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Morphological and physiological responses of CMD resistant cassava (*Manihot esculenta*) genotypes to nutrient regimes

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ABSTRACT

The field studies were carried out on cassava (*Manihot esculenta* Crantz) varieties resistant to cassava mosaic disease (V_1-CR43-2, V_2-15 S 59, V_3-15 S 409 , V_4-15 S 154, V_5-CR43-7, V_6-8S 501-2, V_7-CR24-4, V_8- 15S-436) and three levels of nutrient doses (F_1-75:50:75, F_2- 100:50:100 and F_3- 125:50:125 kg NPK/ha) in spilt plot design during 2018-19 and 2019-20 to assess the response of varieties to nutrition. There was significant difference in morphological and physiological parameters among varieties, but not with different nutrient doses. The rate of leaf production was more 4-6 months after planting (34-40%) and percentage retention was less for first season crop (55.6-41.4%) compared to second season (77.2-52.5 %). Though not significant, higher nutrition levels recorded more number of green leaves as well as leaf area at most of the stages. Tuber bulking rate was 0.19 - 0.37 g/day during initial two months. The rate increased and maximum bulking was recorded between 4 and 8 months (2.15-6.71 g/day). Pooled analysis also showed a gradual increase in tuber yield with nutrient levels, but was not significant (7%). The varieties responded differently to nutrients with respect to tuber yield. F_3 recorded higher tuber yield (66.9 t/ha) than F_1 (45.7 t/ha) in V_7 and V_6 recorded highest tuber yield with F_2 level of nutrition (71.1 t/ha). F_1 was found optimum for rest of the varieties.

Key Words: Leaf area index, Nutrition, Tuber bulking rate, Tuber yield, Varietal response

Cassava (*Manihot esculenta* Crantz) is the fourth most important food crop in the world. Its wide adaptability to various cropping and farming systems, high yield potential, and season insensitivity ensuring year-round availability, make it an ideal food security crop and versatile industrial raw material. Cassava is considered as a low-input crop, able to yield reasonably good under adverse environments with low fertility and acidic soils where other crops fail (El-Sharkawy *et al*., 2012). However, adequate supply of nitrogen and potassium is essential for high productivity and yield stability in cassava (Ezui *et al*., 2017). The total N, P and K uptake requirements for producing one ton of fresh cassava tuber ranged from 2.9 to 6.9 kg for N, 0.68 to 1.3 kg for P and 3.9 to 7.9 kg for K (Byju and Suja, 2020). Cassava mosaic disease (CMD) is prevalent in India, Africa and Sri Lanka. Different CMD resistant varieties were assessed for their morphological and physiological traits under different nutrient regimes and its relation to final tuber yield.

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MATERIALS AND METHODS

Field experiments were conducted during 2018-19 and 2019-20 at ICAR-CTCRI, Thiruvananthapuram, Kerala. The soil is deep, well-drained, sandy clay loam, moderately acidic. Split-plot design in a completely randomized block was used. All CMD resistant varieties were allocated to the main plots (V_1- Sree Sakthi, V_2-15 S 59, V_3-15 S 409, V_4-15 S 154, V_5-CR43-7, V_6- Sree Kaveri, V_7- Sree Reksha, V_8- 15S-436) and three fertilizer doses were allocated to sub-plots (F_1-75:50:75, F_2- 100:50:100 (present recommendation) and F_3- 125:50:125 NPK/ha). The crop was planted uniformly at a spacing of 90 cm × 90 cm with a gross plot size of 36 plants and a net plot size of 16 plants. The farmyard manure @ 12.5 t/ha and full dose of phosphorus were applied as basal. The N and K were applied in two equal splits, half as basal at planting and the rest half, 45 days after planting.

The morphological data on height, number of green and fallen leaves, leaf retention rate and leaf area were recorded at two months intervals. Destructive sampling was done to assess the biomass production and partitioning at two months intervals. Physiological parameters, viz. leaf area index (LAI), total dry-matter production (TDMP), tuber bulking rate (TBR), crop growth rate (CGR), relative growth rate (RGR), leaf area ratio (LAR), leaf area duration (LAD) and harvest index(HI) (Pandey *et al*., 2017) and finally the yield were estimated. All the data collected were analysed statistically for individual years and pooled.

