UDC 631.41 PRODUCTIVITY of LIGHT-BROWN SOILS BY INFLUENCE of POLYACRILIC HYDROGEL

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Highlights: Determine the effect of hydrogels with different molecular weights on the growth and development of plants (in the example of radish) in light chestnut soils in non-irrigated (bog) and irrigated conditions

Abstract: The sorption properties of the hydrogels of two brands “Acrilex P-150” and “Acros” with different molecular weight were studied; the direct dependence of the swelling capacity on their molecular weight was found out. A positive influence of the hydrogels on the yield of radish (Raphanus sativus) in light-chestnut soils was revealed. The efficiency of the hydrogels application in light-chestnut soils is higher under non-irrigated conditions. The prolonged action of a hydrogel in light-chestnut soils was determined.

Keywords: hydrogels, polyacrilates, molecular weight, light-chestnut soils, radish, germination.

Introduction

The application of polyacrylamide–based preparations (PAA) into the soil of arid regions produces an explicitly positive effect on the growth and survival of plants [1-11]. The wide-spread use of acrylic polymers is mainly limited by high cost of such preparations. Polyacrylamide gel can be considered as a potential carrier for insecticides, fungicides, herbicides and fertilizers [12].

Hydrophylic polymers can change soil properties due to the ability to adsorb a large amount of water 400 or more times exceeding their own weight, which in its turn influences the velocity of infiltration and evaporation, the soil density and structure [13-22].

In extremely arid conditions of dry steep zone the key factor for gaining the desired productivity and plant quality is water sufficiency. One of the instruments here is to apply substances or preparations ensuring the retention of the water available for plants in the root habitable layer of soil. Polyacrylamide gel belongs to such preparations. According to the studies of V.I. Verzhikovsky and his colleagues, the application of this preparation in the conditions of arid climate in Kalmykia ensured a significant yield growth owing to better provision of plants with soil moister [1].

Polymeric hydrogels are cross-linked hydrophilic polymers capable of absorbing large amounts of water. In particular, the cross-linked polymeric hydrogels able to absorb the amounts of water 10 times their dry weight are called superabsorbents.

Polymers of acrylic and methacrylic acids and their derivatives are called polyacrylates. They are colorless, light-resistant. The simplest unsaturated monobasic acid has the formula CH2 = CH-COOH. Depending on the chemical composition and internal structure, different polymers vary greatly in their ability to dissolve. V.A. Kireev advanced the theory of the possible physiological activity of polymers or products of their destruction when they come into contact with a low-molecular-weight liquid and their mutual penetration. In the first stage of the process, the penetration of liquid molecules into the polymer environment predominates, since swelling occurs. The process is due to the presence of micropores, which fill the water. The "less porosity due to better" cross-linking ", the less the mass degree of swelling. For each polymer, the ability to swell or dissolve may not be the same. The hydrophilic mesh polymer found in the soil profile ensures the retention of an additional moisture reserve, mainly due to the reduction in gravity losses and physical evaporation, which is especially important under conditions of a water-free water regime and precipitation deficit [23]. Some of these materials can absorb more than 1 liter of water per gram of dry polymer [24, 25].

Objects and methods

The soil of “Michurinets” small-scale gardening district at “Gornaya Polyana” Educational-and-Research Production Centre located 25 kilometres from Volgograd was taken as the object of study. The properties of the soils, their morphological characteristics were described by the authors earlier [26].

During the field experiments two brands of hydrogels with different molecular weights were studied: “Acrilex P-150” (150000 g/mole) and “Acros” ($6 \cdot 10^6$ g/mole).

The experiments with the hydrogel “Acrilex P-150” were carried out during two years, while with “Acros” – during one year. The following variants were studied: boghara (dry-farming land) without gel (control variant) and with gel, irrigation with and without gel, virgin soil.

Land plots measuring 100 x 20 cm^2 were used for the experiment. Both gels were applied to the depth of 5cm, in the amount of 0,5g per 1 m^2. No mineral fertilizers were applied. The dose of manure amounted to 5 kg/m^2. Pink radish (Raphanus sativus) was taken as the test crop, 40 plants were set out at each plot.

Discussion of results.

