. The average annual rainfall was 1985 mm, maximum and minimum temperatures were 31.3°C and 24.5°C respectively and the relative humidity was 80%. The detailed land information is mentioned in Table 1.

Table 1: Detailed land information for performance evaluation of tractor drawn single row TNAU cassava harvester

1.	Location	Block 1, ICAR-CTCRI, Sreekariyam, Thiruvananthapuram, Kerala
2.	Varieties	H-165; Mulluvadi
3.	Type of soil	Laterite soil
4.	Soil order	Ultisols with average pH of 4.7 (Low Nitrogen, High Phosphorus and Low Potassium

Land preparation

To improve and field test TNAU cassava harvester and investigate the effect of cassava agronomic practices such as ridge and mound planting methods on harvesting, a field study was undertaken with 60 cents of land area at ICAR-CTCRI research field of Block I, Sreekariyam. The ridge width maintained was 60 cm and the spacing between plants was 90 cm. Mounds were prepared at 30 cm high with 90×90 cm spacing.

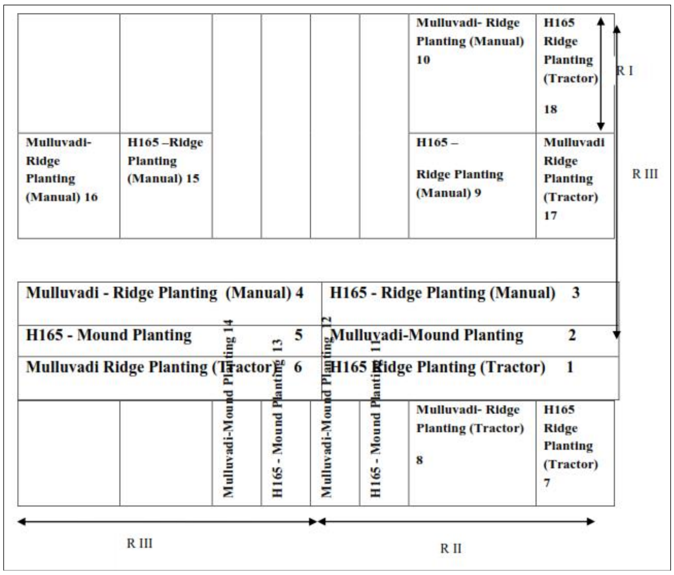
Field layout and Experimental design

This study was made up of six treatments arranged in a randomized complete block design (RCBD) with three replications (60 cents) at an area of 20 cents per replication. The varieties selected were H-165 and Mulluvadi and the methods of planting of cassava selected were mound (manual), ridge (tractor) and ridge (manual) (Fig.1).

Fig 1: Experimental layout for performance evaluation of TNAU cassava harvester

The experimental layout is given in Table 2.

Table 2: Experimental layout for field testing of cassava harvester



Treatment combinations selected for the study were

T1: Variety H-165 planted in ridges made by tractor drawn ridger
T2: Variety Mulluvadi planted in mound
T3: Variety H-165 planted in ridges made manually
T4: Variety Mulluvadi planted in ridges made manually
T5: Variety H-165 planted in mounds
T6: Variety Mulluvadi planted in ridges made by tractor drawn ridger

Specification of the TNAU Cassava harvester

Tractor operated cassava harvester in single row/double row planting system was purchased from Tamil Nadu Agricultural University (TNAU), Coimbatore. It consists of main frame, shanks, digging blade, hitching frame and depth adjustment wheels. It was designed for both two rows and single row operation. The shank is designed as a bent leg plough with an angle of 150º to accommodate the dug cassava tubers. The blade angle of 5º is provided for easy penetration into the soil. The row spacing can be altered by moving the shanks in the main frame. The depth wheels are provided to adjust the depth of operation.

Performance evaluation and field testing of single row cassava harvester

The purchased TNAU cassava harvester was evaluated for its performance with single row without any modifications at ICAR-Central Tuber Crops Research Institute (CTCRI) research field (Fig.1). The cassava stem was coppiced to a stem height of 30 cm above ground level prior to mechanical harvesting. Further the modification was done by varying the digging blade spacing (60, 65, 70 cm) of single row harvester for evaluating performance of the TNAU cassava harvester. Manually uprooting of tubers without any harvesting tool was used as the control. The cassava tuber yield was determined using an electronic balance. The per centage tuber damage associated with each cassava variety was calculated by noting the broken tubers. Further modification was done on the shank height and digging blade width of the harvester from 30 to 38 cm and from 16.5 cm to 22.5 cm respectively (Fig.2). The modified harvester was tested for its field performance for total time taken and per centage damage (%) for all treatments and compared with manual harvesting.

