Evaluation of potassium polyacrylate, in the cultivation of beans (Phaseolus vulgaris L.) as a potential practice adaptation in the face of drought, Parramos, Chimaltenango.

Julio Renato Alarcón Recinos
Instituto Privado de Investigación sobre Cambio Climático -ICC

1. Introduction

Climate change is a major global problem that has worsened since the industrial revolution (ECLAC, 2011). Global and regional climate scenarios show a decrease of precipitation (rainfall) in the country, which will affect crop yields (IPCC 2007 and ECLAC 2010), including beans. Beans (*Phaseolus vulgaris L.*) are one of the main crops in Guatemala, which would impact food security, prompting the present investigation.

According to MAGA (2012), water scarcity cost black bean farmers more than Q6 million in losses in production and performance, just in 2012. The losses reported in the harvest had an impact in the bean quintal[1] prices: in December 2012 the price was Q.388.00, and in January 2013 a quintal of beans was Q.411.00 with an increase of 5.93 %, or Q.23.00. The rise in prices limited accessibility for poor people who consume it daily. (El Periódico , 2012)

This study was conducted from June to September 2013, in the town of Parramos (Department of Chimaltenango), where we evaluated the use of *potassium polyacrylate* as a potential practice in the face of drought for black bean cultivation. This product has the ability to absorb and release water according to crop water needs, remaining in the ground for seven years until it degrades (according to the manufacturer).

2. Objectives

1) To evaluate *potassium polyacrylate* performance in bean crops (*Phaseolus vulgaris L.*) under greenhouse conditions (water deficit) and in field conditions.

2) To determine *potassium polyacrylate* retention capacity.

3) To evaluate yield (measured in kg/ha) in a native and an improved bean seeds when subject to the use of potassium polyacrylate.

3. Methodology

- The present study was conducted in two different environments, under local field conditions and in a greenhouse. In the greenhouse, some water deficit was imposed by reducing, in a controlled fashion, the crop uptake of water (half of the precipitation), leading also to uncontrolled increasing temperatures.
- A water retention test was made by: *i)* weighing the dry polyacrylate potassium; *ii)* adding water to the product (at four different volumes of water with three replicates per volume; see table 1); weighing the product after being moisturized; and comparing the results (weight and volume) to determine the water retention.
- Sixty experimental units were established (each was one square meter) under field conditions, likewise in the greenhouse.
- The potassium polyacrylate was incorporated into the soil (at a dose of 25 kg/ha). Figure 3 shows the incorporation of potassium polyacrylate in field conditions; 15 cm below the top soil. In the greenhouse plants were sowed in a polyethylene bag (see figure 2), which also contained the potassium polyacrylate as described above. The greenhouse's size was 6 x 14 meters.
- Conventional agronomic management was provided: i.e. weed control, fertilization and pest and disease management (following ICTA 2010).
- Temperature and precipitation were recorded (under field and greenhouse conditions), between May and September, and a water balance was constructed from this data; evapotranspiration (Etc) was calculated with the Hargreaves method.
- We measured crop yields (kg/ha). Data tabulation and statistical analysis were performed. This was a bifactorial experiment following a completely randomized design with 4 treatments (see Factors below) and 15 replications per treatment (per each environment –field and greenhouse).

Figure 1. Field and greenhouse conditions

Figure 2. Potassium polyacrylate incorporation to the soil

The evaluation was carried out with the following factors:

Factor A:

A1 = With Potassium polyacrylate (25kg/ha)
A2 = No potassium polyacrylate (control variable)

Factor B:

B1 = *'Cultivar Parramos'* seed
B2 = *'ICTA - Altense'* seed

Instruments used for monitoring temperature and precipitation
- Rain gauge (field)
- Thermometer (field and greenhouse)