RESULTS AND DISCUSSION

During first season, height of plants varied significantly at 2 MAP, and also towards later stages after six months. V_8 recorded lowest values at all the stages. Though not statistically significant, F_2 level of fertilization resulted in taller plants. During second season, difference in height of plants could be noted only after six months, V_1, V_3, V_5, V_6 and V_7 were comparatively taller. The rate of increase in height was more during 2-8 MAP during the first season, whereas during second season, rate was more from 4 months.

The total leaf production was highest in V_2 during both the seasons. Total leaf production varied from 99.18 in V_7 to 151.11 in V_2 during first season (NS) and 171.22 in V_7 to 331.25 in V_2 during second season (p=0.05; LSD: 84.26). The rate of leaf production was more from 2-4 MAP (34%) and from 4-6 MAP (40%) during first and second seasons respectively. Though the effect was not significant, more number of leaves was produced under F_2 and F_3 level of nutrition. Rate of leaf retention was more during initial stages and gradually reduced towards maturity.

Percentage retention was less for first season crop and it varied from 55.6 to 41.4%. The value increased at 8 MAP due to rains received. Rate of leaf retention varied from 77.2 to 52.5 % during second season. Percentage of leaf retention was maximum for V_2 at all the stages during 2018-19 (45.96%). However, during 2019-20, it varied among varieties at different phases of growth, but values were higher compared to first season at all stages. Second crop retained 77.7 % leaves after 4 MAP and 64.2% after 6 MAP, but for first crop, retention percentage was less than 50% from 4 MAP. Consequently, number of green leaves was more during second season, compared to first season. Green leaves were highest for V_2 from 4-10 MAP during first season, while during second season, V_1, V_2,V_4, V_6 and V_8 had more number of green leaves after 4 MAP and all values were on a par.

Higher nutrition levels recorded more number of green leaves as well as leaf area at most of the stages. The leaf area differed significantly among varieties at 2 MAP (p=0.05; LSD: 2.02) and 10 MAP (p=0.05; LSD: 6.76) during first season. The value was maximum for V_6 at 2, 4,6 and 8 MAP and V_1 recorded maximum value at 10 MAP. During second season also V_6 recorded maximum leaf area at 2, 4 and 6 MAP, thereafter, V_8 recorded the maximum at 8 and 10 MAP and values statistically varied towards later stages.

Though cassava is grown mostly under rainfed conditions, supplementary irrigations during drought period could give higher dry-matter production, crop growth rate (CGR), tuber weight and yield (Sunitha *et al*., 2013; Sunitha *et al*.,2016). Cassava responds positively to management practices, it is sensitive to over fertilization, especially with N, which resulted in excessive leaf formation at the expense of root growth (Sagrilo *et al*., 2006). We also recorded more height, number of leaves and leaf area with higher nutrition, though difference was not significant. Dry period coincided with more leaf fall and less retention of green leaves and subsequent leaf area. Under water stress, cassava frequently sheds its leaves, resulting significantly in reduced productivity (El-Sharkawy, 2014; Daryanto *et al*., 2016).

All the growth indices were highly influenced by rainfall pattern received during both growing seasons. Leaf area index increased at a slow pace during establishment phase of initial 2 months in first season. It reached maximum at 4 months, and retained more or less the same value at 6 MAP, but decreased at 8 MAP, followed by a slight increase at 10 MAP during first season. This is mainly because of rains received during later stage, ie., after 8 months, which triggered out- flux of starch from tubers to vegetative parts. During second season, LAI development was slow up to 4 months, reached peak at 6 and 8 MAP, then declined.

During both seasons, leaf area indices were very much dependent on rainfall, temperature and leaf retention. Reduced leaf area represented dry periods of season, resulting in maximum leaf fall, thereby reducing the transpiration loss and above ground growth, which is a self-defending mechanism in cassava. The pattern of leaf area development was more or less similar with all fertilizer regimes, higher levels resulted in higher values, but variation was not significant. This is in agreement with Mwamba (2021) and Sunitha *et al*. (2018), where cassava recorded less LAI with dry periods and an increase with resumption of rains, but more or less uniformly with different fertilization regimes. A similar trend was observed in harvest index values also which showed a decline from 6 MAP (0.55-0.71) to 10 MAP (0.53-0.65) during first season, but an increasing trend during second season (0.53-0.79).