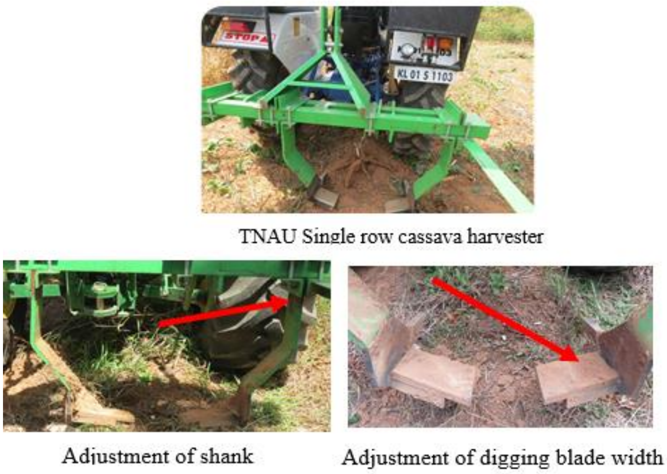


Fig 2: Tractor drawn single row TNAU cassava harvester with shank and digging blade width modifications

Agronomic parameters

The important agronomical parameters *viz*., plant height (cm), stem girth (cm), number of leaves and canopy spread length (cm) were measured during different stages of cassava plant growth. Similarly the maximum root diameter (cm), maximum root length (cm), maximum root depth (cm), number of tubers and tuber spread length (cm) were determined at harvest for 20 plants each for all treatments. Root spread was measured with reference to the soil surface from both sides of the plant. The stem girth (cm) and maximum root girth were measured using a digital vernier caliper, whereas maximum root length and depth were measured using a measuring tape. Three replicates of soil samples during harvest in the field were randomly taken for soil moisture content at depths of 0-10, 10-20, 20-30 and 30-

40 cm using a 5 cm diameter soil core sampler and a mallet. Soil samples were oven dried at a temperature of 105˚C for 24 h to determine soil moisture.

Statistical analysis

Data analysis was performed using R software. Randomized complete block design (RCBD) was applied for analysis. Analysis of variance (ANOVA) and pairwise mean comparison were performed using Tukey's test to determine the significant effect of the treatments on the response variables. The treatments and their interactions were compared at $P< 0.05$ level.

Results and Discussion

Performance evaluation of tractor drawn single row TNAU cassava harvester

The initial performance evaluation of tractor drawn single row TNAU cassava harvester without any modifications was done using Sree pavithra variety. The parameters involved in the performance evaluation of single row TNAU harvester without any modification is presented in Table 3.

Table 3: Performance evaluation of single row TNAU harvester with different width of digging blade

S. No	width of operation	Time taken (sec)	Time taken per plant (s)	Damage loss (%)
1	60	35	1.59	13.5
2	65	30	1.36	11.5
3	65	43	2.04	11.4
4	65	30	1.42	11.7
5	70	35	-	No tubers were uprooted

From the above results, the spacing of 60 cm which was equal to the ridge width, showed higher percentage of damage loss, compared to 65 cm. But the spacing of 70 cm did not uproot cassava tubers due to wider spacing (Table 3). The spacing of 65 cm was found to be optimum for 60 cm of ridge width used for cassava cultivation to use tractor drawn cassava harvester with less average per centage damage (11.53%). The performance of TNAU cassava harvester with single row in the field condition is presented in Fig.3. The parameters influential for damage loss in the field test are depth of cassava harvester and width of digging blade. The maximum depth of cassava harvester in the soil was 32 cm. Since the orientation of tubers follows at 40 cm below the surface of soil, the depth of 32 cm is not sufficient. Similarly the width of digging blade (16.5 cm) is also not sufficient to cover the whole ridge area of 60 cm. Because of non-adequate depth and width of digging blade below the surface of soil during operation, the damage loss was increased.

Fig 3: Harvesting trials with single row TNAU cassava harvester

Measurement of agronomical parameters during and after harvest

The required modifications in the width of digging blade and length of the shank were done as per the performance evaluation trial. The various agronomical parameters measured during different stages of cassava plant growth are presented in Table 4.

