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WATER REGIME EFFECTS ON PHENOLOGY AND SEED YIELD OF TWO COMMON BEAN CULTIVARS GROWN IN DURANGO, MÉXICO

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INTRODUCTION: In the State of Durango, México, common bean (*Phaseolus vulgaris*) is the most important food product used for direct human consumption, after grain cooking. Common bean is cultivated mainly under rainfed conditions in despite of its decisive role in local economy, human nutrition and nutraceutical contribution for human health. Under rainfed conditions water shortage (intermittent drought) and yield losses in common beans are the main factors causing negative impacts on the farmer´s economy. Some attempts have been made to use common beans under irrigated conditions in order to improve water productivity and to stabilize seed yield. Early maturity and low water requirements were introduced in modern 'pinto' common bean cultivars in order to improve seed yield. Characterization of modern cultivars is required in order to implement the use of technological tools for precise irrigation scheduling; as well as for phenology and yield prediction. The growing degree days (°D) concept, which is based on actual temperatures, is considered as a simple and accurate method to predict when a certain plant stage will occur (Miller *et al*., 2001). The objective of this study was to evaluate effects of three water regimes on phenology and seed yield of common bean at three experimental sites in the State of Durango, México.

MATERIALS AND METHODS: In 2015 and 2016, an irrigation experiment was conducted at INIFAP´s experiment stations located in Durango and Canatlán, México. Two common bean cultivars (Pinto Saltillo and Pinto Centauro) were included in the study. The cultivars were sown in July 10th (Durango 2015), July 13th (Canatlán, 2015) and July 7th (Durango, 2016), using randomized block design with split plot arrangement and four (2015) to eight (2016) replications. The experimental plot consisted of 32 rows 10 m in length (Durango, 2015), 16 rows in 8 m length (Canatlán, 2015) and 12 rows with 10 m in length (Durango, 2016) and 0.81 m apart in all the experimental sites. Fertilizer was applied during the first mechanical weeding at the rate of 35-50-00 (N-P_2O_5-K_2O). Data was collected for days to flowering (DF) and physiological maturity (DPM), minimum and maximum temperatures, amount of water (rainfall + irrigation), seed yield and water productivity. Degree days (°D) were estimated according to the following conditions (Ojeda *et al*., 2004): $°D = T_a - T_{c\text{-}min}$, $T_a < T_{c\text{-}max}$; $°D = T_{c\text{-}max} - T_{c\text{-}min}$, $T_a \geq T_{c\text{-}max}$; $°D = 0$, $T_a \leq T_{c\text{-}min}$. Where T_a is daily mean temperature, $T_{c\text{-}max}$ and $T_{c\text{-}min}$ represent the air maximum and minimum temperatures related to the range required for plant growth in common beans (10 and 28 ºC, respectively). Three irrigation treatments were applied (100, 80 and 60 % of soil available water) in order to avoid severe water stress in plants and to determine precise amounts of water required to optimize yield in common bean. At maturity, three plant samples were taken for yield determination, and then the average value was obtained by replication. Plant samples consisted of two rows with 5 m in length by 0.81 m in width (8.1 m^2). Water productivity was calculate using the equation WP= yield/applied water. The analysis of variance was obtained under a randomized complete block design with split plot arrangement and four to eight replications. Mean comparisons were performed using Tukey´s honestly significant difference test ($P \leq 0.05$).

