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Researches Concerning the Effects of Incorporation Into the Soil of Water-Retainer Polymers on Morpho-Physiological Traits in Bean (*Phaseolus sativum* L.) plantlets Subjected to Drought

Beinsan Carmen[1], Sumalan Renata[1] , Schmidt Brigitta[1], Sumalan R.[1*]

[1]University of Agricultural Sciences and Veterinary Medicine of Banat "King Michael I of Romania" from Timisoara, Faculty of Horticulture and Forestry

*Corresponding author. Email: sumalanagro@yahoo.com

Abstract Water retainer substances stimulate the accumulation of water and nutrients in the soil and on the other hand they have direct action on the plant metabolism, providing development conditions for a longer period of time [7]. The purpose of the experiment was to test a polymeric chemical compound with a potential water retention in beans for use as a dry-dampener.
The local bean populations used in this study were: Toager 207, Rudna 143 and Crai Nou. The plants were grown under controlled conditions in the germinator at 25°C until the determinations were performed. Two variants were tested: V_0 (control) - without the addition of water retainer (WR); V_1 - added by WR. The following determinations were performed: plant height, foliar surface, chlorophyll content and leaf dry matter. In the Rudna 143 local population, WR administration helped to reduce the negative effects of stress, the plants having a faster growth rate than the untreated control, WR being more than twice as high as the control variant. The local populations analyzed showed higher foliar surface values when applying WR treatment, evidence that this treatment has beneficial effects in case of drought affecting plants. In the case of chlorophyll content there were no differences between the blank and the WR treated."Water retainer" treatments can improve certain physiological processes in drought conditions, having a positive role in controlling the effects of drought on plants by retaining a higher amount of water in the soil.

Key words

bean, chlorophyll content, dry matter

Drought stress, both as a seasonal phenomenon and as part of climate change, is currently the leading threat to the world's food supply [5].

Drought is a major factor affecting the growth and development of plants and may cause severe reductions in crop yields in many countries in the world. Its importance is likely to increase in response to the effect of global change and increased competition for water. The first signs of drought are visible in leaves, which appear prematurely senescent, although earlier changes, both morphological and metabolic, occur in roots, the first tissues to experience the reduction in water supply. These changes reflect, not merely a progressive reduction of water content in the plant, but qualitative and quantitative changes in its metabolism, suggesting a number of mechanisms by which plants can, within different limits, tolerate drought and recover from its effects. During evolution, plants have developed both physiological and biochemical responses to promote their survival under stress [14].

Several studies have revealed the radical effect of drought stress on common bean performance. Exposure to drought affects total biomass and seed yield, photosynthate translocation and partitioning, number of pods and seeds per plant, root length and mass, and maturation time [3, 4]. In common bean, drought stress during flowering and post-flowering caused reductions of 60–99% in yield [1], 25.4 % in number of pods per plant, 20.3% in numbers of seed per pod [10], and 11% in seed size [6].

Current practices of retention of water and nutrients in the soil by the addition of polyacrylamide synthetic polymers, with 20-50% of the acrylamide chain segments replaced by an acrylic acid group [9, 12] are not absolute novelties. The use of polyacrylamide as a soil stabilizer additive has been widely used in agricultural technologies to control soil erosion during irrigation [8, 11, 13].

In modern agriculture, hydrophilic polymers are used to enhance plant nutrition and water status [2]. The use of polymers as a soil-stabilizing additive has significantly expanded for agricultural purposes to

control soil degradation and desertification, and also to improve arid and semiarid soils [16]. These polymers helps for reducing water consumption and to decreasing the effects of drought and dehydration.
Water retainer substances stimulate the accumulation of water and nutrients in the soil and, on the other hand, they have direct action on the plant metabolism, providing development conditions for a longer period of time. The "water retainer" product absorbs 400 to 500 times more water than its own weight [17].

Material and Method

The biological material was represented by three bean old local landraces; Toager 207, Rudna 143 and Crai Nou.

The purpose of the experiment was to test a polymeric compound of "water retainer" type in a cultivated specie (*Phaseolus sativum* L.), for use as a protection product against drought.

The experiment lasted three weeks, during which measurements, determinations and analyzes were performed in the Plant Physiology Laboratory, Faculty of Horticulture and Forestry Timisoara. The experiment was designed to induce and combat drought, which was accomplished with the "water retainer" product that has shown some positive effects.

