ECOPHYS‾‾OLOGY OF CASSAVA

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General Climatic and Edaphic Limitations on Cassava

Cassava is grown between 30ºN and 30ºS latitude at altitudes up to 2.000 m. Most is cultivated between 15ºN and 15ºS. Jones (1959) suggested that this restriction was due to photoperiodic effects affecting growth in the more extreme tropics. Cassava is grown in regions of less than 1.000 mm/year rainfall per year up to several thousand mm/year. Frequently, it is grown in areas with pronounced wet and dry seasons and has the ability to survive the dry season, becoming essentially dormant.

Cassava grows well on acid soils, often being grown where other crops will not survive due to pH values of less than 4.5. It grows best on friable soils with good fertility, but is frequently stated to yield something where other crops fail, as the last crop in the rotation on relatively impoverished soils. Its ability to grow and survive under poor conditions has led to its extensive cultivation in areas with poor soils such as Bahia (Brazil) and as a famine reserve crop in many parts of Africa.

Reviewing the literature, it becomes obvious that there is an extreme paucity of data on the effect of the environment on cassava growth; however, the limited data available and some of our own results are presented to try to determine some of these effects.

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Temperature

In much of the Andean zone of Latin America, it is very striking to note the change in crop patterns with changes in altitude over quite short distances with similar soil types. In the Valle del Cauca (about 1.000 mamsl), cassava is frequently cultivated on the poor soils whereas potato is not grown. On leaving the Valle a quite abrupt change from cassava to potato occurs between 1.500 and 1.800 mamsl suggesting that cassava does not grow as well as potato above this altitude.

To examine the effect of altitude and temperature, twelve varieties of cassava were grown in four different sites, Cauca Valley site I, was on the fertile soils of the Valley base at CIAT, sites II, III, IV were on poor oxisols at approximately 1.500, 2.000 and 2.300 m up the Valley sides. Mean temperature was estimated from temperature measured at 07:00 hours and 14:00 hours taking the mean (Fig. 1). This gave a mean temperature range of 26-16C. Although it is difficult in such a trial to say categorically that the differences observed are due to temperature and not other climatic or edaphic factors, we feel that the temperature effect was the overriding factor, certainly in the three highest altitudes where soil conditions were relatively stable. Germination was much delayed at lower temperatures (Fig. 2), however, in most varieties the final germination was similar 60 days after planting. The two varieties M Col 22 and Llanera showed very poor final germination at 2.300 mamsl. Between weeks 17-23 after planting leaf production per plant per week was measured and it can be seen that lower temperatures markedly decreased rate of leaf production (Fig. 3). At 9 months after planting, all sites were harvested and total dry matter production measured, dry weight per plant decreased markedly with temperature and root dry matter decreased in a similar fashion (Fig. 4). The distribution of dry matter showed much less variation (Fig. 4) suggesting that the main effect of temperature in decreasing yields is by decreasing total biomass production. It

