The effect of planting density on the crop yield, **the structure and the quality of middle-early variety of potato in the west Kazakhstan**

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Abstract. This paper presents the results of studying the effect of planting density of a promising variety Yagodnyi 19 and the standard variety Nevsky on the yield and quality parameters of potato in the conditions of west Kazakhstan. Experimental factors included potato varieties (Nevsky and Yagodnyi 19) and different density planting (40,8, 47.6, 57.1 and 71.4 thou. pcs / ha). Studies showed that the optimum planting density is 57.1 thou. pcs / ha, at which the variety Nevsky formed a yield of - 25.43 thou / ha, Yagodnyi 19- 27.88 thou / ha. When the density was 57.1 thou pcs / ha, compared with the density 71.4 thou. pcs / ha seeds costs decrease by 25%. The average tuber weight decreases with the thickening of planting. With the increase of the planting norm, we can notice some decline in the marketability and an increase in the yield of seed tubers. Thus, there is a tendency of increasing starch and vitamin C content, and reducing the amount of nitrates in the tubers of the examined varieties.

Keywords: potato, planting density, variety, crop structure, starch, nitrate, vitamin C, marketability, yield

Introduction

Potato is a major food crop, which provides food to the population, and covers the needs of food industry. The high importance of potato confirmed by the growing demand and by the expansion of its production. The number of the world's population with the existing growth trends, in the next two decades will increase on average, more than 100 million people a year. Therefore, one of the actual tasks of our time is to provide the population with qualitative, high-calorie food, subject to the protection of the environment, and saving money and energy [1].

Potato is an important reserve for solving this task because of its high nutritional value, gustatory quality and biological plasticity. Its nutritional value is defined by an optimal ratio of organic and mineral substances, necessary for human beings. Depending on the variety, in the potato tubers contains from 15 to 35 % dry matter, 80-85 % of which is starch, and up to 3 % - protein. Carbohydrates, which are presented in the potato with starch - one of the main sources of muscular energy of the human. One gram of carbohydrates when burned in the body gives more 4 calories and more, and 1 kg of potatoes can give 840 calories. The recommended 300-400 g day intake of potatoes provides about 10 % of the physiological caloric needs of people, engaged in physical labor. Potatoes' calorific value exceeds twice the calorific value of carrots, three times the cabbage, four times tomatoes, and it is less than half of the caloric value of beef and eggs [2].

The importance of potato as a food-technological culture is confirmed by its consistently high demand in the market [1].

We can mention some effective agrarian methods that increase the yield and the quality of potato tubers - the properly selected variety and an optimum plant density. The optimum plant nutrition area - one of the most important conditions that determines the completeness of natural resources using, which promotes the cultivation of high yield of good quality potatoes[3].

The optimal feeding area is the one that achieves not the highest efficiency of one plant, but the maximum total yield of economically valuable product per area unit. The most appropriate planting density of potato is that in which each unit area have the greatest assimilation surface, at the same time the plants are under adequate lighting and the leaves maintains vital functions as long as possible [4].

At the same time, according to many scientists, increasing the planting density may lead to a decrease in the average weight of the tuber, and to an increase the outcome of the amount and weight of the tubers per unit area [5, 6, 7].

According to M.F.Zamil and others [8] when the nutrition area of potato plants decreases, the number of stems and tubers reduces tubers weight per one plant. A. Rahemi and others [9] notice that the yield of potato varieties grown in a nutrition area of 70*20 cm. was higher than in an area of 70*30 cm. B. Esmaielpour and others [10] reported that an increase in the planting density increases potato yield.

The reasons for the low yield of potato in the West - Kazakhstan region are: lack of zoned early-maturing potato varieties of intensive type, which can provide high yields of good quality, the imperfection of agricultural techniques of potato cultivation. To provide people with high quality potatoes, we need to study the varieties, and develop zoned agricultural technology elements, which are the most appropriate for the conditions of West Kazakhstan region.

The aim of this study was to study the effect of planting density of the promising variety Yagodnyi 19 and the standard variety Nevsky on the yield and quality parameters of potato in the conditions of western Kazakhstan.

Materials and Methods

For the selection of the optimum planting density, which provides an increase of the yield, and a decrease of the labor in the cultivation of potatoes in 2010 - 2012 years, the department of " plant cultivation and agriculture" of the Faculty of Agronomy of the West Kazakhstan Agro-Technical University named after Zhangirhana, field experiments were conducted on LP (limited partnership) lands "Izdenis" (51 ° 04'60" N and 51 ° 16'60" E) Zelenovsk district of West Kazakhstan region.