Upon administration of the water retainer solution, the plants exhibited positive behavior. The seeds were sown in pots (0,2 liter) having as a substrate, peat and sandy so (2/1), 4 seeds / pot, 5 pots / each variant. Before sowing, the substrate was oven dried at 120 ° C for 3 hours to bring all variants to the same moisture content. After sowing, the pots were watered with 200 ml of water / pot, and over the course of 2 days with 100 ml of water.

The plants were grown under controlled conditions, in the growth room at 25 ° C, 75% atmospheric humidity, and 16/8 day and night alternance until the determinations were made.

The following variants were tested: V_0 (control) - no water retainer (WR); V_1 - with added WR. In this variant, 2 grams of WR / pots were added, incorporated into the soil under the seed level, the dose being equivalent to 250 kilograms / ha.

When the first 2 leaves appeared, watering was stopped. The measurements were carried out once a week, following: the height of the plant (cm), the foliar surface (cm^2 / plant) - is an important physiological index in the characterization of the metabolic processes, the chlorophyll content (SPAD) and dried leaf material (%).

The foliar surface (cm^2 / plant) were determined by the method of the leaf parameters, by equation S = L x l x k where: L = leaf length (cm), l = leaf width (cm). For beans, the correction coefficient "k" = 0.668 for the central foliole and 0.751 for the two lateral folioles [15].

The quantitative determination of chlorophyll pigments in leaves (SPAD units) was performed using the SPAD 502 Plus chlorophyll meter (Konica Minolta Instruments). The dried leaf material (%) was determined using the KERN MLS-300 thermo balance (Kern &Son Gmbh). Measurements were performed once a week for 3 weeks.

Results

Regarding the plant high (table 1), cultivars Rudna 143 and Toager 207 were more likely to react to the addition of the water retainer polymers and recorded values between 10.8-12.5 cm. Thus, at Rudna 143, the polymer helped to reduce the negative effects of drought, the plants having a faster growth rate than the untreated (control), the WR variants being more than twice as high as the control.

Table 1

Experimental results concerning the plant high (cm)

cultivar	plant high (after 7 days) (cm)		plant high (after 14 days) (cm)		plant high (after 21 days) (cm)	
	V_0	V_1	V_0	V_1	V_0	V_1
Crai Nou	9.7 ± 0.54	8.7± 0.44	9.8± 0.64	10.3± 0.59	10.8± 0.61	12.2± 0.17
Rudna 143	5.0± 0.38	12.5± 0.13	5.3± 0.26	14.7± 0.91	5.7± 0.22	15± 1.12
Toager 207	9.5± 0.75	10.8± 0.87	14.3± 1.03	11.1± 0.72	14.8± 0.89	11.3± 0.67

Regarding the plant high in the second week, as we can see, there has been a significant increase. The Crai Nou and Rudna 143 cvs. had a faster growth rate than cv. Toager 207, which had a more significant increase in the untreated variant. The two local populations have responded positively to WR product management, which suggests that this product is beneficial in the growth process of the plant during the drought.

Three weeks after the drought induction, we notice that of the three populations, only cv. Rudna 143 evolved and responded better to WR solution administration, the value being 15+ 1.12 cm compared to untreated, which measures only 5.7 + 0.22cm. Also cv. Crai Nou recorded a higher value for the treated version (12.2+ 0.17cm) compared to V_0 (10.8+ 0.61 cm).

Fig. 1 Cultivar Crai Nou – after 7 days

Fig. 2 Cultivar Toager 207 - after 7 days

Fig. 3. Cultivar Rudna 143 - after 7 days

Regarding the foliar surface of bean plants after seven days, it was observed an amplitude of variation, so cv. Rudna 143 has a foliar surface significantly superior to the other populations, the recorded value being of 43.9+ 1.52 cm^2. Cultivar Toager 207 recorded a value of 32.6+ 0.78 cm^2 and Crai Nou 26.0+ 1.13 cm^2 compared to the untreated control variant which recorded 37.8+ 0.86 cm^2 (Table 2).

Table 2

Experimental results concerning the leaves area (cm^2/plant)

cultivar	leaves area (after 7 days) (cm^2/plant)		leaves area (after 14 days) (cm^2/plant)		leaves area (after 21 days) (cm^2/plant)	
	V_0	V_1	V_0	V_1	V_0	V_1
Crai Nou	37.8± 0.86	26.0± 1.13	76.3± 1.48	69.9± 1.33	80.5± 0.90	95.5± 1.53
Rudna 143	16.2± 0.74	43.9± 1.52	47.1± 1.27	85.3± 0.82	59.9± 0.71	95.5± 0.65
Toager 207	22.8± 0.90	32.6± 0.78	61.8± 1.39	63.1± 1.04	71.4± 1.11	80.8± 0.60

According to the foliar surface analysis, in the third week, the studied cultivars exhibit high values ranging from 80.8+ 0.60 and 95.5+ 1.53 cm^2 / plant in the variants of which water retainer product were administered, and in the untreated, values ranging from 59.9 + 0.71 and 80.5+ 0.90 cm^2 / plant. The results shown show that beans cultivars has a good reaction in the third week for WR product, demonstrating that this solution has beneficial effects on drought affecting plants (Table 2).