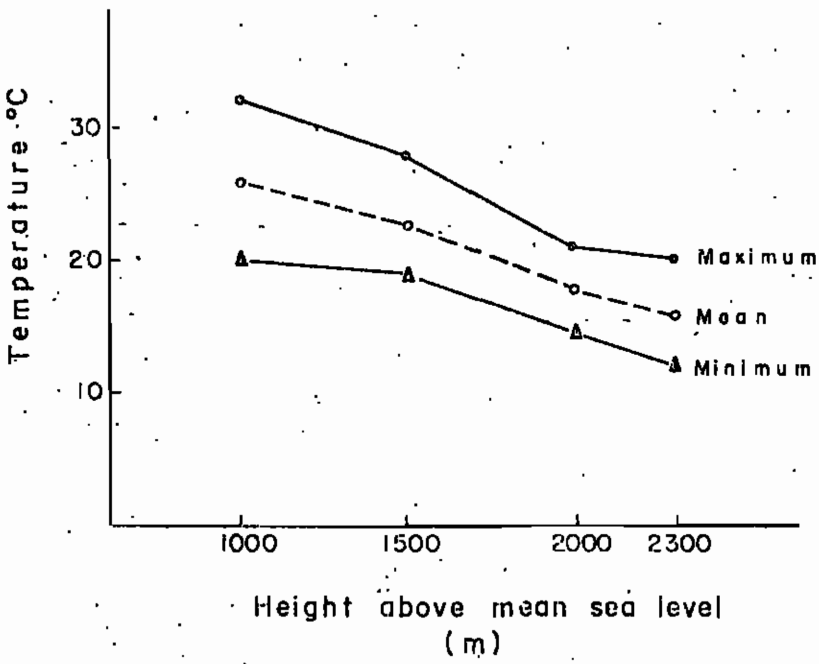


Fig. 1. Temperature at different sites used for experiment

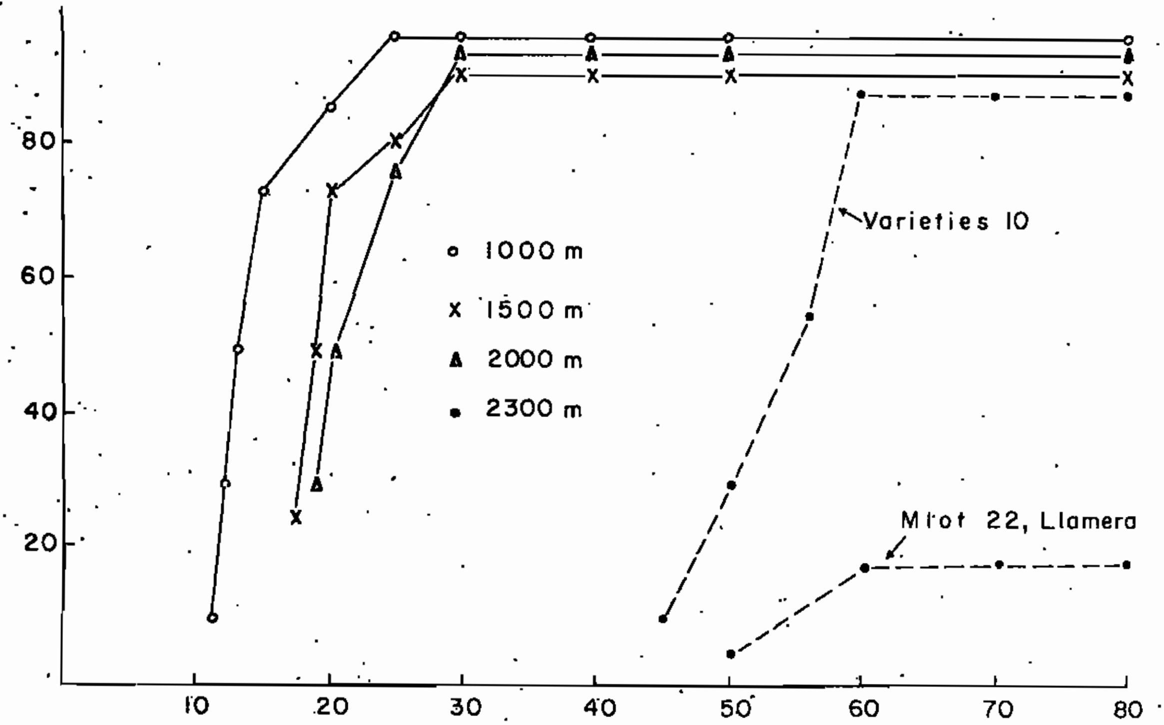


Fig. 2. Germination of twelve cassava varieties at different altitudes

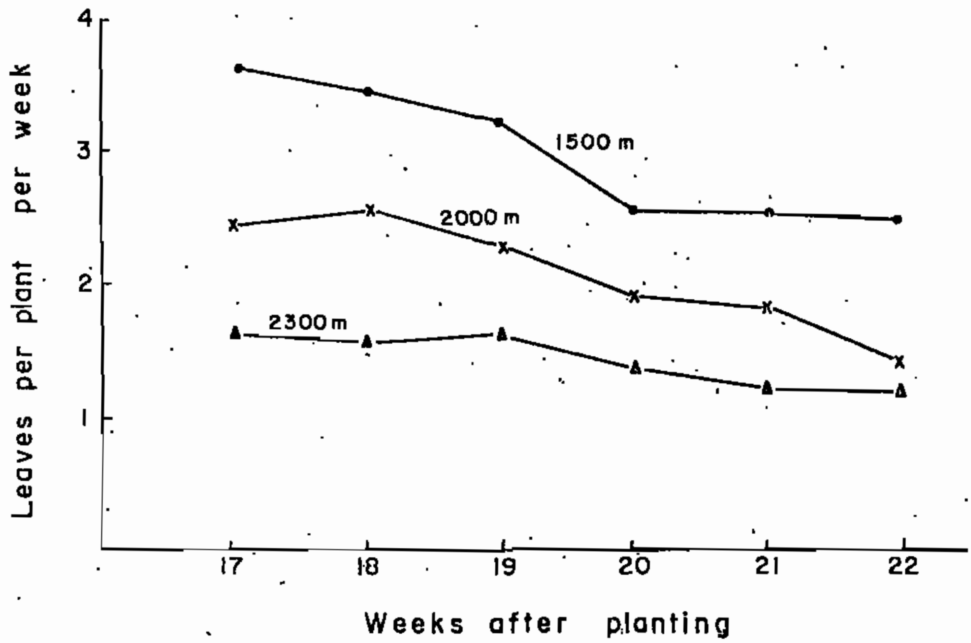


Fig. 3. Effect of temperature on rate of leaf production (mean of twelve varieties)

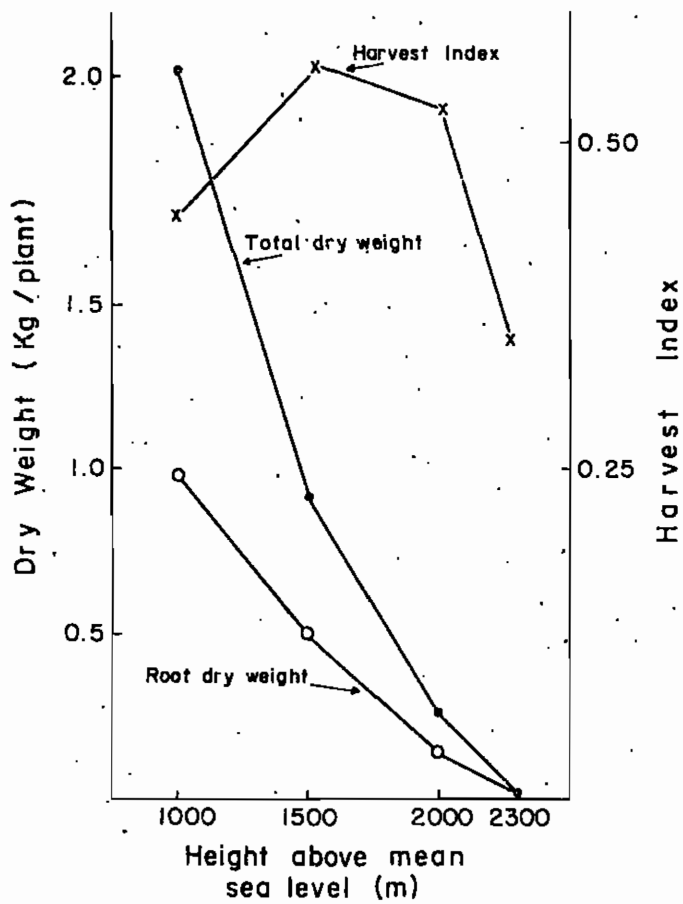


Fig. 4. Changes in plant weight, root yield and harvest index with altitude (mean of 12 varieties).

has frequently been suggested that lack of leaf area limits cassava productivity (Sinha and Nair 1971, Doku, 1965). In this trial, the rate of leaf production was much lower at lower temperatures, and visual observation showed that the plants at higher altitudes had much lower leaf area indices. Unfortunately, we have no data on cassava growth below 1.000 m, however, it seems likely that cassava as a crop, has very limited potential in areas with mean temperatures below 20ºC and for optimal growth mean temperatures of 25ºC or greater are required. The critical periods in the growth cycle when low temperature decreases yield are not known.

