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A GUIDE TO AMARANTH GRAIN CULTIVATION – SUMMARY OF EXPERIENCES AT THE INCAP EXPERIMENTAL FARM

The present report constitutes a guide to amaranth cultivation, as conducted at the INCAP Experimental Farm during the last six growing seasons.

Information on the INCAP Experimental Farm

The Experimental Farm is located in the village of Pachalí, municipality of San Juan Sacatepéquez, Department of Guatemala, at a distance of 41 km from Guatemala City. At an altitude of 1,570 meters above sea level, 14°43' latitude, and 90°31' longitude, its topography is representative of the Guatemalan highlands, with heavy clay soils. The last 20-years precipitation fluctuates between 114-119 cm, with rainfalls from June to the end of October, and a temperature fluctuating between 14° and 28°C. The cooler temperatures are from December to February.

Land Preparation

Before applying the seed into the soil, the land is plowed and harrowed, so as to decrease as much as possible soil lumps of clods, quite common in heavy clay soils. This practice is essential because of the small size of amaranth grain. Application of 17 MT/ha of manure is highly recommended particularly for soils continuously used for grain production, bearing in mind that manure has to be well incorporated into the soil. The best soils for this crop are friable, porous soils, with medium to high fertility and with a 2.5% slope for drainage, since amaranth does not tolerate excessive water accumulation. Because of its relative high grain yields, it is essential that soil contain a high organic matter level as a base. In marginal lands, or lands of low fertility, the amaranth plant does not grow satisfactorily.

Water Needs Through Rainfall

The best yield performance has been obtained with moderate rainfall, well distributed throughout the vegetative growth and development of the plant. It is recommended not to plant amaranth unless 140-150 mm of rainfall has fallen, and continue to fall along the growing period. From planting, to harvest, total rainfall is around 1,125 mm. The experience at the farm indicated that soybeans, maize, common beans and a few green vegetables are more resistant to drought than amaranth. This was quite evident during the 1986 growing season, characterized by irregular periods of rainfall.

Planting Date

Amaranth is photosensitive and, thus, is susceptible to the number of light hours it needs for developing and producing seed. The evidence available at the farm is that June is the best month. Day length in Guatemala from March to September is from 13.5 to 14 hours and from October to February, day length is significantly shorter (11 to 11.5 hours) with cooler temperatures. The best planting date is in June, from the 15th to the end of the month.

Planting System

The amount of seed needed is 5 kg/ha, applied on the furrow continuously on heavy clay soils. The seed is treated with a fungicide (50% CAPTAN) before planting because of the susceptibility of the plant to damping off (*Pythium* spp). Germination percentage runs between 70-80%. The seed is deposited 2.5 cm deep in the furrow, at a distance of one meter between furrows. It will germinate approximately six days after planting.

Distances Between Plants and Furrows

During the first few days after emergence, the amaranth plant is very frail, and because of this and the heavy seed application, there is need to thin out by hand. The first thinning out is conducted when the plant is 3 cm high or about 12 days after planting. The distance between plants at this moment is about 2.5 cm. About 10 days later the plants have reached 12 cm in height, and the second thinning out is then conducted, leaving about 7.5 cm between plants. The third and last thinning out is carried out 15 days after the second thinning out, at which moment plants have reached 30 cm in height; distance between plants at this time is around 25 cm. These cultural practices are necessary to obtain reasonable yields. After six years of experience, we may state that the 25 cm distance between plants, in the furrow, with one meter between furrows, it the best recommendation. This will give a population plant density of between 76,960 and 77,400 plants per ha.

During thinning out, weeds are also removed, particularly when the plants reach 10-12 cm in height. The removal involves hand labor since up to now, a herbicide is not available.

Fertilizer Application

About 40 days after planting and when the plants have reached 30 cm in height, the first fertilizer application is done under the conditions of the Experimental Farm. Plants are fertilized with 252 kg/ha of a 12-24-12 formulation. This is applied along the side of the furrow, at a distance of 16 cm from the plants.

