

Ways to Improve the Productivity and Quality of Potato in Dry Conditions

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DOI: <http://dx.doi.org/10.13005/bbra/1632>

(Received: 10 January 2015; accepted: 10 February 2015)

We give the results of scientific researches for the years 2009-2013, on studying the use of growth regulators to increase stress resistance to drought at potato varieties of different ripening periods. We show the effectiveness of using growth regulators Kampozan 160 g/ha and Humate sodium 200 g/ha for spraying vegetating plants in the beginning phase of budding and after flowering, with a treatment interval of 12-14 days, and with a consumption of the working fluid of 400 hectares, and their mixtures in combination with mineral fertilizers such as chelates "Akvarin-12" (0,3% solution) with a consumption of the working fluid of 100 l/ha. The productivity of potato in drought was determined in 40% by the used drug, in 24% by genotype (Early and Middle-early variety) and in 23% by the influence of the conditions of the year.

Key words: Potato varieties, Growth regulators, Leaf area, Productivity, Quality, Drought-resistance, Ecological plasticity.

In Russia, potato is an important food crop. Its annual consumption should be more than 120 kg per person (B.V. Anisimov, 2000, 2012). In some regions, there is a decrease in the productivity of potato due to the lack of moisture in the atmosphere and soil in different periods of vegetations (Abdulkarimov D., 1987; Alimov V.S., 2003; Galeev R.R., 2011; Dyukarev V.N., 1997; Korshunov A.V., 2001; Kushnarev A.G., 2008). In Siberia the driest conditions for the potatoes' culture are found in such regions as Khakassia, Tuva, the southern area of the Krasnoyarsk Territory, and south of the Irkutsk region, Buryatia and the Trans-Baikal territory. The vast territory with acute lack of moisture causes the need to find ways to improve drought-resistant of varieties

with different ripeness groups (R.R. Galeev, 2010; Kadychev A.N., 2008; Kushnarev A.G., 2010; Poluhin N.I. 2014; Sands P., 1990; Szutkowska M., 2000; Vos J., 1989). Another important aspect in terms of intensification of agriculture is to maintain soil fertility. Soil fertility is determined by the content of humus, the main component of which is humic acid (M.I. Pankow, 2008; Tikhonov T.N., 2010). Currently, in many regions because of a sharp decline in the number of livestock, there is an acute shortage of organic fertilizers. In this regard, it is actual to significantly reduce norms of using organic and mineral fertilizers through their local application, using new types of mineral fertilizers as chelates (NK Yaroshenko, 2007).

In the aspect of improving soil fertility and growth and development stimulation, increasing productivity and quality of potatoes, as well as its drought resistance, it is of particular importance to find effective growth regulators and

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new kinds of mineral fertilizers in the form of chelates.

In this context, the aim of our study was to evaluate the efficacy of the use of growth regulators and mineral fertilizers on the basis of chelates to improve drought resistance, productivity and quality of potato varieties.

METHOD

The experimental work was carried out in the years 2009-2013, in the dry steppe zone on the experimental field of "Rassvet" of the Republic of Khakassia. Studies were carried out on dark brown loam soils with humus content in the topsoil of 2,68%, pH of salt extract – 7,4. Potato Farming equipment, used in the experiments was common for that area. Potatoes were placed after green fallow (rape for green fodder). Weather conditions in the years of experiments differed in temperature and in the amount of precipitation. The highest average of daily temperature in 2009 (May, July and September); in June and August the temperature is higher in 2012. According to the amount of rainfall in May the year 2013 stood out for - 38 mm (142% of norm) and June, September -

2012. In July the amount of precipitation was higher in 2010 - 42 mm and in August - 2011 - 29 mm.

The area of accounting plot was 50 m², replication - 4X.