In certain area with very low night temperatures, Phoma leaf spot becomes very severe, causing defoliation and dieback of the shoots, leading to extremely low productivity (Lozano, pers.comm., CIAT 1973).

Photoperiod

Bolhuis (1966), Nair and Sinha, (1968) have all reported deleterious effects of long days on root production in cassava. Similarly, Lowe (pers. comm.) using growth rooms in Guelph Canada showed a marked reduction in thick root yield when cassava was grown under 14 or 20 hour days as compared with an 8 hour treatment. Unfortunately, all these trials were done under greenhouse or growth room conditions and plants were harvested very young.

At CIAT, 12 cassava varieties were planted at varying distances from an incandescent light source of 15 hour days and harvested 4 and 9 months after planting. After four months growth no effects of the 15 hour day could be seen, however, by 9 months after planting there were marked effects. Total plant production was not changed (Fig. 5) but root yield decreased under long days (Rosas and Cock, unpublished).

The long photoperiod had no effect on flower initiation but reduced abortion of fruits in some varieties and increased it in others. At CIAT, removal of flowers had no effect on yield.

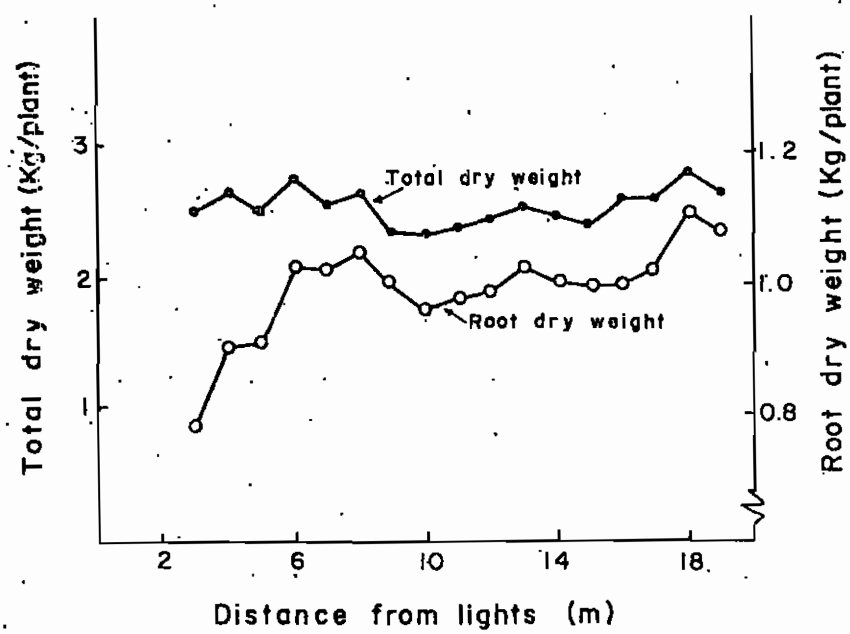


Fig. 5. Total dry weight per plant and root dry weight per plant as influenced by long days (means of 12 varieties harvested 9 months after planting.

Radiation

In general, crop growth rates increase as solar radiation increases Shading was used to decrease radiation receipt of a cassava crop and crop growth rate was markedly decreased (Fig. 6).. However, not only did shading decrease the crop growth rate but also the proportion of dry matter distributed to the roots. Of the newly formed dry matter of cassava under 50% shade during the period 5-10 months after planting only 40% was found in the roots as opposed to 58% in control plants. Shading increased stem elongation and internode weight and little excess carbohydrate was available for root expansion. Shading also decreases leaf life in cassava (CIAT, 1973) resulting in lower leaf area indices. Hence, low radiation levels have very deleterious effects on cassava gorwth; they reduce crop growth rate due to decreased leaf area index whilst low radiation *per se* decreases crop growth rates and also lowers the proportion of assimilate moving to the roots.

