

Full Length Research Paper

Agronomic performance of cassava cultivars subjected to pruning at various population densities and harvest timings

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Optimizing population density and harvest timing in cassava can improve agronomic efficiency, productivity and quality of industrialization. The objective of this study was to evaluate the influence of plant population density and harvest timing on the yield of two cassava cultivars with different canopy architectures (IAC 13 and Branca de Santa Catarina); each planted at four population densities, from 7,000 to 31,000 plants ha⁻¹ for IAC 13 and from 5,000 to 29,000 plants ha⁻¹ for Banca de Santa Catarina. The aerial plant shoots were pruned 12 months after planting, and the whole plant was sampled at three different harvesting times at 4, 8 and 12 months after pruning. The maximum yield was 46.63 t ha⁻¹ for IAC 13 at 7,000 plants ha⁻¹, with no significant effect of harvest timing. The maximum yield was 76.85 t ha⁻¹ for Banca de Santa Catarina at 29,000 plants ha⁻¹ at 20 months after planting. Both cultivars responded differently to variations in population density and harvest timing.

Key words: *Manihot esculenta* Crantz, root, harvest timing, plant density, fresh root.

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) represents one of the primary sources of carbohydrates worldwide, alongside maize, wheat, rice and potatoes crops; presenting a production of more than 303.5 million tons in 2019 (Food and Agriculture Organization [FAO], 2021). It is especially important in developing countries, where it is cultivated in small areas, using limited technology (Almeida et al., 2016). Cassava originated in Brazil and is cultivated in all regions of the country for human and animal consumption, as well as industrial material for flour

production (Cardoso et al., 2002). Brazilian cassava production is responsible for 5.7% of the world production, with an average yield of 14.7 t ha⁻¹ in 2019 (Instituto Brasileiro De Geografia E Estatística [IBGE], 2021). According to Roesler et al. (2008) and Oliveira et al. (2015) the cassava starch industry frequently under-produces due to lack of raw material and high competition for cassava plantation areas with other crops. However, increased production is challenging because cassava is characterized as a subsistence product, and thus the body

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of research is limited for cultivar selection and regionally-specific management practices.

The productivity of the cassava crop, or any other crop, is related to the use of production factors, such as water, light and nutrients for plants. In this way, the organization or arrangement of plants within the same area contributes to greater or less competition, inter-specific or intra-specific, of plants for these factors, with results in productivity and land use. For cassava, plant population density depends on factors such as soil fertility, size variety, crop treatment, harvesting method and destination of the farming (Almeida et al., 2026; Fialho and Vieira, 2013).

The aerial shoots of the cassava plant are pruned for vegetative propagation and also animal feed. Pruning may be advisable in case of high pest or disease pressure or in case of frost. However, pruning is not always recommended in cassava because it can reduce root production and carbohydrate content of roots and can increase fiber content in roots and competition among plants due to increased sprouting stem density. Also, pruning activity may spread pests and diseases, and promote weed pressure (de Oliveira et al., 2015).

When necessary, pruning is ideally done at the beginning of the rainy season in plants, 10 to 12 months of age, at a height of 10 to 15 cm from the soil surface. Cassava plants subjected to pruning should rest for 4 to 6 months prior to harvest to allow nutrient translocation subside; following re-establishment of the aerial shoots (Souza and Fialho, 2003). In Brazil, for economical production, cassava can usually be grown with one or two cycles, but then when harvested for human consumption (sweet cassava) it is preferably with one cycle (10 months to 12 months), and one or two cycles (18 months to 24 months) for starch industry (de Mendonça et al., 2020). Harvesting time decision depends also on climate conditions, once harvesting phase is one of the most costly in the cassava production system, representing about half of the production cost (Fialho and Vieira, 2013).

Optimum harvest timing is relevant because productivity decreases when the roots are harvested early, yet quality of the starch suffers when harvested late (Fernandes et al., 2019). Similarly, dense cassava stands produce smaller and finer roots, which are less desirable than the larger roots produced in sparsely populated and under-productive stands (Almeida et al., 2016). Despite the dry matter accumulation in roots being more significant along with the time of branches maturity, some cassava materials have shown other ideal harvesting periods, which can be justified either by genetics or by climatic influences (Valle and Lorenzi, 2014).

The work evaluates the influence of population density and harvest timing in yield of two cassava cultivars subjected to pruning.