Mass of single root. While testing the hydrogel of “Acrilex P-150” brand, it was found out during the first year of the experiment that the mass of a single root was the maximum one under irrigation without the gel (7,28) and with the gel (7,44). When compared with the control variant, it was 3,2 times higher in the variant of boghara with the gel, 3,8 times higher in the variant of irrigation without the gel and 3,9 times higher in the variant of irrigation with the gel.

Table 1.**Main parameters of the application of Acrilex P-150 hydrogel in the field experiment on radish planting**

Variants of	Germination	Quantity of	Plant	Mass of root, g	Diameter,

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experiment	%		seedlings, pcs		biomass, g				cm	
	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year
without gel, boghara	50,0	45,0	20,0	18,0	38,2	32,3	1,91	1,79	1,3	2,6
without gel, irrigation	45,0	33,0	18,0	13,0	131,0	33,3	7,28	2,56	1,7	7,1
with gel, boghara	38,0	33,0	15,0	13,0	110,5	52,6	6,14	4,05	2,5	5,7
with gel, irrigation	83,0	58,0	33,0	23,0	245,7	155,5	7,44	6,76	2,0	3,2

In the course of the testing of “Acrilex P-150” hydrogel, the following results were obtained during the second year of the experiment: the mass of a single root was the maximum one when irrigation with the gel was applied, and it was 2,6 times lower without the gel.

The experiment with “Acrilex P-150” brand hydrogel showed that in comparison with the control plot the variant of boghara with the gel gave 2,3 times higher result, the variant of irrigation without the gel gave 1,4 times higher result, while with the gel –3,8 times higher result. In comparison with the first year, the afteraction of the second year of the experiment reduces the root mass by 1,5 times in boghara with the gel and by 2,8 and 1,2 times if irrigation is applied without and with the gel, respectively.

In comparison with the control variant, the experiment with “Acros” brand hydrogel showed that the mass of a single radish was 2,6 times higher in the variant of boghara with the gel, and 3,8 and 4,5 times higher when irrigation was applied without and with the gel, respectively.

Quantity of seedlings. In the second year the quantity of seedlings reduces everywhere. The results of the testings of the hydrogels of various brands are summarized in tables 1 and 2 (table 1 for “Acrilex P-150” brand, table 2 for “Acros” brand, figures 1-3).

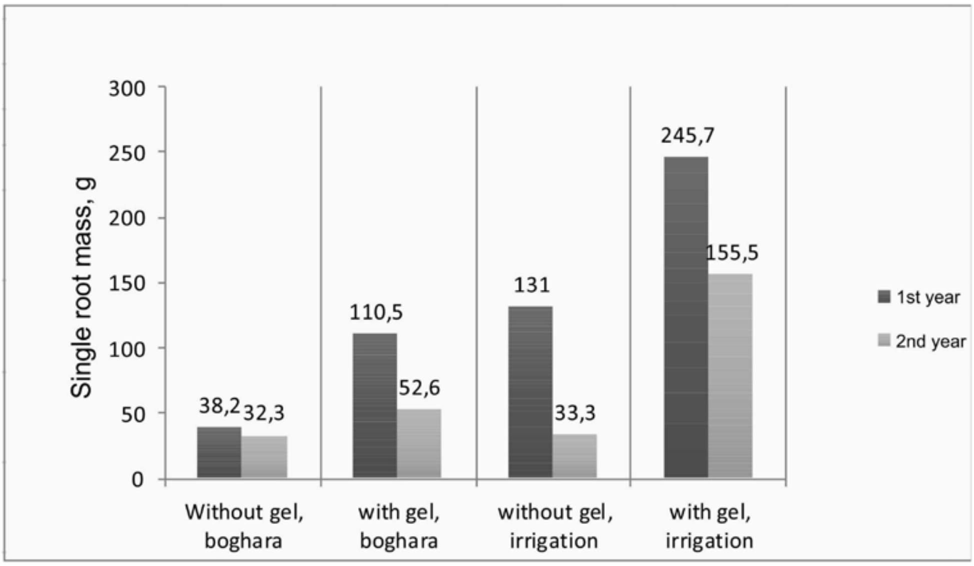

Fig. 1 – Dependence of a single root mass on the variant of the experiment

Table 2. **Main parameters of the application of "Acros" hydrogel in the field experiment on radish planting**