Table 4: Measurement of agronomical parameters during different stages of cassava plant growth

Planting duration	Treatments	Plant height (cm)	No. of leaves	Stem girth (cm)	Canopy spread (cm)
After 6 months of planting	T_1	153 ± 0.25^{g}	44.4 ± 0.35^{e}	5.82 ± 0.01^{h}	95.6 ± 0.25^{c}
	T_2	152 ± 0.4^{g}	61.2 ± 0.15^{a}	7.45 ± 0.05^{df}	96.8 ± 0.15^{c}
	T_3	174 ± 0.5^{f}	46.2 ± 0.25^{d}	6.85 ± 0.05^{efg}	101 ± 0.15^{b}
	T_4	148 ± 0.5^{h}	50.2 ± 0.20^{b}	7.20 ± 0.04^{ef}	90.6 ± 0.25^{d}
	T_5	176 ± 0.7^{f}	48.4 ± 0.45^{c}	8.55 ± 0.05^{bc}	109 ± 0.15^{a}
	T_6	146 ± 1.0^{h}	47.2 ± 0.25^{cd}	6.38 ± 0.21^{gh}	78.4 ± 0.20^{f}
After 10 months of planting (during harvesting)	T_1	262 ± 0.5^{d}	28.4 ± 0.40^{h}	6.78 ± 0.03^{fg}	67.2 ± 0.25^{h}
	T_2	266 ± 0.3^{c}	37.1 ± 0.10^{f}	7.48 ± 0.18^{de}	52.6 ± 0.30^{j}
	T_3	326 ± 0.6^{a}	36.3 ± 0.30^{f}	8.76 ± 0.07^{b}	76.4 ± 0.05^{g}
	T_4	263 ± 0.6^{cd}	32.2 ± 0.20^{g}	8.22 ± 0.05^{bc}	60.8 ± 0.75^{i}
	T_5	320 ± 0.45^{b}	32.1 ± 0.10^{g}	9.60 ± 0.27^{a}	81.6 ± 0.30^{e}
	T_6	251 ± 0.25^{e}	33.0 ± 0.05^{g}	8.06 ± 0.06^{cd}	66.5 ± 0.20^{h}

Values are mean ± SEM, n =3 per treatment group. Means in a column without a common superscript letter differ ($p< 0.05$)

T_1: Variety H-165 planted in ridges made by tractor drawn ridger,
T_2: Variety Mulluvadi planted in mounds,
T_3: Variety H-165 planted in ridges made manually,
T_4: Variety Mulluvadi planted in ridges made manually,
T_5: Variety H-165 planted in mounds,
T_6: Variety Mulluvadi planted in ridges made by tractor drawn ridger.

The vegetative growth for the selected varieties was slower in the first six months and showed fast growth afterwards (Table 4). A significant difference in agronomical parameters during 6 months and 10 months of planting of cassava were found statistically ($p < 0.05$). The maximum plant height, stem girth and canopy spread were observed in H-165 variety as compared to Mulluvadi variety. But in terms of number of leaves, Mulluvadi variety was found to be better than H-165. A maximum plant height of 176 cm and 326 cm were observed in H-165 variety for 6 months and 10 months of planting respectively. Moreover, the different agronomical parameters (plant height, stem girth and canopy spread) were performed better in ridge planting than mound planting system and were found to be statistically significant. At harvest, soil moisture ranged from 9.50% to 25.30% d.b. for both *Mulluvadi* and H-165 varieties in all treatments (mound and ridge planting system) at increasing soil depth between 0 and 40 cm. The statistical difference ($p < 0.05$) in soil moisture between different depths was observed. This could be attributed that soil strength is highly influenced by soil moisture (Utset and Cid, 2001) [12]. The results are presented in the Table 5.

Table 5: Moisture content of soil at different depth

S. No.	Soil depth (cm)	Soil moisture content (%) (d.b)
1.	0-10	19.5 ± 0.145^{c}
2.	10-20	20.5 ± 0.36^{c}
3.	20-30	23.6 ± 0.135^{b}
4.	30-40	25.3 ± 0.065^{a}

Means in a column without a common superscript letter differ ($p < 0.05$)

The various agronomical parameters (tuber yield, maximum tuber length and maximum tuber girth) after harvest are presented in Table 6.

Table 6: Agronomical parameters measured after harvesting of cassava tubers

Treatments	Tuber yield/ plant (kg)	Tuber number	Maximum tuber length (cm)	Maximum tuber girth (cm)	Tuber spread length (cm)
T_1	5.71 ± 0.02^{cd}	8^{a}	28.2 ± 0.15^{e}	36.6 ± 0.30^{a}	49.4 ± 0.25^{d}
T_2	4.50 ± 0.21^{d}	8^{a}	41.6 ± 0.30^{a}	24.6 ± 0.28^{de}	57.3 ± 0.07^{c}
T_3	7.68 ± 0.15^{b}	8^{a}	30.6 ± 0.15^{d}	34.5 ± 0.34^{b}	59.2 ± 0.15^{b}
T_4	6.49 ± 0.35^{bc}	8^{a}	37.6 ± 0.25^{b}	25.4 ± 0.27^{d}	63.5 ± 0.13^{a}
T_5	9.50 ± 0.35^{a}	11^{b}	27.5 ± 0.33^{e}	32.4 ± 0.26^{c}	50.2 ± 0.25^{d}
T_6	5.79 ± 0.12^{cd}	11^{b}	32.6 ± 0.04^{c}	23.3 ± 0.33^{e}	58.5 ± 0.17^{b}

