Tuberization and effect of age of seedlings at transplant on yield of seed-propagated cassava

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SUMMARY

Two experiments were carried out firstly to study the processes of development and tuber initiation in cassava seedlings, and secondly, to determine the appropriate age at which cassava seedlings should be transplanted to ensure optimum field establishment and higher yield. In the first experiment, nursed seedlings were uprooted at weekly intervals from time of emergence for 9 weeks, and observed for root and shoot development. Transverse sections of roots were examined for the presence of starch grains. In the second experiment, seedlings at 27, 34, 41 and 48 days old were transplanted (naked root) to the field and observed for survival and tuber yield after 10 months of growth. Most seeds germinated within 7-16 days after sowing but a few germinated after 70 days. During the first 9 weeks of seedling growth, an average of three leaves unfolded every week on the main stem. Stem elongation occurred at a fairly constant rate of 5.1 mm /day while tap root elongation was 8.6 mm/day for the first week, and 2.4 mm/ day over the next 6 weeks. Lateral root elongation was high, averaging about 9.3 mm/day over the first 6 weeks of growth. Starch grains were first observed in the tap root at 4 weeks and in the lateral root tissues at 5 weeks. Proliferation of starch-filled cortical cells began in the tap and lateral roots at 5 and 9 weeks respectively. Percentage survival were 28, 63, 80, and 67 for seedlings transplanted at 27, 34, 41 and 48 days old respectively. Tuber yield ranged from 6525 kg/ha for the 27 days old seedlings to 17 764 kg/ha for the 41 days old seedlings. It was concluded that the most appropriate age at which to transplant cassava seedlings to ensure optimum survival and yield was 41 days after sowing.

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RÉSUMÉ

TETTEH, J. P., OMENYO, E. L. & DANKWA, A.: *La tuberisation et effet de l' âge de semis pendant la transplantation sur le rendement du manioc graine-propagé.* Deux expériences étaient exécutées premiérement pour étudier les processus de développement et l'initiation de tubercule en semis de manioc et deuxièmement pour déterminer l' âge approprié auquel les semis de manioc devraient être transplantés pour assurer l' établissement optimum sur le terrain et un rendement plus haut. Dans la première expérience, les semis soignés étaient déracinés à intervalles hebdomadaires dès le temps d' apparition pour 9 semaines et observés pour le développement de racine et de tige. Les sections transversales des racines étaient examinées pour la présence des grains de fécule. Dan la deuxième expérience. les semis à l' âge de 27, 34, 41, et 48 jours étaient transplantés (racine nue) au terrain et observés pour la survivance et le rendement de tubercule après 10 mois de croissance. La plupart de grains ont germé dans 7-16 jours après les semailles mais peu ont germé après 70 jours. Au cours des premières 9 semaines de la croissance de semis une moyenne de 3 feuilles se sont déployées chaque semaine sur la tige principale. L' élongation de tige s'est déroulée à une allure légèrement constante de 5.1 mm par jour alors que l'élongation de la racine pivotante était 8.6 mm/ jour pour la première semaine et 2.4 mm/jour au cours de six semaines prochaines. L' élongation de racine latérale était élevée, ayant une moyenne d' environ 9.3 mm/jour au cours des six semaines 5 de croissance. Les grains de fécule étaient d' abord observés dans la racine pivotante à 4 semaines et dans les tissus de racine latérale à 5 semaines. La prolifération des cellules corticales pleins de fécule ont commencé dans les racines pivotantes et latérales à 5 semaines et 9 semaines respectivement. Le pourcentage de survivance étaient 28, 63, 80 et 67 pour les semis transplantés à l'âge de 27, 34, 41 et 48 jours respectivement. Le rendement de tubercule s'étend de 6 525 kg/ha pour les semis de l' âge de 27 jours à 17 764 kg/ha pour les semis de l' âge de 41 jours. La conclusion a été tirée que l'âge le plus approprié pour transplanter les semis de manioc pour assurer la survivance et le rendement optimum était 41 jours après les semailles.

Introduction

Even though cassava is known to produce viable seeds that can be used for propagation, only the stem cuttings are used as planting material by farmers. The non-use of true seed for production may be due to the fact that farmers are uncertain about the prospects of using seed. Cassava seeds are less bulky to handle, can store for a long time, and are not known to carry the mosaic virus. These attributes make it more attractive than stem cuttings for use as planting material provided that they give good yields.