Around 15 days later, a second application of fertilizer is carried out as before, using the same formulation and applying 400 kg/ha. At this time the plant has reached 60 cm in height. When this is done, the base of the plants is covered with soil which helps to keep them erect, and weeds are eliminated.

Flowering

With most cultivars planted at the farm, flowering has occurred at 60-65 days after planting.

Harvest

1. *General*

The vegetative cycle takes from 105 to 120 days from the planting date. Most cultivars reach 1.60 m in height and, on the average, 0.40 correspond to the inflorescence, containing the grain. Harvest time is indicated by the plant itself, by the ease with which seeds are removed by rubbing the flower between the hands. The inflorescence usually weighs around 0.5 kg, of which around 76°/o is the inflorescence with all its vegetative parts, and 24°/o is grain. The 76°/o of the inflorescence weight is readily consumed by cattle in large amounts and no toxic effects have been observed. Consumption has been as high as 32-36 kg/cow/day. Calves start consuming this by-product when they are 1.5 - 2 months of age. Curiously, purple-color amaranth is not accepted by cattle. Because of the large amounts available during harvest, the by-product has been stored as silage.

2. *Inflorescence Removal*

The flowers are removed by hand labor using knives, and when there is sufficient sunlight, so as to have inflorescences with somewhat less moisture. At harvest time, the inflorescence's moisture content is around 82 - 90°/o, and the moisture of the grain, 52°/o.

3. *Threshing*

A thresher is used, as by-hand labor harvest is slow and costly. Since the flower is still moist, the inflorescence is threshed twice for the purpose of obtaining most of the grain. The residue is further processed with a metal screen with very small holes so as to separate the small grain from the vegetative parts of the flower. The thresher removes around 75°/o of the grain, and the other 25°/o is obtained from screening. The thresher used is Bill's Welding Inc. (S.700 Gran Ave. Pullman, Washington, US 99163).

4. *Drying and Cleaning*

Once the grain has been obtained, it is exposed to solar radiation in thin layers for about 12 hours, to decrease moisture content from 52 to 14 - 16°/o. At this moisture, the grain is cleaned by air blowing, thus removing about 1°/o of material, named flower calix, which has been used as an ingredient of broilers feed.

5. *Storage*

After grain cleaning the seed is placed in bags made from cloth, and stored under dry conditions where it keeps well.

6. *Yield*

During a 6-year period a total of 88 cultivars have been tested for adaptability at the Farm. These correspond to 34 materials from Guatemala, 29 cultivars from the Rodale Experimental Station, and 25 from Peru. In each cycle the best adapted cultivars have been selected; these, together with the average yield obtained, are shown below.

Diseases

The main problem has been damping-off, caused by *Pythium spp.*, particularly in heavy clay soils with poor drainage. Cultivars from Peru are not well adapted to the environmental conditions prevailing at the Experimental Farm, and when flowering starts, they are attacked by *Sclerotium Rolfsii* at the base of the stalk. This disease is characterized by a dark spot, watery in nature, that bends the plant causing heavy grain losses.

Insects

Soil insects such as *Lachnosterna arcuata* induce heavy

Table 1. — Best adapted amaranth cultivars and average yields obtained at the INCAP Experimental Farm

INCAP Farm No.	Cultivar	Species	Origin	Yield, kg/ha
7-USA	82S-1011	*A. cruentus*	Mexico	2031
10-USA	82S-1023	*A. hypochondriacus*	Mexico	2769
20-USA	84S-1157	*A. cruentus*	Rodale	3883
26-USA	84S-K-277	*A. cruentus*	Rodale	3664
28-USA	—	*A. hypochondriacus*	Rodale	3647
29-USA	—	*A. cruentus*	Rodale	3744
17-GUA	17-GUA	*A. cruentus*	Guatemala	3537
34-GUA	34-GUA	*A. hypochondriacus*	Guatemala	2191

losses. When plants are very young, they are attacked by insects, which also attack *Phaseolus vulgaris*.