MATERIALS AND METHODS

The experiments were conducted at the Paranapanema Valley

headquarters of the Paulista Agribusiness Technology Agency (APTA), located in Assis, São Paulo (22°40'42"S, 50°26'44"W, 563 m asl). The climate of the region is Köppen classification Cwa; subtropical with dry winter and hot and humid summer. This climate is suitable for cassava cultivation (de Oliveira et al., 2015).

The soil is characterized as Distroferric Dark Red Latosol with moderate A horizon. Lime was not applied because negative or little response to this practice was found in the literature. Fertilizer (4% N, 20% P₂O₅, 20% K₂O, 0.5% Zn) was applied at a rate of 300 kg ha⁻¹, according to the Agronomic Institute of Campinas (IAC) recommended rate for cassava (Lorenzi, 2003). The soil was cultivated with a disc harrow to a depth of 20 cm without need for further finishing. For weed control, trifluralin was applied at a rate of 1112 g ha⁻¹. After preparation, rows were mechanically opened prior to manual planting. Distance between rows was 70 or 105 cm, and plant spacing varied to meet target population densities.

The experiment began in September 2015, using viable cassava stems of good physiological quality approximately 0.15 m in length, with five axillary buds per stem distributed horizontally in the open rows, which were closed mechanically following planting. The cultivars IAC 13 and Branca de Santa Catarina (BSC) were obtained from the IAC genetic seed production program and were chosen due to their different canopy architectures; 'BSC' shows open branching plants, 'IAC 13' has vigorous stems and closed branches. Planting was carried out in four planting densities for each cultivar, adopting spacing recommendations as criteria, according to their architecture.

A randomized complete block split-plot design was used with two replicates. Cultivar and plant density were main treatment factors, with each cultivar × density treatment planted in four rows, 10 m in length. The cultivar IAC 13 was planted at 7,000, 15,000, 23,000 and 31,000 plants ha⁻¹ (Figure 2) and the cultivar BSC was planted at 5,000, 13,000, 21,000 and 29,000 plants ha⁻¹ (Figure 1). Aerial shoots were drastically pruned 12 months after planting (MAP) to simulate removal of material for propagation. Harvest timing was the split-plot factor, with whole plant harvest and evaluation occurring at 4, 8 and 12 months after pruning (MPD) by harvest of the leaf biomass, stumps, and roots of six plants per plot per harvest timing. Weights of separated plant parts were quantified in the field at the time of collection.

Variables analyzed were fresh mass of roots, stumps, leaf biomass, total mass, and derived fresh root yield in ton ha⁻¹. In the statistical analysis, the data were submitted to the Lilliefors and Cochran tests to verify the normality of the residuals and homogeneity among the variances, respectively. After verifying assumptions, the data were subjected to analysis of variance (ANOVA) to determine significant treatment effects. In the case of significance, Tukey's test was applied to determine the differences among treatments at 5% probability for the planting density.

RESULTS AND DISCUSSION

The ANOVA detected a significant difference in the plant density × harvest timing treatment factor interaction only for leaf biomass in both cultivars. Analysis of the main treatment factors did not demonstrate a significant difference for stump weight in the cultivar BSC nor root yield per hectare in the cultivar IAC 13. For the BSC cultivar, the best time to harvest with regards to number of roots per plant is at 8 or 12 MPD. At these harvest timings, the highest plant population (29,000 plants ha⁻¹) showed highest yield at 76.85 t ha⁻¹, which corroborates research by de Oliveira et al. (2015) who found higher starch accumulation at the end of the cycle (Figure 1).