There are contrasting views relating to the yield and quality of seed-propagated cassava. Doku (1969) indicated that seed-propagated cassava gave lower tuber yields of inferior quality than did stem-propagated cassava. On the contrary, seed-propagated cassava was observed to produce equal or higher yields than those propagated from stem cuttings (Rajendran & Ravindran, 1991; Tetteh & Amoako, 1994). Again, it was observed that transplanted seedlings far out-performed direct-seeded ones in both yield and quality of tubers (Tetteh & Amoako, 1994). This was because the direct-seeded plants had their tap roots develop into large but fibrous tubers which suppressed the development of lateral tubers. The process of transplanting partly destroyed the tap root or changed the vertical orientation of the tap root and thereby reduced its dominance over the lateral roots. This enhanced the development of more lateral roots which are less fibrous than the tap root tuber. The processes that lead to the poor development of lateral root tubers in direct-seeded cassava are not well understood.

Direct seeding is also characterized by erratic and protracted seedling emergence, resulting in uneven stand development. However, in transplanted cassava, only healthy seedlings of uniform size and desirable characteristics are selected. This makes transplanted cassava a better option over the direct-seeded ones, particularly for production of an economic crop.

Survival of cassava seedlings after transplanting to the field depends on the age and vigour of seedlings as well as the prevailing environmental conditions.

This work was undertaken to firstly study the anatomical and morphological characteristics of cassava seedlings up to tuber initiation, and secondly, to determine the most appropriate stage of growth that would ensure better field establishment, and higher yield after transplanting.

Materials and methods

Two experiments were carried out during the period from June 1993 to April 1994.

Experiment 1: A study on the morphology, growth and tuberization of seed-propagated cassava

Cassava seeds obtained from line TMS 30555, an introduction from IITA, were sown on two prepared seed beds. After emergence (14 days after sowing), seven seedlings were uprooted at weekly intervals for 9 weeks. The length of stem, tap root and longest lateral root were measured using a metre rule. The diameters of the largest portion of the stem, tap root and lateral root were also measured using the vernier caliper. Between the 3rd and the 9th weeks of seedling growth, both tap root and lateral root were observed for tuber initiation. This was done by observing prepared slides of transverse sections of root samples under the microscope for presence or absence of starch grains.

Experiment 2: Effect of age of seedlings at transplanting on the establishment and yield of seed-propagated cassava

Four batches of seed obtained from line TMS 30 555 were nursed at weekly intervals for 4 weeks. Seedlings were transplanted to the field on 4 Jun 93 when the batches were 27, 34, 41 and 48 days old. Some seeds were sown at stake on the day of transplanting the seedlings. There were two replications per treatment. A plot consisted of 14 stands with two seedlings per stand, and spaced at 1 m × 1 m. Seeds were over-sown on the direct-seeded plots and later thinned out to two plants per stand after emergence.

Harvesting was done on 26 Apr 94, when plants were 10 months and 3 weeks old. Observations were made on height of seedlings at the time of transplanting, number of established plants, number of tubers per plant, mean tuber weight, tuber yield and harvest index.

Results and discussion

Experiment 1

Seed germination and seedling development
Seedling emergence started 7 days after sowing, and by the 16th day, majority of the seedlings had emerged. A few seedlings emerged up to the 11th week after sowing. This often occurred whenever there was rain after a long dry spell. The erratic nature of seed germination resulted in uneven growth and development of plants. Observations were not made on late-emerging plants.

A newly-emerged seedling had a prominent tap root and three to five lateral roots. The two open cotyledons expanded and turned green in colour to give rise to two oval-shaped seed-leaves. The first true leaf began to unfold by the 3rd day. Thereafter, an average of three leaves unfolded every week such that by the end of the 9th week after emergence there were on each plant, an average of 30 leaves on the main stem. Number of lobes per leaf increased by two, from one to three to five, to seven and in a few cases to nine. The optimum number of lobes was first observed at the 11th leaf stage. The young seedlings were observed to be completely free of cassava mosaic virus disease. Symptoms of mosaic were first observed at the 7th to 9th leaf stage. This observation suggested that the seeds were originally free of the mosaic virus.