The critical times when low radiation may have its most serious effects on yield have not yet been studied.

Moisture

Cassava is generally considered as a relatively drought tolerant crop and is frequently grown in low rainfall areas. For example, cassava is a major crop in areas of Pernambuco, Brazil where rainfall is less than 600 mm per year. We recorded a yield of more than 40 t/ha in one year with less than 1.000 mm of rain with a very free draining soil.

Cassava needs adequate rainfall in the established phase, however, one established it can survive a dry period. During dry periods the leaves abscise and growth stops. At the onset of the rains root reserves are mobilizes and a new leaf canopy is formed (Cours, 1951). Nevertheless production is lower when the plant undergoes water stress.

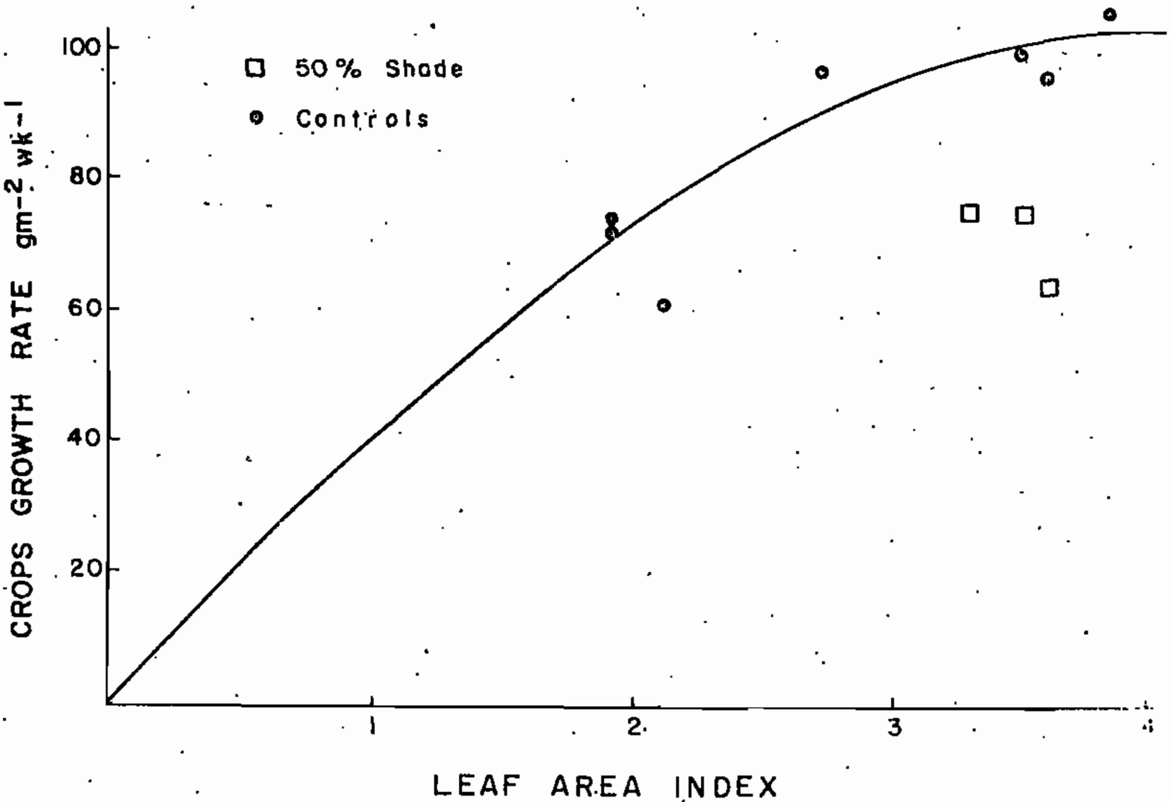


Fig. 6. Crop growth rate of cassava three to five months old of shaded and unshaded plants.