A scheme of a two-factor experiment.

Factor A - varieties:

Nevsky - standard

Yagodnyi 19

Factor B - planting density (planting scheme):

40.8 thou. pcs / ha (70 cm x 35 cm)

47.6 thou. pcs / ha (70 cm x 30cm)

57.1 thou. pcs / ha (70cm x 25cm)

71.4 thou. pcs / ha (70cm x 20cm)

The method of placing the plots in the experiment - is randomized. Repeatability of the experience is three times.

The climate of the zone is dry- steppe, altitude above sea level 33 m. Soil: dark-chestnut loamy. The soil analysis showed that humus content is 2.8 - 3.2%, pH 7.1-7.3, total nitrogen content is 0,24-0,27%, hydrolysable nitrogen – 45-68 mg / kg, movable phosphorus P_2O_5 – 32-42 mg / kg and metabolic potassium K_2O–487-532 mg / kg in the soil.

Predecessor - winter wheat. Fertilizers were applied in a dose N90P120K60. In general, the technology of potatoes cultivation corresponded to zonal agricultural demands.

The total area of the experimental plot is 84 m2, the accounting one - is 56 m2. Planting depth was 8-10 cm. Tubers for planting in the experience were selected of the middle fraction, with a weight of 50-80 g. Planting of potatoes in 2010 and 2012 was conducted on May 5, in 2011 - May 7.

Soil humidity was maintained irrigation. During the growing season phenological observations and biometric measurements were carried, according to the method of state variety trials of crops, and the method of experimental work [11, 12]. In field and laboratory conditions, the following indicators of productivity and quality were determined: yield (t / ha), tuber weight from 1 plant (g), the number of tubers and stems on one plant (pieces), average tuber weight (g), the starch content according to Evers, nitrates content using potentiometric method, ascorbic acid (vitamin C) Murry [13] (mg / %), marketability gravimetric method. Statistical analysis was performed by analysis of variance of B.A. Dospehov (1979) [12].

Results and discussion

Analysis of the data obtained in the experiment (Table 1) shows that with the increasing of planting density - the number of stems, number and weight of tubers formed on one plant, as well as the average weight of a tuber - steadily decreased in both varieties. So, sort Nevsky, with the increasing of planting density from 40.8 thou.pcs / ha to 71.4 thou.pcs / ha. the average weight of one tuber decreased by 10.8 g, and the number of tubers - by 1.23 pcs / bush, in the variety Yagodnyi 19- by 12.7 g and 2.03 pcs/bush, respectively (Table 1, Figure 1, 2).
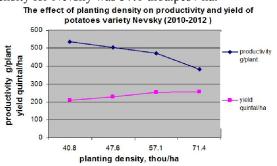
A number of European scientists noticed a reduction of the average size of tubers in the yield, with the increase of planting density, as a result of reducing the income of nutrients to the plants, increasing of intraspecific competition, as well as reducing of the number of tubers with the reducing of the number of stems [14].

Table 1 Effect of planting density on the yield of potato varieties - Yagodnyi 19 and Nevsky in terms of western Kazakhstan (2010-2012)

Variety	Planting density thou.pcs./ha	Tuber mass, g/plant	The number of tubers, pcs/plant	The number of stems, pcs/plant	Average tuber mass, g	Yield, t/ha	Yield excluding seed tubers,t/ha
Nevsky	40.8	536.7	8.03	3.86	66.7	20.87	18.22
	47.6	504.1	7.76	3.76	64.8	22.84	19.75
	57.1	470.6	7.56	3.73	62.1	25.43	21.72
	71.4	380.8	6.8	3.56	55.9	25.74	21.12
Yagodnyi 19	40.8	625.2	8.96	4.56	69.7	24.57	21.92
	47.6	574.7	8.53	4.50	67.3	26.28	23.19
	57.1	509.6	8.03	4.30	63.4	27.88	24.17
	71.4	396.0	6.93	4.06	57.0	26.97	22.35
LSD05						0.75-1.24	

In the variety Nevsky, when planting density was 40.8 thou.pcs / ha, the yield was 20.87 t / ha, when it increasing to 57.1 thou.pcs / ha and 71.4 thou.pcs / ha, we received virtually the same maximum yield 25.43 and 25.74 t / ha, which is excluding seed tubers was 21.72 t / ha and 21.12 t / ha, respectively. Increasing planting density of the variety Nevsky from 57.1 to 71.4 thou.pcs / ha leads
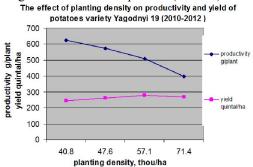
to a significant decline in productivity by 90 g / plant, although the yield remains at approximately the same level in these variants. That is thickened planting 71.4 thou.pcs / ha does not make sense in terms of increased productivity; moreover, it increases by 25% the cost of the seeds. Thus, the optimum planting density for Nevsky was 57.1 thou.pcs / ha.

