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The Effect of Different Planting Methods on Growth and Yield of Selected of Cassava (*Manihot esculenta*) Cultivars

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ABSTRACT

Background: Cassava (*Manihot esculenta* Crantz) is a source of carbohydrate among the population after maize and rice and highly contributes to food security and livelihood to majority of small scale farmers in Sri Lanka as well as in African continent. The production of these starchy plants is declining due to the problem of low yield, high labor cost, pest and diseases damage and shortage of land. However among the yield limiting factors of cassava, the planting method of stem cuttings which depend on plant cultivar and environmental conditions. Therefore, the present study was carried out to reveal information on the effect of planting methods on the growth and yield attributes of cassava.

Methods: The field experiment was conducted at the Farmer's field in the Batticaloa and laboratory experiment was led in South Eastern University of Sri Lanka which is located in Sri Lanka. The field trail was carried out over a period of four months during from May to September in 2018. The treatments used were three planting positions (Angled, vertical and horizontal) and two cultivars ("cv. *Local*" and "cv *Kirikawadi*") were combined in factorial arrangement and laid out in randomized complete block design with three replications.

Result: The result revealed that root yield was significantly ($P \leq 0.05$) affected by the interaction effects of the planting position and varieties. Significant differences were observed among planting methods in all tested variables. Based on the study, storage roots yield of cassava could be enhanced by planting method of angled position.

Key words: Cassava, Leaf area, Planting methods, Stem cutting, Yield.

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is a robust productive starchy root crop which belongs to the family Euphorbiaceae (Wang *et al*. 2010). Cassava, a lengthy period wide spaced crop is gentle in its early growth and development (Amanullah *et al*. 2007). Cassava (*Manihot esculenta* crantz) is a key foundation of nutritional energy for human and domestic animals in many tropical nations. (Suresh and Suriyavathana 2011). It is an important economic crop of Sri Lanka having high demand in both local and export markets because of its ability and capacity to yield well in drought prone, marginal wasteland under poor management conditions where other crops would fail (Wijesinghe, 2008). It is cultivated mainly for its enlarged starchy roots and one of the most important food staples among the human population (Alves, 2002). Starch of cassava has wide industrial applications. It is extensively used in the manufacture of adhesive, dextrines, food paste and as filler in the manufacture of paints (Godfrey, 2012). The recent records have shown that, the estimated annual production of cassava in year 2015 is 324,097 metric tons and the area of land under cultivation of cassava is 23,844 hectares. (Agriculture and Environment Statistics Division of the Department of Census and Statistics of Sri Lanka, 2015). Cassava is mostly propagated vegetatively by stem cutting and the most important practice in cassava production is the planting method of stem cuttings which depends on plant cultivar and environmental conditions (Toroand Atlee, 1984).

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There are three different planting methods usually used in the field. It may be planted uprightly in a vertical position, uprightly at an angle (slant) or horizontally beneath the soil. However there exists conflicting reports about the appropriate cutting orientations (Abdullahi *et al*. 2014) and there are no significant studies have been conducted to compare the effect of three planting methods on yield on the recommended cassava varieties in Sri Lanka. Thus information about the selection of appropriate planting method for cassava grown with varietal trial is a pre-requisite for adoption of this new cropping system. Therefore, the present study was conducted to compare the effect of three planting methods on yield and yield components of three cassava varieties.

MATERIALS AND METHODS

The field experiment was conducted at the Farmer's field in the Batticaloa and laboratory experiment was led in South Eastern University of Sri Lanka which is located in Sri Lanka. The field trail was carried out over a period of four months during from May to September in 2018. Three planting methods; vertical planting (stem cutting inserted into the soil forming 90° angles), horizontal planting (stem cutting forming 180° angles with soil surface) and angled planting (stem cutting inserted into the soil forming 45° angles) were tested on two cassava cultivars (*Kirikawadi* and *Local*). The stem cuttings of healthy plants in the same maturity stage of cassava cultivars were collected. The mature stems were cut about 15cm long and it was inserted into moist soil with two- thirds of its length for vertical planting and the cuttings were planted forming 45 degree angle with the soil surface. In case of horizontal planting, the stem cuttings were placed horizontally to the depth of 2 cm from the surface and fully covered by soil. The distance between and within rows of cassava plants was about 1 m × 1 m. All the agronomic practices were done to crops in accordance with the recommendation of the Department of Agriculture.

