Effect of superabsorbing polymers on potato yield

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Abstract. Climate change is leading to an increase in drought, which is the largest abiotic stress factor leading to a decrease in crop yields. One of the methods in solving this problem is the use of superabsorbing polymers (SAPs) (China, USA, Canada, India, Italy, Iran, Poland, Turkey, and others). The aim of the research is to study the effect of using the superabsorbing polymers (cross-linked copolymer of potassium and ammonium salts of acrylic acid in the form of loose white granules) on the background of fractional-local application of mineral fertilizer to the crop formation. Field experience, accounting and observations were carried out in accordance with general requirements were used in our research. The studies were carried out in 2015-2017 on sod-podzolic sandy soil in the Lyubertsy district (Moscow region, Russia). When using superabsorbing polymers in an average of three years, the yield increased by 1.6...3.4 t/ha (5.5...10.0%) for the studied cultivars; especially helpful was an early sort Meteor and a medium early variety Irbitskiy. It is possible to recommend the use of superabsorbing polymers at a dose of 200 kg/ha when growing potatoes in conditions of moisture deficiency.

1. Introduction

Potato is a crop of mass consumption, the cultivation of which remain high [8]. At the same time, in Russia, the population consumes mainly imported potatoes. Domestic potatoes are in little demand because of the large variance in size and shape of tubers due to the lack of specialized technologies [20].

Current climate change is projected to increase the incidence of drought, the largest abiotic stress factor leading to lower yields [16]. Numerous studies have shown that potato cultivation technology must be flexible [3],[6]. Given the large share of water use in the agricultural sector, the use of superabsorbent polymers (SAPs) is one of the strategies in this regard [16]. The influence of SAPs is studied by researchers from China [15], USA [17], Canada [21], India [18], Italy [19], Iran [22], Poland [13], Turkey [14], and others.

SAPs well retain soil moisture and mineral nutrition in it and, thus, affect the technological parameters of the soil [9], [11], [15], [17]. The use of SAPs, especially in combination with the use of fertilizers and biologics, reduces environmental pollution by retention of nutrients in the soil, leads to an optimum pH value for plants, and can improve the water holding capacity of the soil [5], [11], [12], [15].
It is noted that the introduction of SAPs significantly increases the yield of potatoes, compared with the control groups [7], [15]. A positive effect was also obtained on the following other cultures: cherry tomatoes (Solanum lycopersicum var. cerasiforme) [21], Indian mustard (Brassica juncea L. Czern & Coss.) [18].

2. Materials and Methods

The aim of our research is to study the effect of using SAPs in the context of fractional-local mineral fertilizer application on crop formation in potato cultivation, while relying on moisture-saving technology, as well as on resource saving when using SAPs.

3. Methodology

Bookmark field experience, surveys, and observations were carried out in accordance with the requirements of the methods of field experience [1], [4].

4. Research Conditions

The studies were carried out in 2015-2017 on the experimental basis of the Lorch Potato Research Institute in the Lyubertsy district of the Moscow region.

The soil of the experimental field was characterized as sod-podzolic sandy loam, with high exchange and hydrolytic acidity (pH_KCl = 4.7-4.9; N_g = 3.5-3.9 mg-eq / 100g of soil); average values of the amount of absorbed bases and the degree of saturation with them (S = 3.7-4.1 mg-eq / 100g of soil; V = 48.7-53.9%); high content of mobile phosphorus (265-356 mg / kg of soil) and average content of exchangeable potassium (127-154 mg / kg of soil); typical humus (1.7-1.9%) [10].

The scheme of the experiment in the context of fractional-local application of azophoska mineral fertilizer (16:16:16) with addition of potassium magnesia: 60:60:90 before planting and 30:30:30 at the 1st post-harvest tillage for crop yields. It also included the following factors: (A) varieties of different maturation groups: Meteor (ranniy), Irbitskiy (sredneranniy), Golubizna (srednespelyy), Lorkh (srednepozdniy); (B) introduction of SAPs during planting: 0 g / bush, 4 g / bush (200 kg / ha).

Aqueous superabsorbent is a crosslinked copolymer of potassium and ammonium salts of acrylic acid in the form of loose white granules.

The experiment was laid according to the scheme by the method of randomized allocation of plots. The potato precursor is grain beans. The plot area is 18.1 m\(^2\), a number of replications is 4. The density of planting is 44.4 thousand units per hectare with a row spacing of 75 cm.

Fall plowing, made to a depth of 18-22 cm with a reversible plow, was part of the autumn soil preparation. Planting of experimental variants was carried out with ungrown tubers of the middle fraction (46… 53 mm in size according to the largest transverse diameter), with a clone potato planter into previously cut ridges, to a depth of 8-10 cm. Weed control was carried out using the following herbicides: systemic pesticide (selective herbicide, active ingredient: Rimsulfuron, active ingredient content - 250 g / kg) and systemic pesticide (selective herbicide, active substance - Metribuzin, an active ingredient content - 700 g / kg) in the recommended dose. A two-time spraying of an insecticide, namely an intestinal pesticide (with Imidacloprid as an active substance, 700 g / kg) in the recommended dose was performed against the Colorado potato beetle. During the growth of plants, chemical treatments at the recommended dose were carried out against late blight and early blight as follows: 1-3 times (depending on the conditions of the year) with a fungicide (a contact pesticide). (The active ingredients are as follows: Famoxadone (250 g / l) and Cymoxanil (250 g / l), the first was during the flowering period, then every 10-14 days. The recommended water consumption was 300 l / ha. Potato tuber harvesting was conducted in the second half of August).