Experiments were carried out on new districted varieties: Lyubava (early) and Lina (Middle-early). Phenological phases of potato were noted by the method of Gossortset. Growth dynamics of leaf area was set at the age of 20, 40, 60 days from mass shoots and before the harvest on 20 plants of each variety. Leaf area was calculated using the regression formula based on the method of N.F. Konyaev (1970), the photosynthetic potential of potato - by A.A. Nichiporovich. Plants' diseases were determined by the method of the Academy of Agricultural Sciences (1961).

The chemical composition of tubers was detected in the center of Agrochemical Service "Novosibirsk" by the following methods: dry matter - by drying, starch - using polarographic method of Evers, sugar - by Bertrand, vitamin C - by Murree, nitrates - ion-selective method. Data were processed by methods of dispersion, correlation and regression of B.A. Dospheov (1985).

Table 1. The effect of growth regulators and fertilizers on photosynthetic parameters and productivity of potato plants. The average for the years 2009-2013

Variant	Leaf area, thous. m ² /ha		FSP, thousands.m ² day /ha	Productivity		
	maximum	middle		t/1 thousand.m ² of leaves	FSP	g/m ² day average leaf area
Lyubava (early) variety						
Control (water)	24,5	16,2	1490	0,98	34,6	32,8
Kampoza 160 g/ha	26,3	16,8	1529	1,13	35,2	34,2
Sodiumhumate 200 g/ha	28,1	17,4	1531	1,15	35,8	34,8
"Akvarin-12" 0,3%	29,2	17,7	1522	1,18	36,0	35,6
Kampoza 160 g/ha + 200 g of sodium humate/ha + "Akvariin-12" 0,3%						
	37,1	20,4	1682	1,37	39,2	41,5
Lina (Middle-early) variety						
Control(water)	25,1	17,4	1462	1,09	35,7	38,4
Kampoza 160 g/ha	27,3	17,8	1495	1,12	35,5	40,3
Sodiumhumate 200 g/ha	29,3	17,6	1549	1,31	35,9	39,6
"Akvarin-12" 0,3%	34,2	18,8	1578	1,33	40,3	41,8
Kampoza 160 g/ha + 200 g of sodium humate/ha + "Akvariin-12" 0,3%						
	40,8	22,3	1756	1,48	43,2	44,5
NSR ₀₅	0,82	0,76	43,2	0,11	0,98	1,12

The research results

In the period of 2009-2013, in a dry steppe zone on a dark brown loam soils we carried out studies of growth regulators and mineral fertilizers on the basis of chelates to improve productivity and quality of potato varieties with different ripeness groups in extremely dry conditions.

In the budding phase of potatoes and after mass flowering plants, it was treated with growth regulators Kampozan (2-chloroethylphosphonic acid) and sodium humate 200 g/ha with a consumption of the working fluid 400 l/ha. Sodium humate - a well known growth regulator, produced from brown coal, provides a stable yield and good product quality in a severe shortage of water. In the phase of mass budding and after mass flowering with a treatment interval of 12-14 days, we used the chelate form of fertilizer "Akvarin-12" with a concentration of 0,3%, and with a consumption of the working solution of 100 l/ha. The fertilizer contains N, P, K, Mg, S and trace elements in the form of chelates: Fe, Zn, Cu, Mn, Mo, and B.

Our researches have shown that the studied drugs have a positive impact on the growth

and development of plants: the formation of tubers occurred 5-7 days earlier - than it was without the use of drugs on the background of extremely dry conditions.

The use of growth regulators and fertilizers "Akvarin-12" increased the photosynthetic parameters of potato plants: maximum and average leaf area in the early variety Lyubava were above the control at 26-31%. In Middle-early variety Lina maximum leaf area in using of a mixture of growth regulators in combination with the use of a chelating type of fertilizer "Akvarin-12" 0,3% increased by 63% and the average leaf area by 28%. A similar significant increase was found in the study of photosynthetic capacity. Significant excess to the control (water) during the use of growth regulators combined with mineral fertilizer "Akvarin-12" in the studied varieties is equal to 29-58%. Economic productivity of leaves in the early variety Lyubava in the control group (water) was 0,98 t/1 thousand. m² leaves, and in a combined use of the studied drugs has increased 1,4 times (Table. 1). Plant productivity according to FSP in the variety Lina increased by 33% in the early variety Lyubava by 21%. Plant