The experiment was laid out in the Completely Randomized Design with two factor (Cultivar * Planting method) in a factorial arrangement with six treatments and four replications. Treatments were as follows:

Treatments		
T_1	M_1V_1	"*Kirikawadi*" cultivar planted vertically.
T_2	M_2V_1	"*Kirikawadi*" cultivar planted horizontally.
T_3	M_3V_1	"*Kirikawadi*" cultivar planted in angled position.
T_4	M_1V_2	"*Local*" cultivar planted vertically.
T_5	M_2V_2	"*Local*" cultivar planted horizontally.
T_6	M_3V_2	"*Local*" cultivar planted in angled position.

*M_1, M_2 and M_3: Three Planting Method.

*V_1 and V_2: Varieties.

The data were collected at three different growth stages of Cassava cultivars. The leaf area was computed using Leaf Area Index Meter (Model: LAI-2200C) and the number of leaves and tubers were counted manually. The fresh weight of tubers was measured using a digital weighing balance after cleaning the unwanted materials present in tubers. The data were statistically analyzed and differences between treatment means were compared by Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Effects of planting methods on the sprouting percentage of tested cultivars

The Emergence is the ability of the planting material to develop plumule and radical and plumule develops to form the shoot while the radical develops to form the root which later develops to the cassava tuber. The emergence of cassava cuttings and its growth is an indication of the viability of the planting materials, methods of planting adopted and the fertility of the soil.

It was found that there were significant ($P<0.05$) differences between sprouting percentage among the cultivars with different planting methods during the establishment stage and there was no significant interaction effect observed among the tested cultivars (Fig 1). Cultivar '' Local" showed the highest sprouting percentage compared to "cv. *Kirikawadi*" as the adaptability to the local environment is high in "cv. *Local*" compared to "*Kirikawadi*". El-Sharkawy (2004) stated that sprout emergence and early growth of the plants from stem depends on endogenous nutrients stored in the stems and the adaptability to the local climate or the environment rather than on soil nutrients, so, the success of the planting is determined by the quality of the cuttings and the varietal adaptability to the cultivation area. Significant differences were observed in the sprouting percentage among the different planting methods. The highest numbers of sprouts were recorded in horizontal planting followed by angled planting and the lowest was observed in vertical planting in "cv. *Local*" while highest amount of sprouts were recorded in angled planting followed by horizontal and vertical planting in "cv. *Kirikawadi*". Based on this observation, it could be stated that "cv. *Local*" was able to show relatively high sprouting percentage than the other tested cultivar with the different methods of planting. This is a favourable feature with regard to successful field establishment of this cultivar. In contrast Keating *et al*. (1988) reported that planting method did not have significant effect on sprouting percentage of cassava.

Effects of planting methods on the number of leaves of tested cultivars

It was found that there were significant ($P<0.05$) differences between the number of leaves among the varieties on different planting methods in all the growth stages and there was no significant interaction effect were observed among the tested cultivars (Fig 2). The highest number of leaves were observed in "cv. *Local*" in all three planting methods compared to "cv. *Kirikawadi*". However, it was found that higher numbers of leaves were observed in horizontal planting method followed angled and vertical planting methods respectively as horizontal planting often results in multiple-stemmed plants while vertical and inclined planting of the cuttings encourages plants with a single stem which lead to increase in leaf number in each varieties (Lebot, 2009). Research by Agahiu, (2016) also proved that the pattern of branch production followed that increasing branch production resulted in the production of more leaves which increases light interception, photosynthesis and consequently yield. Phengvichith *et al*. (2006) proved that the effects of higher number of leaves had significant influence frequencies on storage root yields and reported an increase in storage root yield.

Effects of planting methods on the Leaf area of tested cultivars

The leaf area of tested cassava cultivars with different

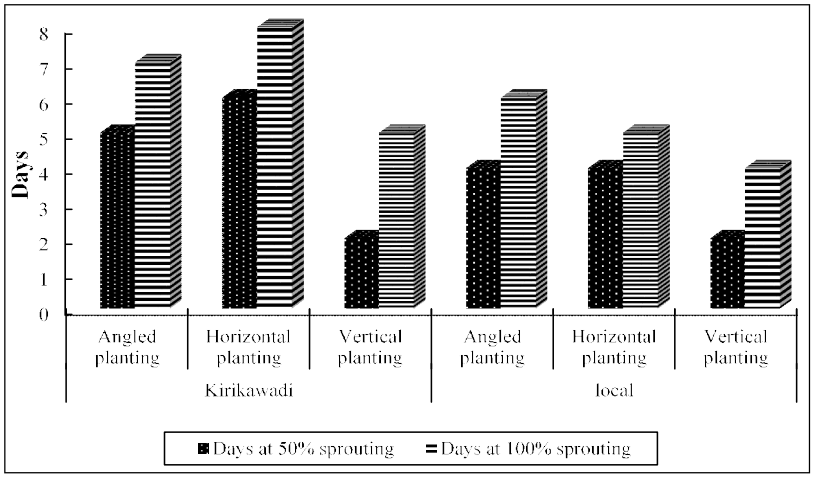

Fig 1: Effects of planting methods on the sprouting percentage.