Regarding the chlorophyll content of leaves in the first week, it is noticeable that the cv. Rudna 143 has the bigger content (51.1 SPAD units) compared to the untreated, that has only 47.1 SPAD units. The Toager

207 cultivar has a lower chlorophyll content than the untreated control variant, the difference being only 1.4. SPAD units. After fourteen days of drought induction, it was observed that the beans plants have positive reactions in the case of WR than in untreated ones. In this case, values ranged from 49.8+ 0.17 to Crai Nou and 52.1+ 0.81 SPAD units in Rudna 143. The third week of measurements shown that the situation has changed so that the high chlorophyll content was recorded in untreated variants, ranging from 51.3+ 0.58 to 57.9+ 0.65 SPAD units. In the variants treated with WR, the highest content of chlorophyll was recorded in the Rudna 143 local population, with 57.1+ 0.76 SPAD units (Table 3).

Table3

Experimental results concerning the chlorophyll content of leaves (SPAD)

cultivar	chlorophyll content (after 7 days) (SPAD)		chlorophyll content (after 14 days) (SPAD)		chlorophyll content (after 21 days) (SPAD)	
	V_0	V_1	V_0	V_1	V_0	V_1
Crai Nou	41.8± 0.64	41.2± 0.59	48.0 ± 0.90	49.8± 0.17	51.4± 0.44	47.9± 0.20
Rudna 143	47.1± 0.73	51.1± 0.60	50.6± 0.77	52.1± 0.81	57.9± 0.65	57.1± 0.76
Toager 207	45.6± 0.21	44.2± 0.33	47.1± 0.24	52.0 ± 0.52	51.3± 0.58	47.1± 0.67

With the regard to the first week's analysis, cv. Toager 207, recorded the highest amount of dry weight (13.6+ 0.30%) in V_1. In the second week of the experiment, the situation is unchanged for the Toager 207 cv., which recorded high values of 12.6+ 0.78% (V_1) versus 11.5+ 0.29% (V_0), while Crai Nou and Rudna 143 showed higher values in control (Table 4).

Table 4

Experimental results concerning the dry weight content in leaves (DW) (%)

cultivar	DW (after 7 days) (%)		DW (after 14 days) (%)		DW (after 21 days) (%)	
	V_0	V_1	V_0	V_1	V_0	V_1
Crai Nou	12.4± 0.11	12.8± 0.75	13.5± 0.81	12.5± 0.92	17.0 ± 0.60	12.6± 0.52
Rudna 143	12.9± 0.20	12.7± 0.62	12.9± 0.14	11.8± 0.35	13.9± 0.49	20.9± 0.76
Toager 207	9.5± 0.44	13.6± 0.30	11.5± 0.29	12.6± 0.78	17.7± 0.54	13.8± 0.19

According to the dry weight results in the third week after drought induction, the situation is completely changed, cv. Rudna 143 significantly increased having a value of 20.9+ 0.76% in V_1, compared to cv s. Crai Nou and Toager 207, which showed values of 12.6+ 0.52 and 13.8+ 0.19% respectively, and for untreated variants, higher values ranged from 17.0 + 0.60 to 17.7 + 0.54% (Table 4).

Conclusions

WR has had positive effects on plant high on two of the cultivars; Rudna 143 and Crai Nou.

The analyzed old local landraces of beans showed higher leaves area when applying WR treatment, indicating that this treatment has beneficial effects in case of plants affected by drought.

In the case of chlorophyll content, there were no significant differences between control and treated plants. In the third week of measurements, the high chlorophyll content was recorded for the untreated variants and variants treated with WR, the highest chlorophyll content was recorded in cv. Rudna 143.

The dry weight values fluctuated throughout the experiment, and the data obtained did not indicate a clear trend in the effect of WR treatment on drought tolerance.

It can be concluded that treatments with "water retainer" polymers can improve certain physiological processes under drought conditions, having a positive role in combating the effects of drought on plants by retaining a higher amount of water in the soil.

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