YIELD AND PHENOLOGICAL ADJUSTMENT IN FOUR DROUGHT-STRESSED COMMON BEAN CULTIVARS

Rigoberto Rosales-Serna¹, Josué Kohashi-Shibata², Jorge A. Acosta-Gallegos¹, Carlos Trejo-López², Joaquín Ortiz-Cereceres³ and James D. Kelly⁴.


Introduction

Common bean (Phaseolus vulgaris L.) is an important rainfed crop in Mexico. In this country, drought is one of the most limiting factors in common bean. Drought, defined as a plant and/or soil moisture deficiency that affects crop growth and development might be intermittent (when it affects different developmental stages and its effect varies on intensity, incidence opportunity, duration, rhythm of establishment and plant preconditioning) in the highlands, or terminal, observed in the tropical lowlands mainly affecting the crop at the end of the growing cycle when soil moisture is gradually receding. The objective of this trial was to assess the role of phenological adjustment and biomass accumulation on the seed yield of four bean varieties grown under intermittent and terminal drought.

Material and Methods

An experiment was established at two locations in México: Cotaxtla, Veracruz in the lowlands, and Texcoco, State of Mexico in the highlands. Four varieties were tested, two type I growth habit: G4523 (drought resistant) and Rayado Rojo (drought susceptible) from the Nueva Granada race; another two of prostrate type III growth habit, Pinto Villa (drought resistant) and Bayo Madero (drought susceptible) from the Durango race. A randomized complete block design with an split plot arrangement and three replications was used at both locations.

Terminal drought (TD) was studied in Cotaxtla, which consisted on the suspension of irrigation at 38 days after planting (DAP). In Texcoco, the experiment was planted under a rainsheeter and the following treatments were studied: 1) intermittent drought (ID), which included two drying cycles before physiological maturity was reached. This treatment consisted of the suspension of irrigation at the first compound leaf stage (18 DAP) and rewatering at the plant wilting condition (50 DAP). Afterwards it was left to mature without irrigation. 2) terminal drought, in which the treatment was similar to that of Cotaxtla. In both locations an irrigated (I) treatment was included as control. The experimental plot consisted of two 5 m rows in Cotaxtia; and two 4 m rows in Texcoco, 60 cm apart (18 plants m⁻²).

In Texcoco, four destructive aboveground biomass samples were done: before starting the intermittent drought treatment, at flowering, after irrigation and at physiological maturity (17, 45, 61 and 102 DAP, respectively). In Cotaxtla three samplings were carried out: at flowering, seed filling and physiological maturity (43, 64 and 85 DAP, respectively). At each sampling date, three plants were taken per plot. Individual plants were dissected by phytomer and its components (stem, leaves, petioles, pods and seeds). Seed yield, days to flowering (DF) and to physiological maturity (DPM) were recorded. The data from each location were analyzed separately.

Results and Discussion

In both locations highly significant differences (P<0.01) were observed among moisture conditions and cultivars for all the evaluated traits. Drought intensity index (Fischer and Maurer, 1978) varied from 0.37 (terminal drought), in Cotaxtla, to 0.49 (terminal drought) and 0.63 (intermittent drought) in Texcoco. Pinto Villa showed the highest seed yield in all moisture conditions at both locations (Table 1). Significant modifications in number of days to physiological maturity (DPM) were observed under drought, mainly in the high yielding cultivars G4523 (type I) and Pinto Villa (type III). The latter showed the largest reduction for DPM from 93 under irrigation (I) to 80 in terminal drought and 77 under intermittent drought (Figure 1). This phenological adjustment, in Texcoco, combined with a high daily
average of seed yield per plant per day (g plant\(^{-1}\) day\(^{-1}\)) of 0.50 under I, 0.34 in TD and 0.30 for ID contributed to an overall high seed yield. A similar trend was observed for G4523. The response of the four varieties under irrigation and terminal drought was similar at the two locations.

In Texcoco, the susceptible cultivar, Bayo Madero (type III), exhibited a significant reduction in the harvest index (HI) from 0.34 under I to 0.29 under ID, while in Rayado Rojo (type I) the reduction was from 0.33 under I to 0.26 under ID. These results were related to the larger pod and seed number reduction observed in susceptible cultivars. Similar results were obtained at Cotaxtla.

Biomass production was related to seed yield across moisture conditions with R\(^2\) values of 0.99** in Texcoco, and 0.93** in Cotaxtla. Earliness to flowering and to PM showed negative and significant relationship with seed yield. Cultivars with phenological adjustment, of the period from flowering to maturity, showed high yield. In both locations biomass partitioning was similar in all cultivars despite growth habit differences. Across moisture treatments larger values for plant biomass accumulation, pods and seed number were registered at the six basal phytomers. Pinto Villa showed the lowest variation in individual seed weight among phytomers.

The above results suggest that earliness to flowering and the adjustment in days to maturity, are important traits in the adaptation of common bean under limited moisture environments. All the evaluated varieties showed basal dominance in biomass accumulation, pod set, seed number and individual seed weight. High aerial biomass production and a high rate of biomass partitioning to pods and seeds, in tolerant cultivars, allowed the stabilization of yield across moisture conditions.

**Figure 1.** Days to physiological maturity in four common bean cultivars under drought intensity index of 0 (irrigated), 0.5 (terminal drought) and 0.58 (intermittent drought). Texcoco, State of Mexico. 2001.

**Table 1.** Days to flowering (DF) and seed yield (g plant\(^{-1}\)) of four common bean cultivars (18 plants m\(^{-2}\)) under different moisture conditions\(^1\), at two locations in Mexico. 2001.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Growth Habit</th>
<th>DF</th>
<th>TD Yield</th>
<th>I Yield</th>
<th>DF</th>
<th>TD Yield(^1)</th>
<th>ID Yield</th>
<th>I Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>G4523</td>
<td>I(^2)</td>
<td>37</td>
<td>14</td>
<td>20</td>
<td>44</td>
<td>16</td>
<td>15</td>
<td>28</td>
</tr>
<tr>
<td>Rayado Rojo</td>
<td>I</td>
<td>39</td>
<td>8</td>
<td>17</td>
<td>48</td>
<td>10</td>
<td>8</td>
<td>33</td>
</tr>
<tr>
<td>Pinto Villa</td>
<td>III</td>
<td>32</td>
<td>17</td>
<td>21</td>
<td>40</td>
<td>26</td>
<td>23</td>
<td>47</td>
</tr>
<tr>
<td>Bayo Madero</td>
<td>III</td>
<td>35</td>
<td>9</td>
<td>18</td>
<td>42</td>
<td>21</td>
<td>15</td>
<td>35</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>36</td>
<td>12</td>
<td>19</td>
<td>44</td>
<td>18</td>
<td>15</td>
<td>36</td>
</tr>
</tbody>
</table>

\(^1\) TD = terminal drought, ID = intermittent drought and I= irrigated (control); \(^2\) I = determinate bush and III=Indeterminate prostrate.

**Reference**