Seedling growth. Growth rates of the stem, tap root and first lateral root are shown in Fig. 1. The rate of stem elongation was fairly constant, averaging about 5.1 mm per day over the 9-week period following seedling emergence. In the 1st week after emergence, tap root elongation was rapid, averaging about 8.6 mm per day. It slowed down to 2.4 mm per day over the next 6 weeks to attain an average length of 17.5 cm by the 7th week after emergence. Lateral root elongation

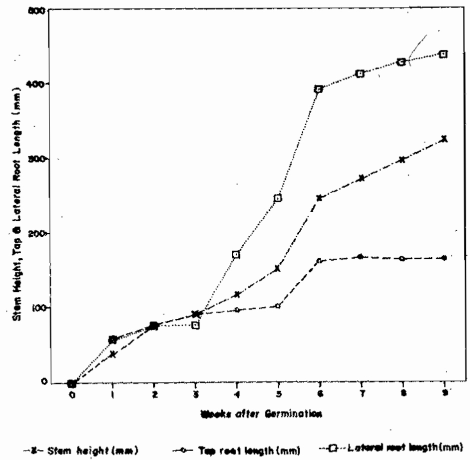

Fig. 1. Rate of seedling stem, tap root and lateral root elongation

within the 1st week after emergence was similar to that of the tap root. But unlike the tap root, the rate of elongation remained high beyond the 1st week such that by the 9th week, the lateral root was about three times as long as the tap root. The other lateral roots also increased in length in a manner similar to that of the first lateral root.

Tuber initiation and development. During the first 5 weeks after emergence, stem diameter

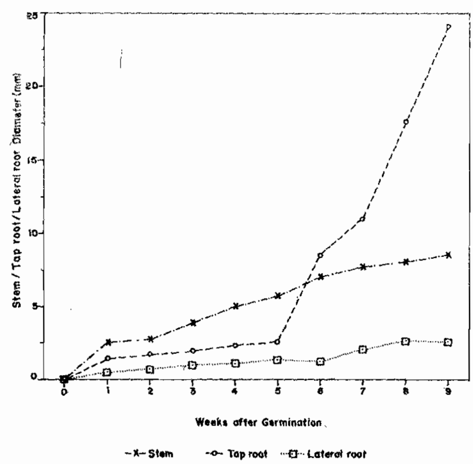

Fig. 2. Rate of seedling stem, tap root and lateral root expansion

was greater than those of the tap and lateral roots. Stem diameter increased steadily at a rate of about 1 mm per week (Fig. 2). Tap root diameter was also very small from the onset. It increased steadily at about 0.5 mm per week over the first 5 weeks and then sharply at a rate of about 5.0 mm per week over the period from 5th to 9th week of growth (Fig. 2). The rapid increase in tap root diameter was an indication that tuber initiation had occurred and dry matter accumulation was taking place. The diameter of the largest lateral root was rather very small initially. Similarly, the rate of expansion was also very slow (about 0.3 mm per week) over the entire 9-week period that observations were made (Fig. 2). This implied that the presence of an active tap root seemed to suppress the early development and expansion of lateral root tubers.

TABLE 1

Agronomic Performance of Cassava Seedlings Transplanted at Different Ages

	Age of transplants (days)				
Observations	*0*	*27*	*34*	*41*	*48*
Seedling height (cm) at transplant (range)	-	6.2 (5-10)	10.7 (6-20)	28.8 (14-36)	39.7 (20-47)
Establishment after transplant (%)	64*	28	63	80	67
Mean number of tubers/plant	2.4	6.0	5.9	4.2	5.2
Mean tuber wt (g)	300	320	270	300	270
Mean tuber yield/plant (kg)	0.71	1.91	1.39	1.24	1.41
Tuber yield (kg/ha)	6 816	6 525	11 734	17 764	13 793
Harvest index	0.57	0.70	0.64	0.62	0.67

* Figure represents percentage germination of seed sown *in situ.*

No starch grains were observed in both the tap roots and lateral roots of 3-week-old cassava seedlings. By the 4th week, few starch grains were observed in the parenchyma cells between the xylem arms of the tap roots, but none in the lateral roots. By the 6th week, starch grains had filled up all the tissues of the tap root except the outer periderm and the sclerenchyma tissue beneath the periderm. If presence of starch grains marks the beginning of tuber initiation, then the results suggested that tuber initiation in the tap root began in the 4th week. This was followed by a sharp increase in the rate of diameter expansion from the 5th week.

For the lateral roots, traces of starch grains were first observed in the 5th week. It was not until the 8th week that starch grains were found to fill up all the cortical cells and the xylem vessels. There were, however, fewer cortical cells than in the tap root.

The results indicated that tuber initiation takes place fairly early in seed-propagated cassava plants. Tuber initiation takes place first in the tap root and later in the lateral roots. The early formation of the sink organ in the tap roots tended to suppress the development of the lateral roots as effective sink organs. Consequently, lateral root tuber development was poor.