Values are means ± SEM, n =3 per treatment group. Means in a column without a common superscript letter differ ($p < 0.05$)

Maximum tuber yield and tuber girths were noticed in H-165 variety, whereas maximum tuber length and tuber spread were noticed in Mulluvadi variety. A maximum tuber length was observed in Mulluvadi variety and ranged between 32.6 and 41.6 cm. Similarly, a maximum tuber girth was observed in H-165 variety and ranged between 32.4 and 36.6 cm. A significant difference was observed in different treatments between tuber yield, maximum tuber length, maxiumum tuber girth and tuber spread. The cassava planted in ridge planting system showed better results in terms of tuber length, girth and tuber spread as compared to mound planting system. This results in agreement with the reports by Odigboh and Moreira 2002, Ennin *et al.* 2009 and Sam & Dapaah 2009 about the advantage of ridge planting system to control the spread of cassava tuber to suitable length both across and along row. But the maximum yield per plant was noticed in mount planting system as compared to ridge planting system.

Field testing of the improved TNAU single row cassava harvester: Cassava tuber damage attributed to the harvester digging blade damaging the cassava tubers during harvesting is due to either shallow harvesting depths or relatively longer horizontal tuber spread beyond the harvesting blade width. The total number of plants, number of tubers, number of damaged tubers and percentage (%) damage tubers and time taken for harvesting in mechanized harvesting and manual harvesting are presented in Table 7. The percentage tuber damage associated with each cassava variety was calculated by noting the
broken tubers.

Table 7: Maximum tuber yield and per centage damage loss of tubers in different treatments

Treatments	No. of Plants	Time taken (sec)	Time taken /plant (sec)	No. of Tubers	No. of damaged tubers	% damage	Total tuber yield (kg)
Mechanized harvesting							
T_1	120	108^{j}	0.90^{f}	1240^{a}	55^{e}	4.44 ± 0.02	652 ± 0.25^{c}
T_2	120	120^{g}	1.05^{e}	816^{k}	90^{a}	9.07 ± 0.01^{a}	596 ± 0.15^{k}
T_3	120	110^{ij}	0.91^{f}	987^{e}	65^{e}	6.66 ± 0.07^{f}	629 ± 0.49^{e}
T_4	120	118^{gh}	0.98^{ef}	931^{i}	80^{b}	8.7 ± 0.1^{b}	576 ± 0.51^{l}
T_5	120	114^{hi}	0.95^{f}	1060^{d}	70^{d}	6.65 ± 0.03^{f}	665 ± 0.54^{b}
T_6	120	112^{ij}	0.91^{f}	952^{g}	74^{c}	7.85 ± 0.06^{d}	610 ± 0.23^{h}
Manual harvesting							
T_1	120	514^{f}	4.28^{d}	1220^{b}	50^{i}	4.15 ± 0.04^{j}	640 ± 0.23^{d}
T_2	120	591^{a}	4.90^{a}	846^{j}	70^{d}	8.35 ± 0.05^{c}	615 ± 0.28^{g}
T_3	120	522^{e}	4.36^{d}	973^{f}	59^{g}	6.07 ± .01^{gh}	620 ±0.35^{f}
T_4	120	566^{b}	4.72^{b}	945^{gh}	71^{d}	7.56 ± 0.03^{e}	598 ±0.02^{j}
T_5	120	544^{d}	4.54^{c}	1070^{c}	62^{f}	5.85 ± 0.04^{h}	673 ± 0.23^{a}
T_6	120	554^{c}	4.62^{c}	937^{hi}	59^{g}	6.35 ± 0.05^{g}	603 ± 0.3^{i}

Means in a column without a common superscript letter differ ($p < 0.05$)