Variants of experiment	Germination %	Quantity of seedlings, pcs	Plant biomass, g	Mass of root, g	Diameter, cm
without gel, boghara	50	20	38,2	1,91	1,3
without gel, irrigation	45	18	131,0	7,28	1,7
with gel, boghara	35	13	60,72	4,67	5,81
with gel, irrigation	70	28	243,26	8,69	2,75

Through the analysis of the data on the seedlings quantity against the control variant, it was determined that the results in the control variant during the two years of the experiment were higher than in the variants of irrigation without gel and boghara with gel. During the first year of the experiment with "Acrilex P-150" and “Acros” gels the results were equal in the variant of irrigation without gel and amounted to 18 seedlings. The largest number of seedling was in the variant of irrigation with “Acrilex P-150” gel where in each of the two years it amounted to 33 and 23 pieces, respectively, and with «Acros» gel where the number was 28 pieces.

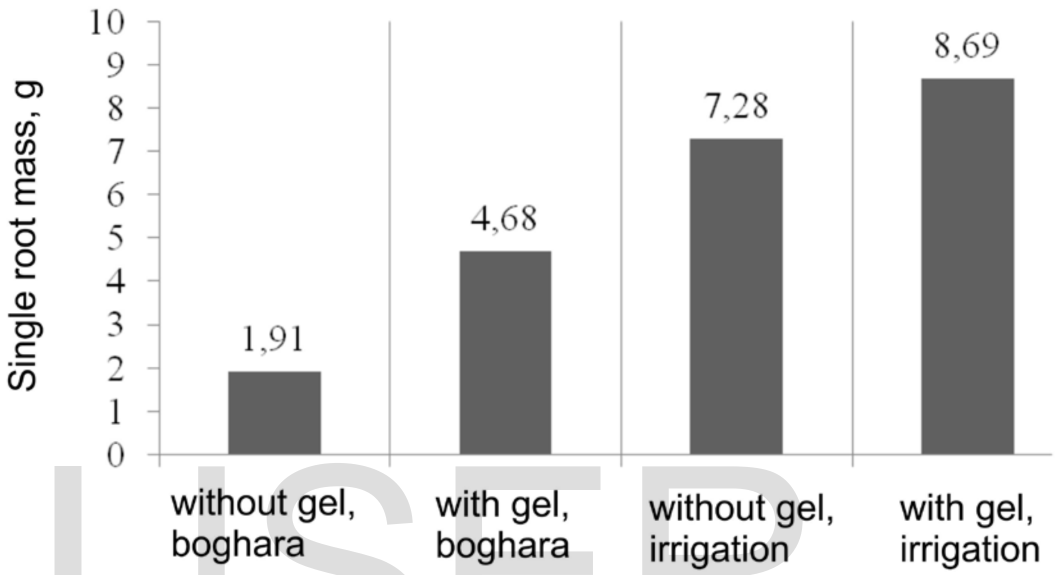

Fig. 2 – Dependence of root mass on the variant of the experiment

Size of the test crop. When “Acrilex P-150” hydrogel was applied, the following results were obtained during the first year of the experiment: the diameter of radish grew 4,4 times in the variant of boghara with the gel, 5,5 times in the variant of irrigation without the gel and only 2,5 times in the variant of irrigation with the gel if compared with the control plot.

But even in the second year of “Acrilex P-150” hydrogel application, fundamentally different results were obtained: in the variant of boghara with the gel they were practically equal to the control ones, in the variants of irrigation with and without the gel – smaller than in the control one.

Under identical conditions, various hydrogel brands showed the results which did not differ essentially.

In the variant of boghara the results with both gels were similar, with “Acrilex P-150” - 5,7cm, with “Acros” - 5,4cm. “Acros” hydrogel showed 4,2 times higher results in the variant of boghara with the gel than in the control one, while in the variant of irrigation without gel the growth was only 0,4 cm, and with the gel it was 2,2 times higher.