The CGR expressed a steady increase from planting up to harvesting, during both seasons. Tuber development from 6 months at a faster rate caused a rapid increase in CGR from 6 MAP. The values ranged from 0.65 (V_8) to 2.83 g/day (V_3) during first two months and increased to 7.49 (V_2) to 21.56 g/day (V_1) from 8 to 10 months. Though vegetative growth was less, tuber development and maturity caused a significant increase in CGR towards later stages, after six months. However, relative growth rate (RGR) was comparatively higher during first two months in both seasons and the values ranged from 0.026 (V_8) to 0.037 g/g/ day (V_3). Leaf area duration expressed a progressive trend from planting to harvesting. The rate of increase was more from 6-8 MAP. Consequently leaf area ratio (LAR) showed a declining trend from planting to harvesting. The values ranged from 0.005 (V_3) to 0.014 (V_8) at 4 MAP and 0.0015 (V_3) to 0.0053 (V_8) at 10 MAP.

Tuber bulking rate was 0.19-0.37 g/day during initial two months as tuber initiation occurs only 40-45 days in cassava. Then rate increased and maximum bulking was recorded between 4 and 8 months (Fig.1). Once tuber bulking initiated, rate of increase in tuber dry- matter continued until, it is lower than other vegetative parts. This is mainly because, dry-matter accumulation in tubers occurs mainly by the translocation of starch assimilated from vegetative parts to storage roots and is not by formation of new tissues. This is in line with Adalton *et al.* (2017) which indicted that late application of potassium for second cycle growth of cassava encouraged fresh plant growth and storage yield.

Biomass partitioning at various stages of the crop was not affected by nutrient levels, but only with varieties, but in a similar trend. At 2 MAP, leaves and stem portion contributed a major share of biomass. Leaves accounted for 32.2% (V_3) to 63.6 % (V_6) of biomass in different varieties and stem accounted for 18.3 (V_6) to 56.1 % (V_2). Leaf biomass was reduced to 3.7-7.9% at 10 months, except in V_5 and V_8, where stem and leaves retained almost equal biomass, restricting the tuber biomass production after 8 months, as reported by Adalton *et al.* (2017). This is due to regrowth of stems and leaves at the expense of tubers with favourable soil moisture conditions.

A major share of the tuber bulking occurred between 4-8 MAP in all the varieties except V_8 in both the seasons, where tuber bulking was more during 6 to 8 MAP. There was a decrease in tuber biomass and increase in stem and leaf biomass during second season irrespective of the varieties. Intermittent rains received during summer season, just before harvesting triggered vegetative growth, even causing the reverse translocation of starch from tubers to vegetative parts because of excess soil moisture. During drought stress, LAI and dry matter partitioning to stems and leaves reduces rapidly as photo-assimilates are mostly channelled to growth of storage roots and only increase after resumption of rainfall as reported in some studies (Ezui *et al.*, 2015).

There was significant difference in tuber yield, only with varieties. During first season, a corresponding increase was noticed from F_1 to F_3, in second season the values were almost the same. Pooled analysis