Table 2. Yield and chemical composition of tubers depending on the use of growth regulators and fertilizers. The average for the years 2009-2013

Variant	Yield, t / ha		Contents in tubers			
	general	commodity	Dry substance, %	Amount of sugars, %	Vitamin C, mg/kg	nitr ates, mg/kg
Lyubava (early) variety						
Control (water)	16	14	20,4	0,90	14,3	43
Kampozan 160 g/ha	19	16	20,3	0,88	14,8	48
Sodium humate 200 g/ha	20	18	20,7	0,96	14,2	40
"Akvarin-12" 0,3%	22	19	20,6	1,12	15,0	76
Kampozan 160 g/ha + 200 g of sodium humate/ha + "Akvarin-12" 0,3%	28	26	20,8	1,06	15,2	62
Lina (Middle-early) variety						
Control (water)	19	17	20,2	0,74	15,5	34
Kampozan 160 g/ha	20	18	20,4	0,80	15,2	40
Sodium humate 200 g/ha	23	21	20,2	0,83	15,4	53
"Akvarin-12" 0,3%	25	23	20,6	0,77	15,5	60
Kampozan 160 g/ha + 200 g of sodium humate/ha + "Akvarin-12" 0,3%	33	29	20,9	0,92	16,1	58
NSR ₀₅	1,43	1,15	0,18	0,07	0,86	10,23

Note. The results of variance analysis of three factor experience (2*5*3) on the total yield: NSR₀₅ for particular differences - 1,43m, NSR₀₅ for main effects - 1,05; NSR₀₅ for private interactions - 1,27 m. The main effects and interactions: A factor (genotype) - 23,6%, B factor (drugs) - 39,8% (year) - 22,5%; AB - 2,2, AC - 0,8, BC - 2,4, ABC - 0,5%.

productivity in the average leaf area is also higher in the integrated use of growth regulators and chelate types of fertilizer. Their combined use increased this rate by 18% compared with their separately use.

The yield indicators of two potato varieties of different ripening periods were higher with the use of the studied growth regulators Kampozan 160 g/ha by 17-21%, and sodium humate 200 g/ha - by 25%. In the version with mineral fertilizer, spraying vegetating plants provided an increase of total productivity - 35% and market productivity - up to 40%. The maximum yield parameters are set with the use of a mixture of growth regulators combined with mineral fertilizers of the helate form, on vegetative plants. Increase to the control in the early variety Lyubava was in the total yield 75%, in the commodity yield- 86%,

while in the Middle-early variety Lina it was respectively 70 and 73% (Table. 2).

Conducting a variance analysis of a three-factor experience allowed determining the part of operating factors on the overall yield. The greatest influence is due to the used drugs 40%, and then - 24% genotype and conditions of the year - 23%.

The used growth regulators and fertilizers in budding phase and after flowering significantly increased dry matter content by 0,4-0,7%, the amount of sugars by 0,22%, vitamin C by 0,9 mg/kg. Nitrate concentration in all variants is significantly below normal - by 4-6 times (MPC for potatoes 250 mg/kg).

Drought resistance of potato plants was assessed by changes in the rate of recovery of chloroplasts potassium ferricyanide in the reaction medium, containing no SO₂ and in medium enriched

Table 3. Assessing the impact of growth regulators on the index of drought resistance of potato plants