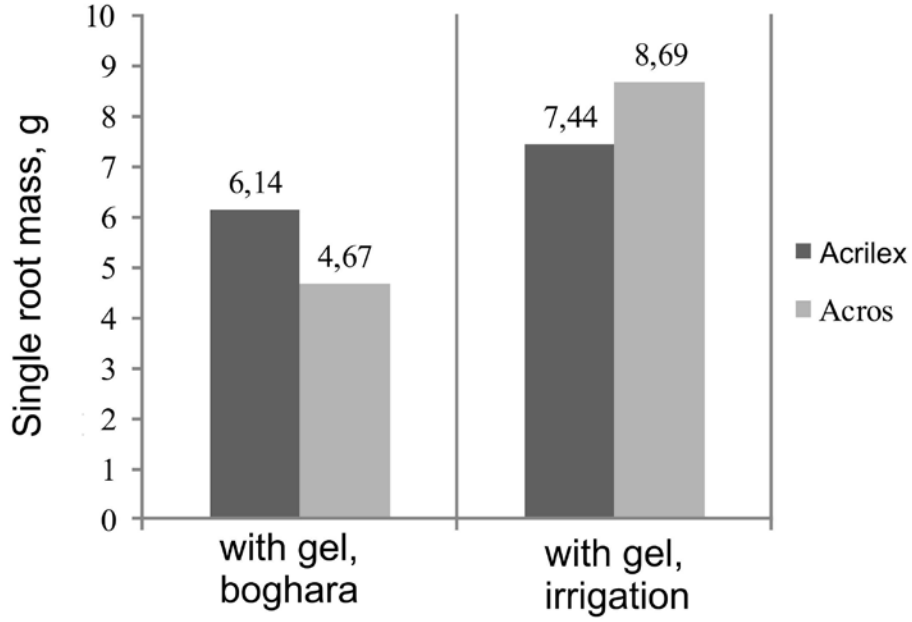

Fig. 3 – Dependence of single root mass on the variant of the experiment for the two hydrogels

Germination of the test crop, percentage ratio.

“Acrilex P-150”, the 1st year of the experiment. The germination was the maximum one in the variant of irrigation with the gel (2,2 times higher than in the control one). The results in the variant of boghara with the gel were 2,2 times lower than in the variant of irrigation with the gel. Both in the variant of boghara with the gel and irrigation without the gel the germination was lower than in the control variant, 38 and 45%, respectively.

“Acrilex P-150”, the 2nd year of the experiment. In the second year the maximum germination was also achieved in the variant of irrigation with the gel (1,3 times higher than in the control one). The lowest germination was in the variants of boghara with the gel and irrigation without the gel – 33 % in each of the cases.

“Acros”. The maximum germination achieved in the variant of irrigation with the gel (70%) was 1,4 times higher than in the control variant, it was lower in the variant of boghara with the gel than in the control variant (35%), and in the variant of irrigation without gel it amounted to 45%.

Comparing both gels, the germination of seeds was the maximum one in the variant of irrigation with “Acrilex P-150” or “Acros” gel amounting to 83% and 70%, respectively, it was equal in the variants of boghara without gel (50% each) and irrigation without gel (45% each), and comparable in the variant of boghara with gel amounting to 38 and 33%, respectively.

Hydrogels are a highly effective instrument for artificial optimization of soil properties which allows increasing the soils’ moisture-retaining power and improving their structural condition.

Conclusion

1. Melioration measures – irrigation and gel application – increase the germination indices of radish.
2. The application of gel in boghara is the most efficient variant.
3. In the second year of hydrogel application, its efficiency decreases in 4 times in the variant with irrigation, and in two times in boghara.
4. The comparability of the application efficiency of hydrogels with different molecular weights allows recommending the one with the lower molecular weight, which is “Acrilex P-150”.
5. Comparing the two gels, the seeds germination is the maximum one in the variant of irrigation with gel and amounts to 83% when “Acrilex P-150” is applied and to 70% when “Acros” is applied, it is equal in the variants of boghara without gel (50% each) and irrigation without gel (45% each) and comparable in the variant of boghara with gel amounting to 38% and 33%, respectively.

Note

The sorption properties of hydrogels with different molecular weight were studied. The direct dependence of the swelling capacity on their molecular weight was found out. The positive influence of hydrogels on radish yield in light-

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chestnut soils was revealed;

The efficiency of hydrogels application in light-chestnut soils is higher under non-irrigated conditions.

The prolonged action of hydrogel in light-chestnut soil was determined.

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