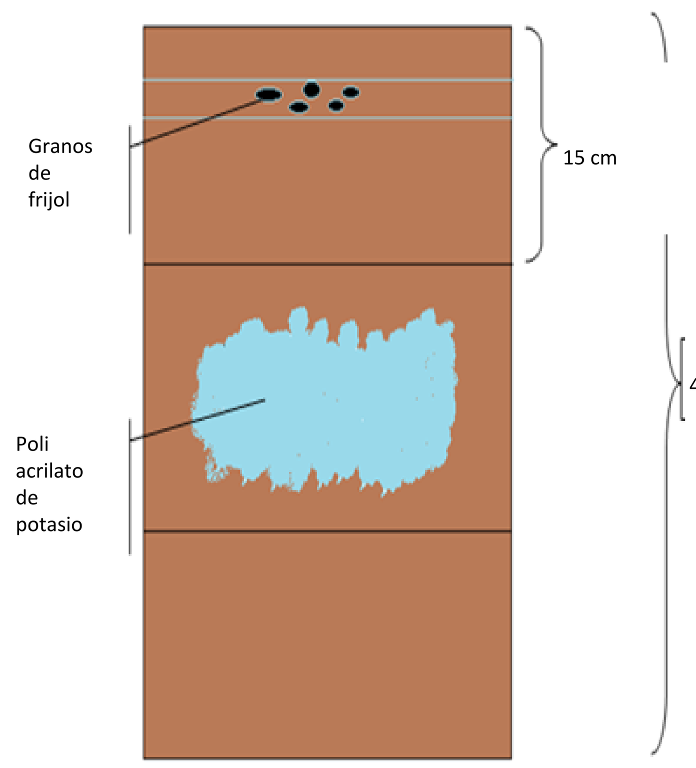

Figure 3.Incorporation of Potassium polyacrylate during bean sowing

4. Results

1. For the water retention test, the water volumes applied to each experimental unit of polyacrylate were: 700ml, 500ml, 300ml, and 100ml. According to the manufacturer (Aqua Warehouse, 2009), the product absorbs 500 times its weight. However, as we can see in Table 1, this have not occured, at any of the four concentrations tested.

Table 1. Water Absorption by Potassium Polyacrylate

Water Volume	Solid rain Initial Weight (gr)	Paper Filter Weight (gr)	Paper Filter Weight (gr) - wet	Difference	ml obtained	Soild rain Weight (gr)	Product Absorption	TOTAL
700	1	5	13.83	8.83	547.67	134.73	**120.90**	681.40
500	1	5	11.27	6.27	348.00	137.57	**126.30**	483.10
300	1	5	9.70	4.70	163.33	129.00	**119.30**	291.33
100	1	2.5	4.47	1.97	0.00	100.17	**95.70**	99.17

Table 1, shows the water absorption rate by potassium polyacrylate, which was, aproximately, between 119ml and 126ml per gram of potassium polyacrylate (with an average value of 122ml) for water volumes ranging from 300ml to 700 ml. For a water volume of 100ml the absorption observed by the product was lower than the volume of water applied. This can be due to loss by chemical reactions, by traces of water left on the filter paper, or in the containers where the polyacrylate potassium was hydrated during the test.

2. Table 2 shows the results (yields at the environments -field and greenhouse conditions- and factors evaluated -application, or not, of potassium polyacrylate and kind of seed tested-) in kg/ ha. Under field conditions, for instance, the use of potassium polyacrylate increased the yield of the *'Cultivar Parramos'* and the *'ICTA - Altense'* seeds by 49% and 37% respectively.

Table 2. Location, Treatment, Bean Genetic Materials, and Yield.

Location	Treatment	Genetic Material	(kg) 15m2	Kg/ha
Field	Potassium Polyacrylate	ICTA Altense	3.82	2549.26
Field	No Potassium Polyacrylate	ICTA Altense	2.8	1863.6
Field	Potassium Polyacrylate	Cultivar Parramos	2.48	1652.63
Field	No Potassium Polyacrylate	Cultivar Parramos	1.66	1107.62
Greenhouse	Potassium Polyacrylate	ICTA Altense	2.53	1687.79
Greenhouse	No Potassium Polyacrylate	ICTA Altense	1.56	1037.3
Greenhouse	Potassium Polyacrylate	Cultivar Parramos	3.38	2250.39
Greenhouse	No Potassium Polyacrylate	Cultivar Parramos	1.56	1037.29

In greenhouse conditions, we reduced 50% the precipitation that fell under normal field conditions. During the experiment, we provided the resulting reduced amounts of water through irrigation, in an environment that also resulted in an increased average temperature of 6 °C. Under these conditions, the use of potassium polyacrylate increased the yield of the *'Cultivar Parramos'* and the *'ICTA - Altense'* seed by 117% and 63 respectively.

In this study, we found statistically significant differences for the potassium polyacrylate factor as well as for the kind of seed factor.

After performing the water balance for both conditions, we determined that in the field the only month with a water deficit for the bean crop was June. While, in the greenhouse, the deficit extended to the months of June, August, and September.

Figure 3. Water Balance in Field and Greenhouse Conditions.

Water Balance					
Field					
Month Registered	**May**	**June**	**July**	**August**	**September**
Accumulated Precipitation	152	74	220	402	297
Evapotranspiration (monthly)	122.3	146.3	151.2	142.8	129.5
Kc	0.4	1.15	1.15	1.15	1.55
Etc=Kc*Evo	48.9	168.2	173.9	164.2	200.7
Difference	103.1	-94.2	46.1	237.8	96.3
Greenhouse					
Month Registered	**May**	**June**	**July**	**August**	**September**
Accumulated Precipitation	76	37	110	201	148.5
Evapotranspiration (monthly)	141.3	162.7	171.5	161.72	149.9
Kc	0.4	1.15	1.15	1.15	1.6
Etc=Kc*Evo	56.5	187.1	197.2	185.98	232.3
Difference	19.5	-150	-87.2	15.021	-83.8

Conclusions

1. Potassium polyacrylate increased the yield of the *'ICTA - Altense'* bean genetic material by 37% under field conditions, and in 63% in greenhouse conditions.
2. In the Cultivar Parramos bean genetic material, potassium polyacrylate increased yield by 49% under field conditons and in 117 % in greenhouse conditions.

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[1] One *quintal* (abbreviated qq) equals 100 Lbs or 45.45 Kg