Variant	Recoveryrate K ₃ Fe / CN ₆		
	Without CO ₂	In the presence of SO ₂	without CO ₂ / in the presence of CO
Lyubavavariety			
Control (water)	934	881	1,06
Kampozan 160 g/ha	1012	822	1,23
Sodiumhumate 200 g/ha	1048	794	1,32
“Akvarin-12” 0,3%	962	837	1,15
Kampozan 160 g/ha + 200 g of sodium humate/ha + “Akvariin-12” 0,3%	1118	761	1,47
Linavariety			
Control (water)	943	850	1,11
Kampozan 160 g/ha	1026	814	1,26
Sodiumhumate 200 g/ha	1053	763	1,38
“Akvarin-12” 0,3%	985	821	1,20
Kampozan 160 g/ha + 200 g of sodium humate/ha + “Akvariin-12” 0,3%	1202	761	1,58
NSR ₀₅	20,6	41,2	

with SO₂. The value of their relationship characterizes drought resistance of the plants: drought resistance is higher with increasing of the absolute value of the ratio. As we can see from Table, in the 3 variant with treating potato plants in the beginning budding phase by Kampozan by 160 g/ha, the ratio of the rate of recovery rates of chloroplasts potassium ferricyanide in a reaction medium without SO₂ and in an environment

enriched with SO₂ varies in the variety Lyubava (early) from 1,23to 1,26 in the variety Lina (Middle-early). With the use of sodium humate in the beginning of budding phase, the ratio of these indicators is in the range 1,32-1,38. In the case of a mixture of growth regulators we achieved the highest rates of recovery speed of chloroplasts potassium ferricyanide in the reaction medium, and the ratio is in the variety Lyubava1,47- and Lina1,58.

DISCUSSION

The problem of increasing drought resistance of potato is very important. In Siberia this issue has not been studied. In our previous studies, we paid special attention to the selection of the varieties that best adapted to extremely arid conditions. We revealed that these varieties, in particular, are varieties of Siberian breeding, early variety - Lyubava (originator Kemerovo Agricultural Research Institute, Kemerovo, Russia) and the variety Lina (originator - Siberian Institute of Plant and breeding, Novosibirsk, Russia). Along with stress-resistant to drought, these varieties have a complex of valuable agronomic features: high productivity, yield of early production, good quality, relative resistance to disease and some pests, long-term preservation during storage. We have chosen environmentally acceptable growth regulators Kampozan and sodium humate, the last natural growth regulator of brown coal from Siberian fields. The used mineral fertilizer "Akvarin-12" contains macronutrients and trace elements in chelate form, this makes it active even in extremely dry conditions.

The use of drugs on vegetating plants in the beginning of vegetation phase and after flowering, with treatments time difference of 12-14 days, in the varieties of two ripeness groups (early and Medium early) in extremely arid steppe of Khakassia on dark chestnut soils, provided the formation of well developed leaf surface up to 26-60 % above control, spraying with water. Total yield of tubers increased with their application up to 73%, and the commodity yield - up to 86%. We got products with high quality indicators with nitrates content 6 times below the MRL for this culture. As a test to improve the drought tolerance of plants, we selected the change of recovery speed of chloroplasts potassium ferricyanide in a reaction medium containing no CO₂ and a medium enriched with CO₂. Against the background of a mixture of growth regulators, the highest indicators were received: in the studied varieties at a level of 1,50, versus 1,10 in the control (water).

ACKNOWLEDGMENTS

In order to increase drought resistance, productivity and quality of potato plants we should

use spraying vegetating plants in the beginning of budding phase and after mass flowering with an interval of 12-14 days, by growth regulators Kampozan 160 g/ha (2-chloro-ethylphosphonic acid) and sodium humate 200 g/ha, obtained from brown coal with a working fluid consumption 400 l/ha.

The highest effect is obtained by using a mixture of these growth regulators combined with mineral fertilizer in the form of chelates "Akvarin-12" (0,3% solution) with a consumption of the working solution of 100 l/ha.

Statistically proved that the productivity of potatoes depends on drugs in 40%, on genotype - 24, and the weather conditions - 23%.

Further studies will examine the biological characteristics of potato plants of different geographical origin, on the background of using adaptogens, and we will track changes in the biochemical composition of potato proteins by releasing of markers of increased drought resistance of plants in terms of obtaining high productivity and resistance to adverse environmental factors.

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