Experiment 2

At the time of transplanting, mean seedling height were 6.2, 10.7, 28.8 and 39.7 cm for the 27, 34, 41 and 48 days old seedlings respectively (Table 1). Seedlings transplanted at 41 and 48 days were more vigorous in growth in comparison with direct-seeded ones which took 7 to 17 days to emerge. Consequently, the latter initially competed poorly with weeds (visual observation). This implied that the use of seedlings rather than seeds for field planting would ensure better weed control.

During the 1st week after transplanting, seedling growth was minimal and most seedlings shed off the lower leaves. In a few cases (especially, among the 48 days old seedlings), the terminal bud died giving way to the development of lateral shoots. Some transplanted seedlings also died of shock. The percentages of seedlings that survived and became established were 28, 63, 80 and 67 for the 27, 34, 41 and 48 days old seedlings respectively. It was evident that the percentage survival of seedlings increased with age of seedlings up to 41 days old, and thereafter declined. On that basis, transplanting seedlings at 41 days old was the most appropriate to ensure optimum seedling survival. Where necessary, seedlings at 34 to 48 days old could be used as transplants; however, two seedlings per stand could be planted and later thinned to one after establishment. It should be noted that seedlings were transplanted with naked roots in order to impose maximum stress on them. It is likely that percentage survival would be higher if seedlings are transplanted with some earth around the roots.

The agronomic performances of the transplanted seedlings and seeds sown at stake are shown in Table 1. The direct-seeded plants yielded the lowest mean number of tubers per plant. Among the transplanted seedlings, number of tubers per plant ranged from 4.2 to 6.0. Number of tubers per plant decreased as the percentage establishment increased. Consequently, the 27 days old seedlings with 28 per cent establishment recorded the highest number of tubers per plant (6.0) whereas the 41 days old seedlings with 80 per cent establishment had the least number of tubers per plant (4.2). The direct-seeded plants developed prominent tap root tubers which tended to suppress the development of lateral tubers. The process of transplanting disturbed the tap root and consequently made it possible for several lateral roots to develop into tubers.

There was very little variation among the treatments for mean tuber size. It ranged from 270 to 320 g/tuber (Table 1). There was considerable variation in tuber size within treatments. For instance, mean tuber size ranged from 70 to 1,100 g/tuber/plant among the plants transplanted at 48 days.

Mean tuber yield per plant was highest for seedlings transplanted at 27 days and lowest for the direct-seeded plants. Among the transplanted seedling treatments, the 41 days old seedlings yielded the smallest tubers per plant. This was expected, since the plant population for the 41 days old seedling plots was the highest and that of the 27 days old seedling was the lowest. Plants on the thinly-populated plots had enough room to expand. A similar trend was observed for harvest index (HI). The direct-seeded plots gave the least. Among the transplanted seedling plots, those transplanted at 27 days gave the highest HI of 0.70, whereas those transplanted at 41 days gave the least HI of 0.62.

Tuber yield ranged from 6525 kg/ha for the 27 days old seedlings, to 17764 kg/ha for the 41 days old seedlings. The difference in yield was associated with low plant population of the former treatment in comparison with the latter. Even though the 27 days old seedlings gave the highest number of tubers per plant, mean tuber weight, mean tuber yield per plant, and HI, it was not enough to compensate for the low plant population that occurred on these plots.

On the basis of percentage seedling survival, and overall tuber yield, the best time to transplant seedlings is 41 days after sowing. An added benefit is that seedlings would be vigorous enough to compete effectively with weeds. Plant population on plots with 41 days old seedlings was estimated to be 14320 per hectare which was close to the recommended 10000 plants per hectare for stem cuttings. It should be noted that when stem cuttings are planted, one, two or more stems may arise from each cutting per stand. In the case of seedlings, only one plant arises per seedling. It is, therefore, appropriate to transplant more than one seedling per stand in order to obtain the advantages associated with multiple shoots that arise per stand when stem cuttings are used as planting material.

Conclusion

Most cassava seeds germinate within 7 to 16 days after sowing. Tuber initiation, which is marked by starch accumulation, begins as early as 4 weeks after seedling emergence.

Tuber bulking begins in the tap root and subsequently in the lateral roots. The early sink formation in the tap root tends to suppress the development of lateral roots into tubers.

A disturbance of the tap root through transplanting of seedlings tends to break tap root dominance, and this leads to the development of more lateral root tubers. Transplanted cassava tend to out-yield direct-seeded cassava.

The appropriate age to transplant cassava seedlings is 41 days. At that age, seedlings survive better, are more able to compete with the weeds, and also give higher tuber yields than seedlings transplanted at other ages.

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