RESEARCH PROGRAM ON Grain Legumes

CGIAR

Water use in bean and cowpea: efficiency or effective use of water?

ABSTRACT:

Water stress is one of the major abiotic stress limitations for grain legume production in smallholder agricultural systems. Phenotypic characterization of water consumption by different species of legumes and genotypes within them plays a key role in adaptation to drought. Dynamics of water use may differ depending on the origin and evolution of the species of legume and the agro-climatic conditions faced by the legumes. The supply of nitrogen from symbiotic fixation is also critical for filling seeds and is even more limiting than water in bean, but not in cowpea.

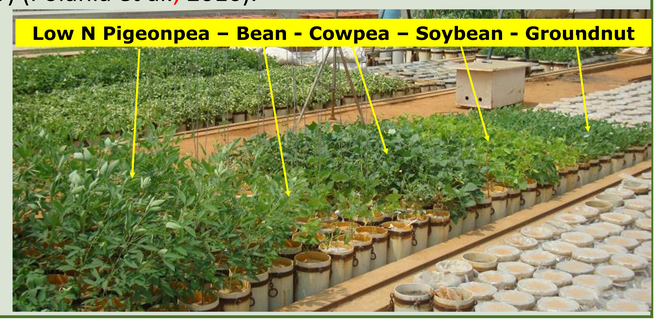
INTRODUCTION

- **Common bean and Cowpea are two major food legumes cultivated by small farmers in Latin America and Africa, where unfavorable climatic conditions and minimum use of inputs frequently limit productivity.**
- **The development of bean varieties adapted to water stress conditions through breeding is a useful strategy to ensure food security in marginal areas.**
- **Water use efficiency (WUE) is defined as "more crop per drop", while effective use of water (EUW) implies maximal soil moisture capture for transpiration (Blum 2009).**
- **Bean and cowpea fix N symbiotically and cowpea is known for fixing a larger proportion of its N needs than bean (Peoples et al., 2009; Sinclair and Vadez, 2012). Here the extent of N and water limitation is tested in these two legume crops.**

MATERIALS AND METHODS

- **Field trials in common bean:** Two field trials were conducted during the dry season (June to September in each year of 2012 and 2013), at the main experimental station of CIAT. The trial included 36 Mesoamerican genotypes. A partially balanced lattice design with 3 replicates was used. Two levels of water supply (irrigated and rainfed) were applied. Stomatal conductance and canopy biomass were measured at mid-pod filling. At the time of harvest, grain yield, yield components and carbon isotope discrimination (CID) were determined. CID in grain is shown to be related with whole plant water use efficiency (WUE) and effective use of water (EUW) (Polania et al., 2016).

- **Lysimeter trials in common bean and cowpea:** 16 lines of common bean and 25 lines of cowpea were grown in 1.2m deep and 20-cm diameter PVC tubes filled with Alfisol, in a factorial of N and water treatment (low/high N – WW/WS).
- The picture on the right represents a similar trial carried out with additional legume species and showing the experimental setup.



RESULTS

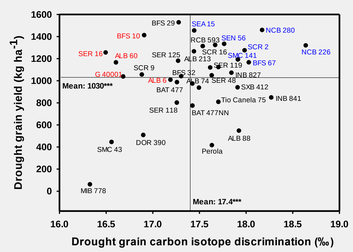
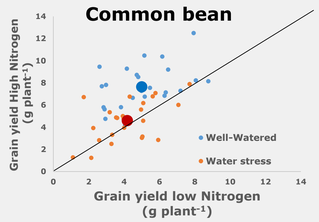
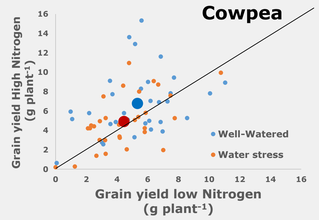


Figure 1. Identification of bean genotypes with greater values of grain yield combined with low or high water use based on carbon isotope discrimination (CID) under drought conditions in a Mollisol at Palmira, Colombia. Genotypes with efficiency in water use – water savers (red) and genotypes with effective use of water – water spenders (blue) are highlighted.

Field trials in Common bean: Under drought stress, leaf stomatal conductance presented a significant positive correlation with grain yield (GY) (r=0.31***). Grain CID showed a positive and significant correlation with GY under rainfed (r=0.36***). Results from two field trials on stomatal conductance and grain CID showed that many of the higher yielding bean genotypes under drought stress are using more water, with better plant growth and biomass partitioning, through Effective Use of Water (Fig. 1). Results also revealed a few genotypes that are combining higher values of Water Use Efficiency with better GY under rainfed conditions, classified as water savers, such as BFS 29, SER 16, ALB 6, ALB 60 and *P. acutifolius* (G 40001)(Fig. 1).





Lysimetric trials in common bean and cowpea: Relationship between the seed yield in low N conditions and seed yield in high N conditions across water regimes (well-watered and water stress) in 16 common bean and 25 cowpea genotypes. Line is y = x.

- Water stress reduces yield more in cowpea than in common bean
- Bean yield is limited more by N supply in both water regime (data points above y=x)
- Cowpea yield is somewhat limited by N supply under WW conditions but not under stress (data points on both sides of y=x)
- Both species have lines achieving high yield under both low and high N, which can be used for breeding high symbiotic N fixation capacity

DISCUSSION

- Adaptation to drought in common bean from the group of water spenders is related to the effective use of water to produce biomass, combined with an increase in dry matter partitioning from vegetative structures to pods and seeds. Water spenders are bean lines that would adapt very well to humid to sub-humid environments with intermittent droughts and soils that retain more moisture. Water savers are bean lines that show higher water use efficiency, combined with a moderate growth and a better remobilization of plant reserves for pod and grain production. These water saver lines are recommended for semi-arid to arid environments, where terminal droughts prevail and soils have a poor moisture holding capacity.
- Bean yield is limited by N supply and lines of both bean and cowpea with high yield under low and high N supply were identified and these lines could serve as parents for genetic enhancement of symbiotic nitrogen fixation capacity.

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Leveraging legumes to combat poverty, hunger, malnutrition and environmental degradation