

ANDEAN GRAIN CROP INTRODUCTION TO THE BRAZILIAN SAVANNAH

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Abstract

Agricultural history of the Brazilian savannah dates back 150 years, beginning with extensive cattle ranching on native grassland, eventually developing into a rice-pasture system, followed by today's modern grain production on 10 million ha. For the past 20 years the cropping system has been soybean and maize in the rainy season, with little agricultural activity during the long dry season. A recent trend toward growing crops as a source of mulch has been limited to a few species of two botanical families: *Gramineae* such as maize, millet, and sorghum; and *Leguminosae* such as soybean. Such highly specialized monocrop systems, which are becoming common in Brazil, threaten the sustainability of the region, because of increased pests, diseases and weeds problems, loss of soil organic matter content due to excessive soil preparation, nutrient loss, soil compaction and erosion, increased production cost due to excessive/unbalanced use of fertilizers and pesticides, yield reduction, and negative environmental impacts.

Introduction of new crops is essential to improve the sustainability of the system, serving as break-crops to increase soil fertility and provide additional income to farmers. The selection criteria for new species are drought resistance, rapid growth, nutrient improvement, and diversified uses. Two species that meet these characteristics are the Andean grain crops quinoa (*Chenopodium quinoa* Willd.) and amaranth (*Amaranthus* spp.). They are characterized by a high quality protein and a high vitamin and mineral content.

Introduction

The Brazilian savannah is facing increasing problems with erosion and nutritional imbalance caused by inappropriate crop and soil management after 20 years of modern production of soybean and maize in the rainy season, with little agricultural activity during the long dry season (Spehar, 1996; Matson et al., 1997). These problems have increased the interest for a no-tillage system, dependent on mulch production (Spehar and Landers, 1997).

Experiments with quinoa have been conducted in Brazil since 1987, with locally selected genotypes originating from hybrid populations (Spehar and Souza, 1993; Santos, 1996). More recent work has included species of grain amaranth (*Amaranthus caudatus*, *A. hypocondriacus*,

A. cruentus, and *A. hybridus*). A remarkable characteristic of these crops is the nutrient value of the protein in the seed (Cardozo and Bateman, 1961; Negron et al., 1976), which may be of particular importance for the savannah grain production system, relying partly on processing raw material at the community level and on an industrial scale in the region (Spehar, 1996).

Amaranth is photoperiod sensitive and is classified as a short daylength plant, whereas quinoa may be short daylength sensitive or daylength insensitive. There are less sensitive species of amaranth (*A. hypocondriacus* and *A. cruentus*) that perform well under the short days of autumn sowing in the savannah region (Spehar, unpublished data). Varietal response has been detected for flowering and maturity under different temperature and daylength regimes. The onset of flowering, however, did not vary between early and late maturity types (Santos, 1996) as it did in European experiments (Jacobsen, 1997).

Quinoa is yet not cultivated in Brazil, although preliminary data on its agronomic performance conducted in the savannahs of the Central Plateaux show its potential (Spehar and Souza, 1993), so this study was undertaken to identify quinoa and amaranth genotypes less sensitive to daylength and temperature, and to adapt the crop to various sowing dates in a double-cropping system in the low altitude savannah. Germplasm selection and evaluation has been done to identify saponin-free varieties with high grain and biomass yield, and other suitable agronomic characters for crop adapting to modern grain production systems.

Materials and methods

Quinoa

Breeding Procedure

Progenies originating from seeds of Bolivian, Chilean and Peruvian material in Cambridge, England, were grown in the dry season (winter), in Planaltina, DF, Brazil, the core area of the savannah region (1000 masl; 15° S latitude). Late individuals with reduced branching and compact panicles were selected from the varieties Amarilla de Marangani, Chewecca, Kancolla, Real, Salares-roja, and Blanca de Junín. Their respective progenies were grown in individual plots. Selection was carried out during five growth cycles within plots to select breeding lines, which were given the identification Q1, Q2, etc. The method used was a modified pedigree, allowing some variability among lines of the same cycle, without attempting to generate more uniform lines with undesirable effects of inbreeding, except for plant height (PH), days to maturity or growth period (GP), stem diameter (SD), plant color, and inflorescence type. Almost all selected lines had amarantiform inflorescences, either lax or compact, although the glomerulate type also exists. Dry matter yield (DM) and grain yield (GY) were determined. Additional germplasm introduction has taken place more recently from the USA, Europe, and the Andean region. The same procedure of selecting panicles within populations has been used and new breeders lines have been generated. The new lines underwent preliminary tests in Planaltina, DF.

Agronomic Evaluation

The selected lines were tested in a randomized complete block design. The same genotypes were sown in Planaltina and in Rio Verde (700 masl; 18° S latitude) in the summer (wet season, October-February), autumn (with and without supplemental irrigation, February-April), and winter (dry season under irrigation, May-September). The lines were characterized for days to first flower, days to maturity, plant height, inflorescence type and size, stem and peduncle color, seed production, seed size, seed quality, and saponin content. Data reported here are from lines further selected from available germplasm (Spehar and Souza, 1993). This paper presents data primarily on winter cultivation, from sowing on 26 June, 1995.