At higher population density, the branching of the plant

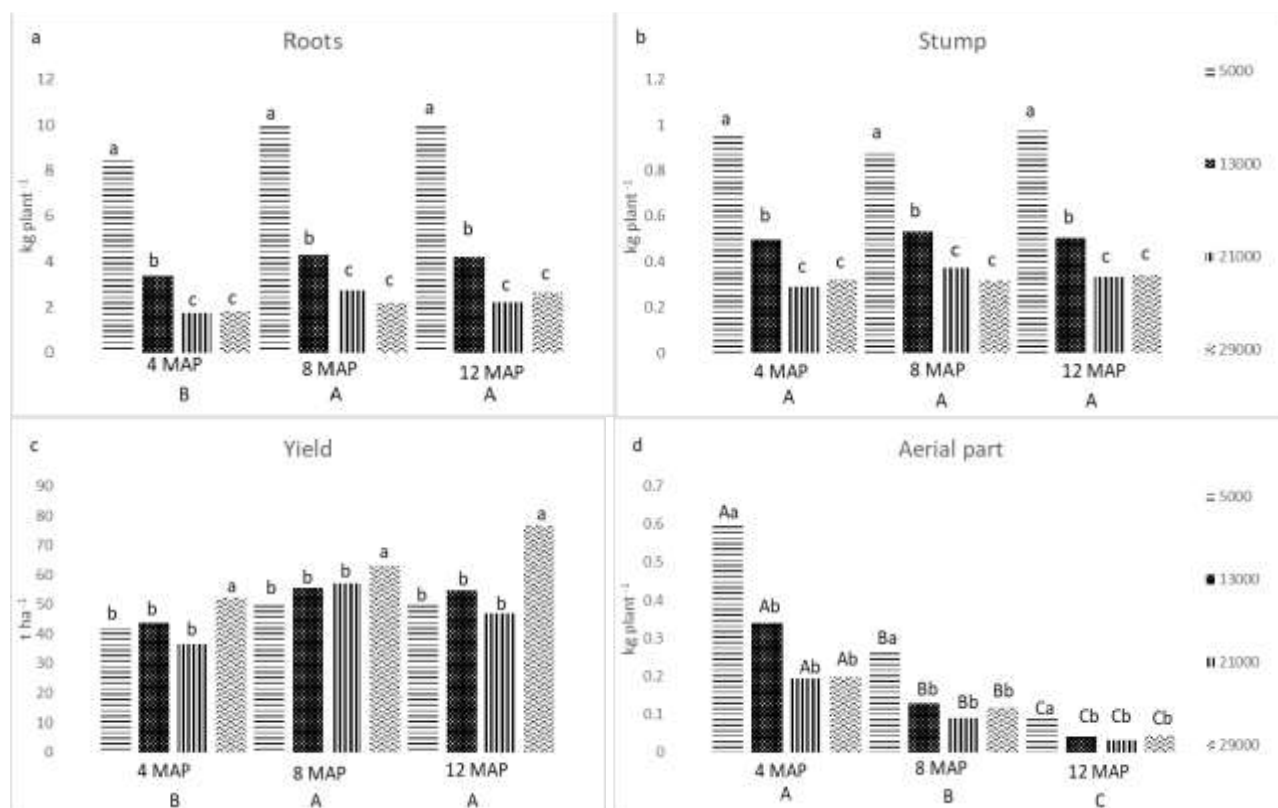


Figure 1. Cultivar BSC; (a) mass of roots per plant, (b) mass of stumps per plant, (c) root yield in ton ha⁻¹ and (d) leaf biomass per plant. A- Caps lock letters refers to the harvest season; b- Lowercase letter refers to the population density per hectare.

may have interfered with root production. At lower planting densities, there were more roots per plant; however, yield still lagged behind that of higher population density, where there was smaller number and size of roots per plant, yet increased yield.

The cultivar IAC 13 responded similarly to BSC with respect to number of roots per plant as a function of population density, but harvest timing was not significant. These results also influenced yield, because IAC 13 produced highest at the lower population densities (7,000 and 15,000 plants ha⁻¹), with no significant effect of harvest timing. This demonstrates a tendency for root development to occur earlier in IAC 13 that has a more precocious starch accumulation than BSC.

Evaluating harvest timing in cassava cultivars, Ponte (2008) found that the Sergipe cultivar yielded highest in August, 9 MAP. In this study, the optimum harvest timing for yield was at 16 MAP for IAC 13 and at 20 MAP for BSC, showing that the ideal harvest timing is specific to cultivar. Carvalho et al. (2007) evaluated 11 cassava cultivars at three harvest timings: 14, 16 and 18 MAP, and also found that productivity increases linearly as a function of harvest timing, with averages of 21, 22 and 24 t ha⁻¹, respectively. Starch accumulation, maturation and productivity varied according to the cultivar used in this study.

With respect to leaf biomass production, there was more

growth in the less dense populations (5,000 and 7,000 plants ha⁻¹ for BSC and IAC 13, respectively). At higher planting density, the greater competition for space resulted in decreased leaf production per plant. As for the harvest timing, there was more leaf biomass at the first harvest timing. This is a period of greater vegetative development for the crop, coinciding with higher rainfall as compared to the subsequent harvest timings. At the end of the growing cycle, leaf loss occurs and leaf biomass declines for both cultivars.

According to Oliveira et al. (2010), pruning stimulates the development of the aerial shoots, resulting in greater leaf biomass and, consequently, a greater leaf area index. The increased leaf area index can be attributed to the excessive production of new leaves, which may reduce the root yield (Lenis et al., 2006).