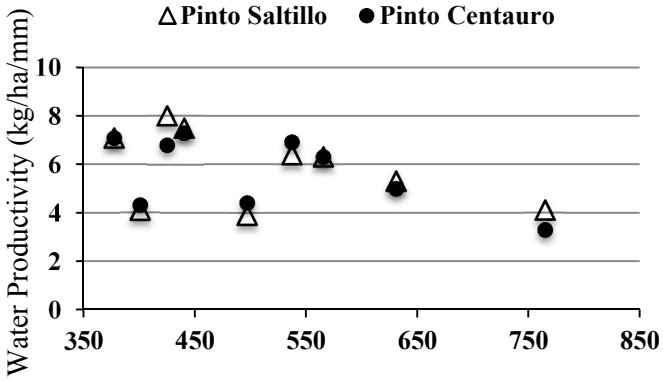
RESULTS AND DISCUSSION: The total amount of water applied across water regimes showed fluctuations between 377 mm (60 %) to 765 mm (100 %) (Table 1). Pinto Centauro cultivar showed precocious flowering (40-41 DAP) and physiological maturity (92-98 DAP) across sites and water regimes, resulting in lower accumulation for ºD at the flowering (406-430 ºD) and physiological maturity (893-958 ºD). Fluctuation observed on phenological stages and accumulated ºD showed low influence

over seed yield across water regimes. Higher and stable seed yield values were observed during 2016, across water regimes in both common bean cultivars, showing values among 3,200 kg/ha to 3,687 kg/ha. Across years, both cultivars showed higher values for seed yield under the 80 % and 100 % treatments of soil available water. In 2015, differences were observed between sites and higher yields were observed in the 80 % treatment (Durango) and in the 100 % treatment (Canatlán). Yield reductions were observed under 100 % treatment due to excessive amount of water (765 mm) which surpassed theoretical crop water requirements (300-362 mm), thus causing seed yield reductions. Results suggest that common beans grown in Durango require a water supply ranging from 425 to 631 mm in order to achieve increments in seed yield, registering values for water productivity from 3.9 to 8.0 kg/ha/mm (Figure 1).

Table 1. Phenology and seed yield observed in three sites and three water regimes applied to two common bean cultivars.

	Durango 2015			**Canatlán 2015**			**Durango 2016**		
Cultivar	[1]DF	DPM	Yd	DF	DPM	Yd	DF	DPM	Yd
	*100 % (765 mm)			*100 % (631 mm)			*100 % (566 mm)		
P. Saltillo	$43_{(448)}$	$103_{(1,015)}$	3,129	$45_{(459)}$	$101_{(950)}$	3,344[a]	$43_{(448)}$	$95_{(917)}$	3,576
P. Centauro	$41_{(427)}$	$97_{(967)}$	2,546	$40_{(406)}$	$99_{(937)}$	3,157[a]	$41_{(430)}$	$92_{(893)}$	3,548
	80 % (425 mm)			80 % (497 mm)			80 % (538 mm)		
P. Saltillo	$42_{(438)}$	$102_{(1,007)}$	3,380	$45_{(459)}$	$99_{(937)}$	1,946[b]	$42_{(440)}$	$94_{(909)}$	3,466
P. Centauro	$41_{(427)}$	$96_{(958)}$	2,890	$41_{(416)}$	$98_{(930)}$	2,190[b]	$41_{(430)}$	$93_{(900)}$	3,687
	60 % (377 mm)			60 % (401 mm)			60 % (440 mm)		
P. Saltillo	$43_{(448)}$	$103_{(1,015)}$	2,665	$44_{(447)}$	$100_{(943)}$	1,645[c]	$43_{(448)}$	$93_{(900)}$	3,292
P. Centauro	$41_{(427)}$	$97_{(967)}$	2,686	$41_{(416)}$	$97_{(923)}$	1,705[c]	$41_{(430)}$	$92_{(893)}$	3,200
Mean	**$42_{(438)}$**	**$99_{(986)}$**	**2,883**	**$43_{(436)}$**	**$99_{(937)}$**	**2,331**	**$42_{(440)}$**	**$93_{(900)}$**	**3,461**

[1]DF= days to flowering, DPM= days to physiological maturity, subscript represents accumulated ºD; Yd= seed yield; *Relative value based on soil available water. Letters in each column indicate significant differences according to Tukey´s test ($P \leq 0.05$) between cultivars [a-c].



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