Amaranth

The experiments with amaranth began in 1996 with germplasm introduced from the USA. Accessions of *A. cruentus*, *A. hypocondriacus*, *A. hybridus*, and *A. caudatus* have been selected and tested. They were evaluated for days to maturity, plant height, inflorescence length and diameter, stem diameter, dry matter production, and grain yield. The experimental design was similar to the one used for quinoa. Variability within accessions has been observed, and segregants have been individually selected for progeny tests.

Results and discussion

Highest grain yield of the 17 genotypes tested was 2.4 t/ha and maximum biomass production 6.4 t/ha. The total growth cycle for the genotypes varied between 112 and 143 days, shorter than that normally observed in the Andes. When sown in autumn the same genotypes had a shorter growth period of only 85-130 days. The data indicated that the quinoa genotypes selected at the savannah responded to daylength and temperature. Plants were smaller and had a longer growth period when temperature decreased and days became shorter in winter, which is consistent with results from the Andean region (Espíndola and Gandarillas, 1986). The large day-night temperature range in the winter dry season may have contributed to extending the growth period. The mean temperature in the Andes is much lower than on the savannah, which explains the slower plant development there.

Correlation coefficients for a number of characters showed that the length of the growth period was positively correlated to GY and PH. Late genotypes grew taller and were superior in grain yield. GY was positively correlated to GP, PH and DM, which was not true for HI, where late varieties with low HI and early varieties with higher HI could be found (Fig.1). Usually in specialized crops produced commercially (e.g. soybean), HI is high in comparison to less specialized, multipurpose crops, used for forage, grain, and mulch, bred for low-input systems, as seen for at least some of the quinoa cultivars (Spehar et al., 1997). Thus, it is possible to develop crops such as quinoa to high grain, high biomass or both grain and biomass production to satisfy different production systems.

Grain yield for the best quinoa lines across experiments was 1.8 t/ha for summer, 1.3 t/ha for nonirrigated autumn sowings, 2.6 t/ha for irrigated autumn sowings, and 3.0 t/ha for winter sowings. These results confirmed previously results at the Brazilian savannah, and are higher than the yield at the Altiplano of the Andes. High yields, however, have been obtained in other environments with selected genotypes (Risi, 1986; Jacobsen and Stølen, 1993; Jacobsen et al., 1994). In addition, stability of various quantitative traits is encouraging for crop improvement (Jacobsen et al., 1996). This evidence for crop adaptation increases the prospects for including quinoa in rotation/double-cropping systems on the savannah. The preliminary experiments with grain amaranth accessions have shown promising GY of 3.5 t/ha and DM yield of 7.0 t/ha for the best performer.

Conclusion

1. Quinoa and amaranth have an exceptionally high nutritive value, and in addition quinoa has high drought resistance.
2. Quinoa and amaranth may contribute to improving the diet of low income populations, and raise their standard of living.
3. The high quality protein may be a key factor for the agroindustry in the cattle, cow and chicken production.
4. Preliminary seed yields are encouraging, and selection will be continued to attain saponin-free quinoa.

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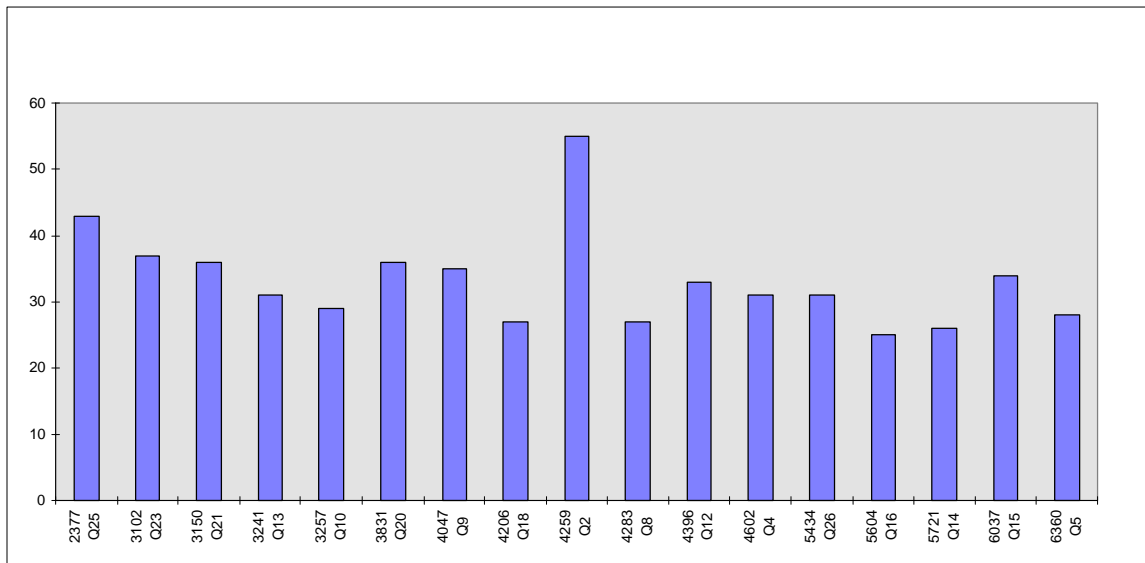


Figure 1. Harvest Index (Grain Yield/Dry Matter x 100) and dry matter production (kg/ha) of 17 quinoa varieties selected in the Brazilian savannah, Planaltina, DF, dry season 1995.