From the treatments by using the improved TNAU harvester with optimized spacing of 65 cm showed a maximum tuber damage of 9.07% for H-165 cassava variety planted in ridges made by tractor drawn ridger and a minimum damage of 4.42% for Mulluvadi cassava variety planted in mounds. Among the varieties, the improved TNAU harvester resulted a maximum damage of 9.05% for *Mulluvadi* variety followed by H-165. Since the tuber spread length is correlated with damage loss, the damage loss of H-165 was lesser than the Mulluvadi. The average tuber spread length of H-165 and Mulluvadi varieties was found to be 46.49 cm and 62.19 cm respectively. The maximum damage loss of 8.30% was found for treatment T_2 for manual harvesting. By comparing the different planting system (Mound and Ridge) for manual harvesting, the damage loss was found high for harvesting mound planted cassava tubers compared to the ridge planted cassava tubers. This could be due to relatively shorter tuber spread both along and across the row in mound planting system. Among the varieties, H-165 showed lesser damage than Mulluvadi. A minimum percentage damage loss of 4.11% was found for treatment T_1. In comparison with the mechanized harvesting method, the percentage damage loss was slightly less for manual harvesting method.

Conclusion

The system of cassava cultivation varies with the type and topography of the soil. Commercially cassava is cultivated in irrigated condition with ridge planting system. Most cassava cultivated in India is harvested by hand. The cassava planted in ridge planting system showed better results in terms of tuber length, girth and tuber spread as compared to mound planting system. In contrast, tuber yield was high in cassava mount planting system among the treatments selected as compared to ridge planting system. Based on the initial field performance evaluation studies, the required modification of the cassava was done. The modified single row TNAU cassava harvester performed well in ridge cassava planting system as compared to mount planting system in terms of minimal per centage damage loss (%). The modification of shank and digging blade of the TNAU cassava harvester drastically reduced the damage. The digging blade width of 65 cm for the modified TNAU cassava harvester was found to be optimal. Overall, the damage loss was less in manual harvesting and significant differences in % damage loss were found between mechanized and manual harvesting.

Acknowledgements

The authors are thankful to Deputy Director General (Agricultural Engineering Division) of ICAR for providing fund under Extramural Research Projects and also thankful to Director, ICAR-CTCRI for providing the research facilities to conduct this study.

References

1. Anonymous. Success stories, All India Co-ordinated Research Project on Farm Implements and Machinery. Extension Bulletin No. CIAE/FIM/2016/191, ICAR-CIAE, Bhopal. 11.
2. Amponsah SK, Addo A, Gangadharan B. Review of various harvesting options for cassava. In Cassava. Intech Open, 2017.
3. Amponsah SK, Sheriff JT, Byju G. Comparative evaluation of manual cassava harvesting techniques in Kerala, India. Agricultural Engineering International: CIGR Journal. 2014; 16(2):41-52.
4. Ekanayake IJ, Osiru DSO Porto MCM. Agronomy of Cassava. IITA Research Guide 60. Available at: http://betuco.be/manioc/Agronomy%20of%20cassava%20IITA%20nr%2060.pdf. 1997 (accessed August 20, 2020).
5. Ennin SA, Otoo E, Tetteh FM. Ridging, a mechanized alternative to mounding for yam and cassava production. West African J Appl. Ecol. 2009; 15:1-8.
6. Krishnakumar T, Sajeev MS. Response surface optimization of bath type ultrasound-assisted extraction (UAE) of native starch from fresh cassava tubers. Advances in research, 2017, 1-13.
7. Krishnakumar T, Sajeev MS. Effect of ultrasound treatment on physicochemical and functional properties of cassava starch. Int. J Curr. Microbiol. App. Sci. 2018; 7(10):3122-3135.
8. Krishnakumar T, Sajeev MS, Raju S, Giri NA, Pradeepika C, Bansode V. Studies on the development of cassava based reconstituted dry starch sago with modified starch as binder and characterization of its physico-functional properties. Journal of Environmental Biology. 2020; 41(1):29-34.
9. Odigboh EU, Moreira CA. Development of a Complete Cassava Harvester 1-Conceptualisation. Journal of Agricultural Mechanisation in Asia, Africa and Latin America. 2002; 4(33):1-7.
10. Sam J, Dapaah H. Baseline Survey Report, West African Agricultural Productivity Programme (WAAPP), Ghana. pp. 13-18. Available online:http://waapp.coraf.org/documents/WAAPP/Rapports/Final%20WAAPP%20Baseline%20Survey%20Report%20Ghana.pdf, 2009; Date accessed: 20-08-2020.
11. Sheriif JT, Nanda SK, Sajeev MS. Current status of cassava processing Industries in South India. Technical Bulletin No. 42, Central Tuber Crops Research institute, Sreekariyam, Thiruvananthapuram, Kerala, India, 2005.
12. Utset A, Cid G. Soil penetrometer resistance spatial variability in a Ferralsol at several soil moisture conditions. Soil and Tillage Research. 2001; 61(3):193-202.