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A proposal for a working group on acid soil tolerance in grain legumes *

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Abstract

Grain legumes are an important source of protein in the diets of humans and livestock, as well as being components of sustainable cropping systems. Poor productivity of legumes on acid soils is a major problem globally. The severity of damage depends on the soil characteristics and sensitivity of plant species. There has been substantial research into and increased understanding of crop management on acid soils, but little progress has been made in characterising genetic variability in grain legume crops in response to acid soil conditions. We propose to explore such genetic variability, primarily for groundnut but also for other grain legumes depending on the interest expressed by potential cooperators. We propose to address this objective by initiating a working group, to integrate global efforts in screening genotypes of grain legumes for tolerance to acid soils. We would like to involve scientists from countries where acid soils are a major constraint, to establish appropriate field screening facilities. We are also seeking support of national and international organisations conducting research on acid soils. We believe that this approach would contribute to development of acid tolerant genotypes, leading to sustainable grain legume production and sustainable cropping systems on acid soils.

Introduction

Grain legumes are an important source of high quality protein: they are relatively cheap and diversify the human diet. Grain legume crops are particularly important for marginal and resource-poor farmers in developing countries to supplement their family diet and as animal feed and fodder. Grain legumes are important components of sustainable cropping systems due to their long-term beneficial effects such as symbiotic nitrogen fixation, improvement of soil properties and breaking of pest and disease cycles (Hoshikawa, 1991). Continued increase in population in the developing world will demand expansion of cropping to marginal and difficult soils, including acid soils, which constitute about 38% of the world's arable lands (IBSRAM, 1987). The poor productivity of crops in general, and legumes in particular, on acid soils is a significant problem. The main limiting factor for crop growth in the acid soil is aluminium toxicity (Fageria et al., 1988; Foy et al., 1978). In addition to aluminium toxicity, a number of associated factors such as manganese toxicity and elemental deficiencies of phosphorus, calcium, magnesium and molybdenum also are responsible for poor crop growth on acid soils (Wright, 1989).

There has been substantial research on management of acid soils compared to genetic improvement of crop species for adaptation to acid soils. Although application of lime in large quantities can alleviate acid soil problems, it is expensive and can only ameliorate the topsoil, resulting in shallow root systems and consequent drought susceptibility. By selection of crops and genotypes tolerant to acid soil, it should be possible to obtain reasonable yields with a minimum of management inputs. Howeler (1987) has shown that tolerance to Al toxicity is a major cause of the large variation between crop species in acid soil conditions. Genotypic differences within crop species for Al tolerance have been shown for sorghum (CIAT, 1987), wheat (Aniol, 1983; Rincon and Gonzales, 1992), barley (Foy et al., 1967), snapbeans (Foy et al., 1972), and *Phaseolus*

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(Cumming et al., 1992). Little progress has been made to date in exploiting genetic variability in grain legume crops such as groundnut, pigeonpea and chickpea for their adaptation to soil acidity. This is because of lack of adequate information on the extent of genotypic variability for acid soil tolerance. In limited work done on groundnut, genotypic variation in acid soil tolerance has been shown (Gani et al., 1992). It is however, recognised that genetic improvement alone cannot be expected to substantially overcome acid soil limitations but only to improve crop production potential to some extent on particular acid soils. Genetic improvement should complement management improvement efforts to alleviate acid soil effects on crop production.

We propose to explore genetic variability for acid soil tolerance in some of the most important grain legume crops, in the first instance for groundnut, but for other legumes at a later stage, by initiating a Working Group (WG) involving scientists from the National Agricultural Research Systems (NARS) of countries where acid soil is a constraint for growing legume crops. We believe that this approach can contribute to sustainable grain legume production in acid soils.

Objectives

The overall goal is to establish and coordinate a WG to integrate global research efforts on acid soil tolerance in grain legumes. Specific objectives are to:

- establish a database of institutions and researchers interested in acid soil tolerance,
- organise collaborative research to screen for acid soil tolerant grain legume genotypes and symbioses with strains of *Rhizobium*,
- stimulate strategic research at selected centres to understand mechanisms of acid soil tolerance applicable to grain legumes,
- facilitate exchange of germplasm and information on acid soil tolerance in grain legume crops and
- solicit funding to support the above activities.

Methodology

- Initially, selected groundnut germplasm will be evaluated in screening nurseries for acid soil tolerance at selected sites in cooperation with NARS. Germplasm of other grain legumes will also be evaluated later depending on priorities expressed by group members.

- Each site will be characterised so as to identify the particular soil limitation(s) to which a genotype, including its symbiotic association, is tolerant or susceptible. This information will be related to geographic distribution of acid soil problems.

- Planning and review meetings will be conducted on a regular basis involving resource persons and working group members to review the results and develop technical work plans.

- Strategic research will be encouraged at selected centre(s) to develop reliable screening technologies to identify legume genotypes and symbioses with *Rhizobium* tolerant to acid soils.

Structure and operation of the working group

The Coordinating Unit (CU) identified by the WG members, and located in one of the regional or international institutes, would facilitate coordination of the acid soil research activities. A Technical Coordinator (TC) nominated by the WG members, will liaise with resource persons and WG members to plan and facilitate research. The TC will also provide technical support to the WG.

Partners in the working group

To the present, the following national programs and international / regional institutes / organisations have expressed their interest to join the working group.

National programs

Central Research Institute for Food Crops (CRIFC), Bogor, Indonesia. Centre for Soil and Agroclimatic Research (CSAR), Bogor, Indonesia. Field Crops Research Institute (FCRI), Bangkok, Thailand. National Research Centre for Groundnut (NRCG), Junagadh, India. Philippine Council for Agriculture, Forestry, and Natural Resources Research and Development (PCARRD), Los Baños, Philippines. Institute of Agricultural Research (IAR), Addis Ababa, Ethiopia. University of Queensland (UQ), Brisbane, Australia.

Regional/international institutes

Australian Centre for International Agricultural Research (ACIAR), Canberra, Australia. International Bureau of Soil Research and Management (IBSRAM), Bangkok, Thailand. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, India. The Soil Management Collaborative Research Support Program (North Carolina State Univ.), Raleigh, USA. University of Hawaii at Manoa (TROPSOIL and IBSNAT), Hawaii, USA.

Expected outputs and impact

- Development of appropriate field and controlled environment screening techniques for the test legumes and the different acid soil syndromes.
- Assessment of yield losses and the extent of variability in germplasm of grain legume crops for adaptation to acid soils and thus the extent to which this variability can be exploited by genotype selection and plant breeding.
- Strengthen expertise and self reliance in conduct of acid soil tolerance research among scientists in NARS.
- Generation of knowledge on mechanisms of acid soil tolerance in grain legumes.
- Enhancement and stabilisation of grain legume production under particular acid soil conditions.

Time frame

It is expected that comprehensive data on site characterisation would be available, and appropriate screening techniques developed, after two years of concerted effort. Assessment of extent of genotypic variation in target species would require a further 1–2 years. By this time expertise of NARS scientists involved in this activity should be considerably enhanced. Understanding of mechanisms of tolerance, which should further enhance screening capabilities is a long term process and may take more than four years before useful insights are developed. If a breeding program is required to combine acid soil tolerance traits with other desirable plant characteristics then a 10-year time frame needs to be considered, depending on the breeding methodology applicable to the particular target legume. However, acid tolerant selections with otherwise suitable plant characteristics would be available for multilocation testing as soon as they are identified. In this case, impact, in terms of regional production increases, due to use of varieties with enhanced acid soil tolerance, may be visible before the turn of the century.

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