The grazing observed in less dense plant populations also interferes with the stump mass, where smaller populations grazing will consequently have more amount of stumps in the two cultivars. However, the harvest time did not influence the amount of BSC stumps, precisely because the amount of stumps will always be the same in function of the architecture and vegetative development of the plant, and will not be influenced by the length of the resting period after pruning. This was not observed with IAC 13, which had a greater number of stumps in the later harvests, showing

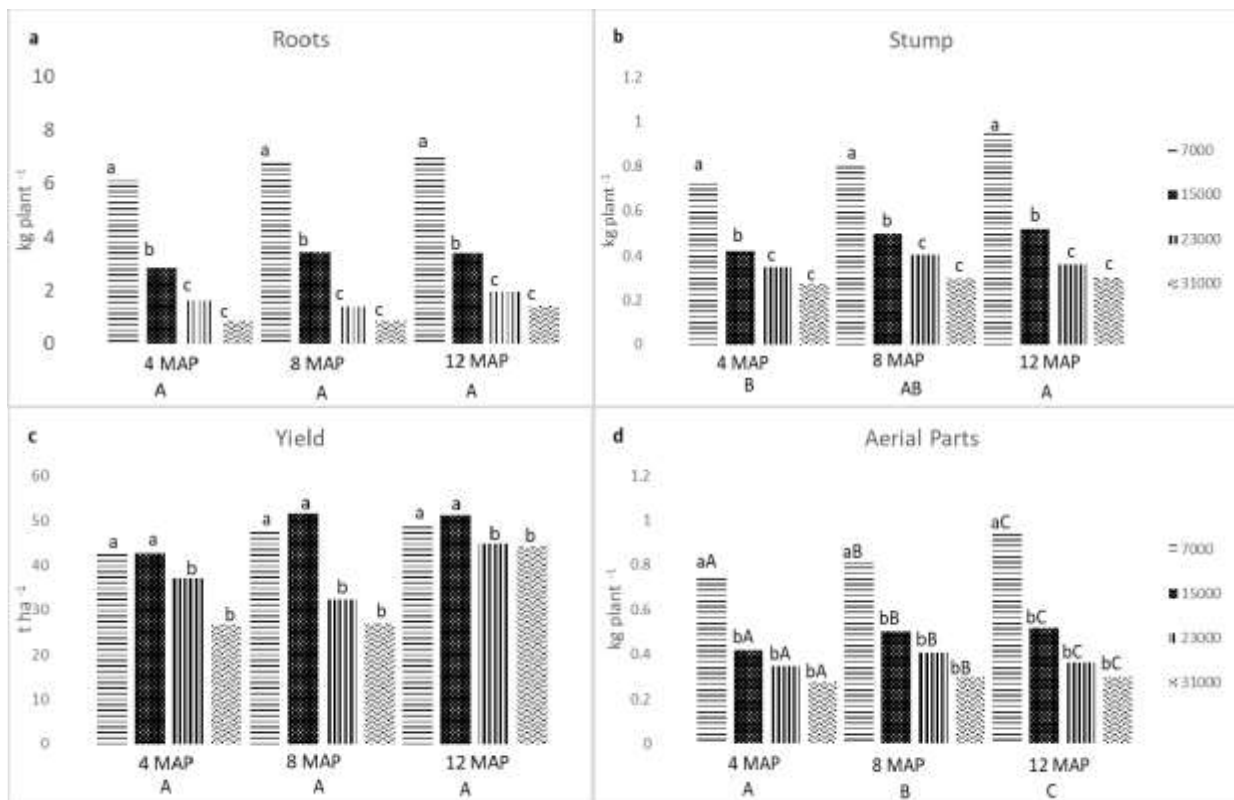


Figure 2. Cultivar IAC13; (a) mass of roots per plant, (b) mass of stumps per plant (c) root yield in ton ha⁻¹ and (d) leaf biomass. A- Caps lock letters refers to the harvest season; b- Lowercase letter refers to the population density per hectare.

that the development of aerial parts is relatively later than that of BSC.

Conclusion

Planting density and harvesting timing influenced growth and production of the cassava cultivars IAC 13 and BSC submitted to pruning, based on measurement of physiological and agronomic characteristics. IAC 13 produced highest at the lower population densities (7,000 and 15,000 plants ha⁻¹), with a maximum yield of 46.63 t ha⁻¹ with no significant effect of harvest timing. For the BSC cultivar, the best time to harvest was at 8 or 12 MPD at the highest plant population (29,000 plants ha⁻¹) with a yield of 76.85 t ha⁻¹.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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