In 2017, the average air temperature during the growing season was 16.2 °C, with a norm of 16.5 °C (18.6 °C in 2016 and 17.5 °C in 2015). Total precipitation during the growing season of 2017, 378.4 mm or 145.3% of the norm (260.5 mm) precipitation fell (470.2 mm or 180.5% of the norm in 2016, and 302.45 mm or 116.1% of the norm in 2015). The 2017 hydrothermal coefficient was 2.06 (wet) with a climate norm of 1.3 … 1.4. (It was 2.16 (very wet) in 2016 and 1.46 (wet) in 2015).
5. Research Results

In 2015, the average values of soil moisture were below the optimal values in different phases of plant development (37.6 ... 61.5% of digestible nutrients / PPV in the budding-tuberization phase). The average values of soil moisture in the zone of the tuberous nest gradually decreased from 55.1 ... 55.7% during the budding stage to 34.3 ... 37.6% before harvesting. In 2016, the soil moisture values were sufficient for developing the above-ground plant mass. In 2017, for developing the above-ground mass of plants and tubers throughout the growing season, the soil moisture values were mostly optimal.

Table 1 presents data on the yield of potato varieties depending on the variety (ripeness group) and the use of SAP. The average yield of the Ranniy Meteor variety was 33.7 t / ha under control and 37.0 t / ha with water absorbents; the Srednerannyi Irbitskiy variety — 28.0 t / ha and 30.0 t / ha; the Srednespelyy Golubizna variety - 29.6 t / ha and 31.2 t / ha; the Srednepozidni Lorkh variety - 29.2 t / ha and 31.0 t / ha, respectively.

Table 1. Potato yield depending on the variety (factor A) and the use of SAPs (factor B), t / ha, 2015-2017

| Variety       | 2015     | 2016     | 2017     | Average | ± to control | %     |
|---------------|----------|----------|----------|---------|-------------|-------|
|               | Without superabsorents (control) |          |          |         |             |       |
| Meteor (ranni) | 30.3     | 33.6     | 37.1     | 33.7    | -           | -     |
| Irbitskiy (sredneranni) | 33.7     | 23.4     | 26.9     | 28.0    | -           | -     |
| Golubizna (srednespelyy) | 34.7     | 28.4     | 25.6     | 29.6    | -           | -     |
| Lorkh (srednepozidni) | 34.2     | 26.5     | 26.9     | 29.2    | -           | -     |
| Average variety | 33.2     | 28.0     | 29.1     | 30.1    | -           | -     |
|               | With superabsorvents |          |          |         |             |       |
| Meteor (ranni) | 34.2     | 34.4     | 42.5     | 37.0    | +3.4        | +10.0 |
| Irbitskiy (sredneranni) | 37.1     | 23.6     | 29.3     | 30.0    | +2.0        | +7.1  |
| Golubizna (srednespelyy) | 34.8     | 33.1     | 25.7     | 31.2    | +1.6        | +5.5  |
| Lorkh (srednepozidni) | 35.9     | 26.6     | 30.6     | 31.0    | +1.8        | +6.3  |
| Average variety | 35.5     | 29.4     | 32.0     | 32.3    | 2.2         | 7.2   |
| HCP50, by factor A | 1.11     | 3.58     | 4.87     | -       | -           | -     |
| HCP50, by factor B | 1.34     | 0.69     | 0.74     | -       | -           | -     |
| HCP50, common | 1.84     | 4.17     | 5.72     | -       | -           | -     |

6. Results and Discussion

The greatest amount of water needed by potatoes in the second half of the growing season, during the formation of tubers, falls on the period between the phases of the onset of budding and the drying of the tops. Optimum soil moisture for potatoes is 60-85% of digestible nutrients. With optimal hydration, the effectiveness of fertilizer application is manifested [2]. Soil moisture during the growing season is largely determined by the amount and distribution of precipitation and changes under the influence of certain factors [2]. Vegetation periods of 2015–2017 were characterized by uneven precipitation, which affected soil moisture.

Productivity is the main criterion for evaluating cultural activities. On average, over three years, we can note (Table 1) that when using SAPs, the yield of the studied varieties increased by 1.6 ... 3.4 t / ha (5.5 ... 10.0%). The Ranniy Meteor variety (+3.4 t / ha) and the Srednerannyi Irbitskiy variety (+2.0 t / ha) were particularly responsive, which confirms the greatest need for moisture and early varieties [2]. The Srednespelyy Golubizna and srednepozidni Lorkh varieties were less responsive to the application of SAPs. The highest average yield for all varieties was obtained in a sufficiently moisture-proof (2015), and it was 33.2 t / ha in the control variant and 35.5 t / ha in the variants with the use of SAPs. In 2017, it amounted to 29.1 t / ha and 32.0 t / ha, respectively. At the same time, in very wet conditions of 2016, the yield increase on average for varieties was significant, but not so high and amounted to 28.0 t / ha and 29.4 t / ha, respectively. According to the research results, it was revealed that the use of SAPs provides a conditional net income of up to 39.1 thousand rubles / ha.
The use of SAPs when planting allows one to increase the yield of potatoes. This technology is to reduce the stresses affecting the yield of potatoes, by making superabsorbent polymers. Thus, the application of SAPs from an economic point of view can be promising [7], [9].

7. Conclusion
The application of SAPs increased the yield of the studied potato varieties of different groups of ripeness by 1.6 ... 3.4 t / ha (5.5 ... 10.0%), which makes it possible to get conditional net income up to 39.1 thousand rubles / ha.

We can recommend the use of superabsorbent polymers at a dose of 200 kg / ha when growing potatoes in conditions of moisture deficiency.

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