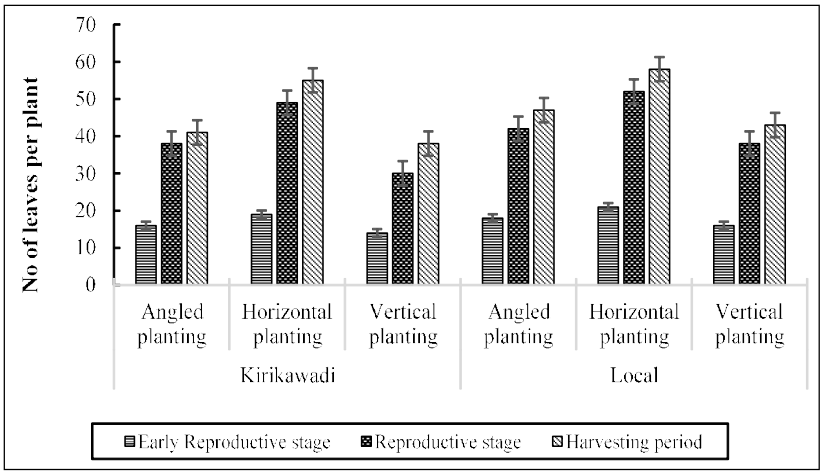

Fig 2: Effects of planting methods on the sprouting percentage.

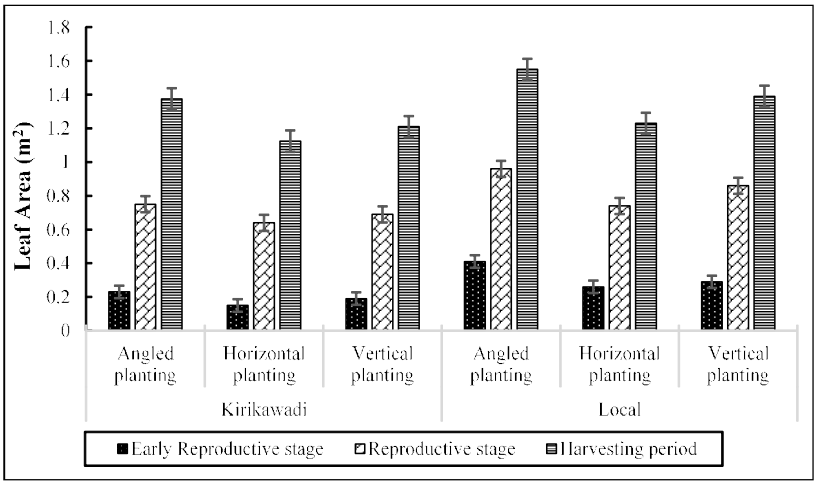

Fig 3: Effects of planting methods on the Leaf area.

planting method is shown in Fig 3. There were significant differences were obtained in the Leaf area of tested cultivars among the different planting methods in all three stages and no interaction effect was observed among the treatments. Cultivar '' cv. *Local*'' showed higher leaf area in all three stages with three planting methods than that of "cv. *Kirikawadi*". The angled planting showed the highest effect with LAI of 0.23,0.75 and 1.375 m^2 per plant at vegetative, reproductive and harvesting stages respectively than those of vertical planting (LAI of 0.15,0.64,1.124 m^2 per plant) and

horizontal planting (LAI of 0.19,0.69 and 1.21 m^2 per plant) in "cv. *Kirikawadi*" whereas in "cv. *Local*", highest LAI was observed angled planting showed the highest effect with LAI of 0.41, 0.96, and 1.55 m^2 per plant at vegetative, reproductive and harvesting stages respectively than those of vertical planting (LAI of 0.29, 0.86, 1.39 m^2 per plant) and horizontal planting (LAI of 0.26, 0.74 and 1.23 m^2 per plant). The data showed that planting method markedly influenced the LAI of tested cassava varieties. The higher LAI observed when cuttings were planted at angled position on the "cv. *Local*" compared to "cv. *Kirikawadi*". This result is important because LAI largely determined the amount of intercepted radiation and its direct effects on storage root growth (Keutgen *et al*. 2002) as the quality of light intercepted at the leaf or stem allows for rapid reallocation of resources between roots to shoot system to Smith (1995). Therefore, angled planting of "cv. *Local*" can be suggested as most suitable cultivar in order to get higher root yield among the farming community of Batticaloa district.