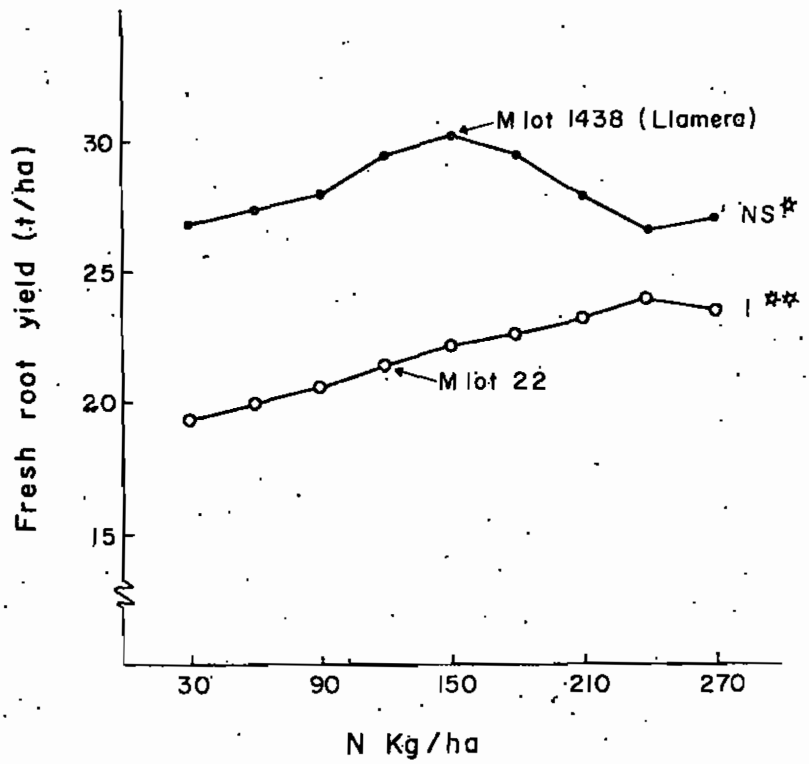
There is little published in.ormation on the response of cassava to irrigation. Smith (1968) u ed different intervals between irrigations and found that yields increased as frequently of irrigation was increased to 15-30 day intervals, however, more frequent irrigations depressed yield. Similarly Sena and Campo (1973) found that irrigating every ten days produced less yield than every 14 days. Part of this yield decline may have been due to increased root rotting. However, it is highly possible that it was associated with excessive foliage production.

In one trial at CIAT the apex was repeatedly cut to reduce foliage production during the period 5-10 months after planting. This treatment increased yields five months after planting due to more favourable dry matter distribution, but by ten months yield was less than that of controls due to very low leaf area index. The authors feel that irrigation may in certain cases lead to excessive leaf production leaving little excess carbohydrate for root growth.

Soil Fertility

At CIAT on fertile soils at an altitude of 1.000 m the variety M Colombia 22 consistently outyields Llanera. When the same two varieties were planted at La Zapata, a nearby farm 1.100 meters above sea level, which has much lower inherent fertility Llanera consistently outyielded M Colombia 22. However, when a basal dose of 100 kg/ha of P_2O_5 and K_2O were applied and various nitrogen treatments superimposed the difference in yield decreased markedly as nitrogen level increased (Fig. 7). Thus it appears that strong varietal differences in adaptability to fertility differences exist.

Cassava is generally grown on lower fertility soils. In La Zapata Llanera showed little response to NP (Toro pers. comm.) when in nearby fields Phaseolous beans showed a marked response. However, on less fertile soils it shows marked fertilizer response.



* NS = no significant differences between N levels at 5 %
** LSD = using BET at 5 %

Fig. 7. Yield of two varieties at different Nitrogen levels 11 months after planting, La Zapata.

Summary

Cassava is a high yielding crop well adapted to areas of the tropics with low uncertain rainfall with mean temperatures above 20°C. It has the ability to grow on very acid soils where few other crops will grow at all, however, highest yields are obtained under more fertile conditions. It will not tolerate excessive moisture in the soil which leads to root roots and lower yields. It responds well to the high radiation levels likely to be found in the drier tropical regions. Where long days are encountered yields will decline slightly.

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