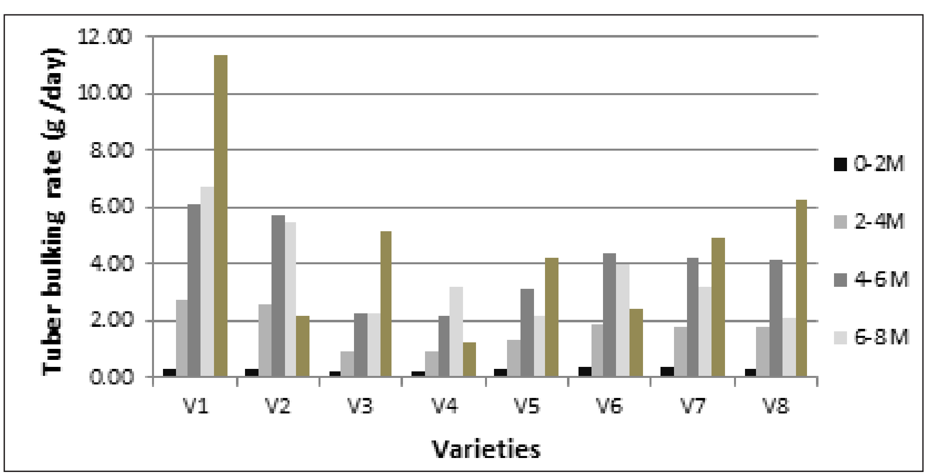

Fig. 1: Tuber bulking rate in different varieties from planting to harvesting (pooled means)

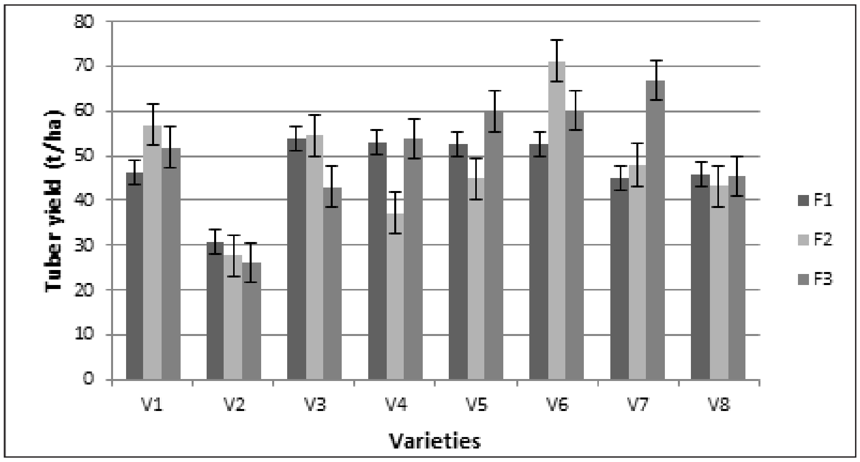

Fig. 2: Tuber yield of varieties under different nutrient doses (pooled means)

also showed a gradual increase in tuber yield with nutrient levels, but was not significant. F_3 level of nutrition resulted in only 7% increase in tuber yield compared to F_1 based on pooled data analysis and the variation was not significant. Variable response of varieties in growth and yield attributes is reported in cassava (Nedunchezhiyan *et al.,* 2022) and potato (Jatav *et al*., 2023).

The interaction effects were significant, ie., varieties responded differently to nutrients with respect to tuber yield. Higher level of nutrition, F_3 recorded significantly higher yield in V_7 in both seasons and pooled performance. V_6 recorded highest tuber yield with F_2 level of nutrition. Rest of the varieties did not express any significant variation in yield with nutrition, ie. a lower level of nutrition, F_1 is found optimum for these varieties (Fig.2). In earlier study (Mutchima, 2018), it was observed that cassava starch waste at 12.5 t and 75 kg of N or 25 t of cassava starch waste and 25 kg N resulted in more harvest index and storage root yield in cassava compared to other higher levels of nutrition. It could be inferred that these treatments supplied a good balance between total production of carbohydrates by the plants and their distribution to the roots as reported in cassava through fertigation (Sunitha *et al.*, 2013; Sunitha *et al*., 2018).

Significant variation was noted in tuber yield among varieties and in among seasons. First season crop which experienced a dry period during critical growth stage suffered yield loss compared to second season (61%). The first 3–5 MAP is a critical period for cassava (Turyagyenda *et al*., 2013; Sunitha *et al*., 2017). Moisture stress, during these first months of leaf formation, root initiation, and tuberization can reduce the yield of storage root by up to 60%.

A 30% yield reduction of cassava cultivated in Kerala was observed due to late monsoons and planting followed by a period of drought. The study emphasized the need for timely planting of cassava, coinciding with initiation of monsoon season so that crop will get enough soil moisture during establishment and tuber bulking stages with subsequent monsoon rains or else need for supplementary irrigation to realise maximum tuber yield. Also the possibility of reducing fertilizer doses by 25% in medium fertile soils.

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