Effects of planting methods on the number of tubers of tested cultivars

It was found that there were significant ($P<0.05$) differences between numbers of tubers among the tested varieties on different planting methods and there was no significant interaction effect were observed among the tested cultivars (Fig 4). In both varieties angled planting showed the highest number of tubers than the rest of planting methods. In "cv. *Local*", angled planting was the most efficient in terms of numbers of tuber (6, 9 and 13 tubers per plant) compared to those of horizontal planting (3, 7 and 9 per plant) and vertical planting (4, 8 and 8 per plant) (Fig 4) in early reproductive, reproductive and harvesting stages respectively. However, in "cv. *Kirikawadi*" also highest number of tubers were observed in angled planting (4, 7 and 9 per plant) compared to than those of vertical planting (3, 5 and 8 per plant) and horizontal planting (3, 5 and 6 per plant) in all three stages respectively. Therefore, it's clear that angled planting method is the most suitable planting method in order to achieve higher tuber yield in cassava varieties. The greater tuber formation in angled planting, the gravitational force could be the driving force. The present findings are in close agreement with those of several investigators.

Franck *et al*. (2008) reported higher number of lateral roots formation when shoots were bent within 1 mm of the root tip, followed by 3 mm away from the root tip and the lowest when bent further away 3 mm. The reduction in tuber formation when cuttings were planted at vertical position could be due to low light interception in vertically oriented foliage compared to inclined leaves. Marcelis *et al*. (1998) reported higher light interception in inclined leaves compared to vertically positioned leaves which could be a reason to higher productivity in horticultural plants. According to Smith (1995), the quality of light intercepted at the leaf or stem allows for rapid reallocation of resources between roots to shoot system and shoots depend on the roots for nutrient and water uptake, while the continued root growth is reliant on photosynthetic fixed in the leaves (Kramer and Boyer, 1995).

Effects of planting methods on the fresh weight of tubers of tested cultivars

The data shows that planting method had significant effect on fresh weight of tubers in cassava using different planting methods (Fig 5). In all treatments, "cv. *Local*" showed the higher amount of fresh weight of tuber yield per plant compared to "cv. *Kirikawadi*". The angled planting recorded the highest tuber yield in both cultivars followed by vertical and horizontal planting in all three stages (Fig 5). In "cv. *Local*", angled planting showed the higher fresh weight of tubers (325, 1459.5 and 4969.6 g per plant) compared to those of vertical planting (290, 1035 and 3903.6 g per plant) and horizontal planting (242.2, 840.6 and 3345.2 g per plant) (Fig 5) in early reproductive, reproductive and harvesting stages respectively. However in "cvs. *Kirikawadi*" also highest number of tubers were observed in angled planting (223.5, 976.5 and 3702 g per plant) compared to than those

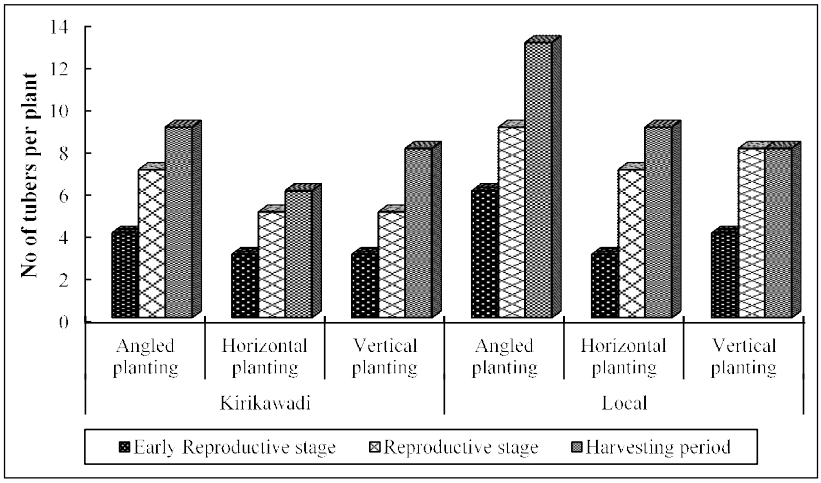

Fig 4: Effects of planting methods on the Numbers of tubers per plants.