The effect of planting density on productivity and yield of potatoes variety Nevsky (2010-2012)

In the variety Yagodnyi 19, the highest yield was provided by planting density 57.1 thou.pcs / ha - 27.88 t / ha, with a further increase of planting density to 71.4 thou.pcs / ha, productivity reduced by 114.0 g / plant, and the yield reduced by- 0.91 t / ha. The same pattern is observed in the analysis of yield data excluding seeds. Many researchers note [15], [16] that the increasing of the planting density causes first, an increase of potato yield, and then it begins to decline. The variety Yagodnyi 19 showed a higher yields compared to the variety Nevsky at low planting density 40.8 thou.pcs / ha, so thickening it to 71.4 thou.pcs / ha resulted in a greater increase in competition between plants of this variety, and to a stronger reduction of the yields.

One of the main quality characteristics of potato tubers is the content of the starch. Russian researchers [17], [18], [19] notice that the increase in planting density starch content in many varieties of potatoes increases. In Cyprus, an increase of starch content associated with a decrease of potatoes nutrition area was noticed [20].

Our study shows that the increase in planting density affects the starch content, but not essentially. This index was the largest in the varieties with planting norm of 71.4 thou.pcs / ha (Table 2).

The effect of planting density on productivity and yield of potatoes variety Yagodnyi 19 (2010-2012)

Collection of starch per hectare mainly depends on mainly the level of yield. The largest gathering of starch was observed in the variety Nevsky, in the variant with planting norm 71.4 thou.pcs / ha, the variety Yagodnyi 19 - in the variant with 57.1 thou.pcs / ha. This indicator was the lowest in both varieties in planting variant 40.8 thou.pcs / ha. Nitrate content in tubers of Nevsky variety ranged from 54.5 to 59.0 mg / kg, in the variety of Yagodnyi 19, from 46.6 to 54.1 mg / kg of wet mass. Relatively a greater amounts of nitrate was found in tubers grown with planting density 40.8 thou.pcs / ha. At the same time, it was noted that with the increasing of planting density, nitrate content in tubers somewhat decreased in both varieties. Other researchers reported the same information [21].

The findings of our experiments show that vitamin C content depends on the planting density. With increasing the planting density, we see an increase of vitamin C content in tubers of both varieties. Vitamin C content in potato tubers of Nevsky variety was a bit higher than in Yagodnyi 19 variety.

Table 2 Effect of planting density on the quality indicators of potato crop Yagodnyi 19 and Nevsky, in terms of western Kazakhstan (2010-2012)

Variety	Planting density thou.pcs/ha	Starch, %	Starch collection from 1 ha, t	Nitrate, mg/kg	Vitamin C, mg/%	Marketability,%
Nevsky	40.8	15.49	3.23	59.0	18.17	87.45
	47.6	15.6	3.56	57.3	18.53	86.00
	57.1	15.68	3.98	55.6	18.67	83.89
	71.4	15.8	4.06	54.5	18.86	81.78
Yagodnyi 19	40.8	15.84	3.89	54.1	17.7	89.56
	47.6	15.92	4.18	53.0	17.76	87.43
	57.1	16.14	4.49	50.9	17.93	85.86
	71.4	16.27	4.38	46.6	18.06	83.26

By increasing planting density, the portion of small tubers increases, the portion of large ones declines, the yield of seed fractions increases [22,23].

In our experiments, with an increasing of planting density, the marketability of the tubers declines. The difference between the extreme variants in Nevsky variety came to 5.67%, and in Yagodnyi 19 variety depending on planting density it was 1.48 - 2.11% higher than the Nevsky variety.

Conclusion

According to the conducted studies, 57.1.thou.pcs/ha can be considered as the optimal planting density, at which the variety Nevsky formed a yield - 25.43 t / ha, Yagodnyi 19 - 27.88 t / ha. When the density was 57.1 thou.pcs./ha compared with 71.4 thou.pcs./ha, seeds costs are reduced by 25 %.

The average tuber weight decreases with the thickening of planting. With the increase of the planting norm, we noticed some decline in

marketability, and an increase the yield of seed tubers. Thus, there is a tendency of an increase in the content of starch and vitamin C, and reducing the amount of nitrates in the tubers of the examined varieties.

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