Table 2. — Summary of production costs based on 1 ha of land, with a yield of 3,600 kg/ha

1.	Hand labor (5) (5 months)	Q3,000.00
2.	Operational costs at harvest	122.00
3.	Supplies - organic and chemical fertilizers, other chemicals	820.79
	Total	Q3,942.79
		US$ 1,577.16

Cost per kg: US$ 0.438 = Q 1.095.

Local Production Costs

On the basis of all the labor expenditures as well as cultural practices, the present cost of local production is Q1.09 per kg (US$ 0.43/kg), a detail of which is shown in the Table 2.

These costs are high. The authors, therefore, believe efforts should be done to reduce those associated with the planting practices followed in the establishment of the crop.

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PHYSIOLOGY

GROWTH ANALYSIS OF TWO *Amaranthus* SPECIES

Introduction

At present, cultivation of various *Amaranthus* species is acquiring increasing importance in some countries of the American Continent, due, among other factors to: its double-use potential (as vegetable and as grain); its excellent quality protein; tolerance of the plants to water scarcity, and high photosynthetic efficiency in climates with good luminosity (they are C4 species). The objective of the study herein described was to analyze, under field conditions, the growth and yield potential of several *A. cruentus* genotypes, and two *A. caudatus* genotypes.

Literature Review

Olufolake and Tayo, in their studies on amaranth, found that three *A. cruentus* cultivars did not present differences in regard to plant height, foliar areas, number of leaves and number of branches per plant; furthermore, the three cultivars reached the maximum value of foliar area (350 cm^2 /average of 20 leaves) at 11 weeks (1). On the other hand, Pandey (2) working with six parental lines and 30 segregating populations of *A. hypochondriacus*, found a positive and significant correlation between grain yield and plant height, days to flowering, days to harvest, and harvest index. From the nutritional analysis of the areal biomass, Olufolake and Tayo also observed that the nitrogen content decreased from 3.4o/o at five weeks, to 0.5o/o at 13 weeks of planting (1). Furthermore, Medina (3) in his research work with *A. hypochondriacus* (whole plant), found 3.29, 2.50, 1.59 and 0.97o/o nitrogen at 70, 90, 110 and 154 days, respectively. As far as grain yield is concerned, very variable data have been determined, as follows: 2 to 3 mt/ha (4); 0.4 to 3.5 mt/ha (5), and 387 to 4,409 kg/ha (3).

Material and Methods

The work was carried out at the Tropical Agronomic Center for Research and Training (Centro Agronómico Tropical de Investigaciones y Enseñanza) (CATIE), Turrialba, Costa Rica, at 600 m altitude, with an average temperature of 21oC, 479 mm rainfall during the cycle, 88o/o average relative humidity, and 12.740 cal/cm^2 /month average solar radiation. Seeds of four genotypes were used: G1 and G2 of *A. cruentus*, and G3 and G4 of *A. caudatus*, originating at the Germ Plasm Bank of INIAP, Ecuador. Samplings were done 25, 40, 60 and 75 days from the planting date, to harvest. The experimental unit consisted for a 6.3 m^2 lot, and each sampling of four plants randomly taken and in perfect competence. Evaluation was done on the basis of some agronomic variables and several growth indexes.

Results and Discussion

Table 1 shows the average values for genotypes and by sampling periods in regard to plant height, stem diameter, length of sheaf, foliar area, total dry biomass and nitrogen content of the whole plant. The main growth indexes values for genotypes, by sampling periods, are presented in Table 2 while the harvest indexes values (K), that is, the grain proportion in relation to the total biomass production and the energy efficiency (EE), i.e., the solar energy percentage (photosynthetically active radiation) that the plant transformed in chemical energy, are detailed in Table 3.

In agreement with biomass production and with nitrogen concentration of same (Table 1), the four genotypes evaluated constitute a vegetable production alternative. In general, biomass yields were far superior to those found by other