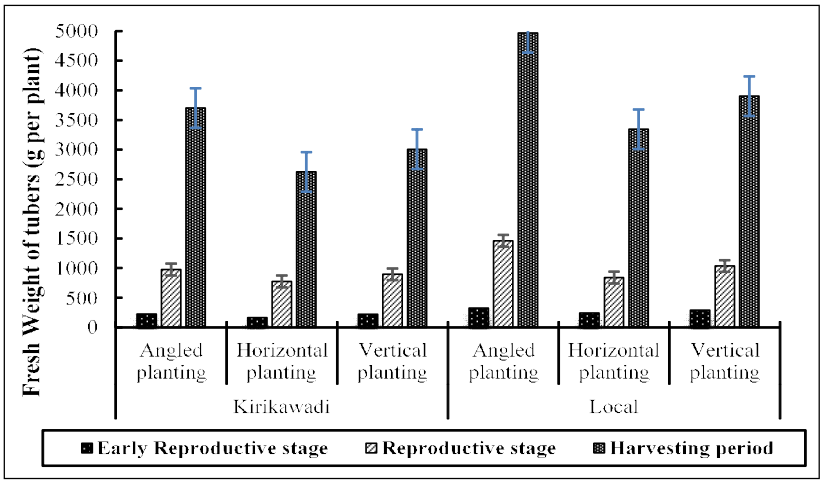

Fig 5: Effects of planting methods on the Fresh weight of tubers per plants.

of vertical planting (165.4, 775.5 and 2624 g per plant) and horizontal planting (220.3, 895.2 and 3007.2 g per plant) in all three stages respectively. The observed increase in storage production under angled orientation could be related to better light interception in angled leaves and higher above ground biomass compared to vertical and horizontal leaves. The present findings are in agreement with those of several investigators Legese *et al*. (2011) and Abdullahi *et al*. (2014). Research by Boote and Loomis (1991) on light harvesting and photosynthesis by the canopy showed that, light interception efficiency was higher for incline arranged leaves, but lower for vertical leaf arrangements. According to Ross *et al*. (2005) light regulates stem elongation in a wide range of higher plants, and its effects are manifested in different ways throughout the plant life cycle.

According to Ekanayake *et al*. (1997), when stakes are planted vertically, tuberous roots bulk deep into the soil and makes harvesting very difficult eventually leads to higher tuber loss while Stakes that are angled produces the tuberous roots in the same direction and the inclination of the stem and roots provide a leverage which makes harvesting easier than in the other orientations and Stakes planted horizontally produce multiple stems and more tuberous roots but they are comparatively smaller in size (Ekanayake *et al*. 1997). Abdullahi *et al.,* (2014) and Legese *et al*. (2011) concluded that storage roots yield of cassava could be enhanced by planting cuttings in an inclined or slanted position. In contrast, Keating *et al.,* (1988), however, reported that planting orientation did not have significant effect on growth and yield of cassava. However, Legese *et al*. (2011) stated that vertical and horizontal planting methods did not show any significant effects with respect to number of storage roots per plant. Similar results are in agreement with Tongglum *et al*. (1992). In the present study, planting method was seen to influence fresh storage roots yield of cassava although the effect was amplified by effect of variety and similar result was observed by Aina *et al*. (2007). However, Amponsah *et al*. (2014) found that different cassava varieties will respond differently under different planting conditions. Therefore, "cv. *Local"* showed higher tuber yield in Batticaloa district compared to "cv. *Kirikawadi*" as the well adaptation to the local climatic condition.

CONCLUSION

It was clear that planting methods of cuttings and varietal characters had a profound influence on the growth and root yield of cassava cultivars. Angled planting method of cuttings showed the better performance than those of vertical and horizontal planting method and cv. Local performed better than "cv. *Kirikawadi*" on the yield attributes as the higher adaption local cultivars to the environment than the "cv. *Kirikawadi*". The highest mean root yield was achieved from the angled planting followed by vertical and horizontal planting. Based on the findings of this study, regions which are prone to dry conditions, angled planting of local cultivars could be recommended for cassava production for efficient agronomic practices to maximize the potential yield of cassava.

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