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Ways to increase the use of photosynthetic active radiation by early ripening varieties of potato in Middle Volga Region, Russia

Vladimir Petrovich Vladimirov[1], Gareev Ilgiz Ravilevich[1], Antonina Anatolevna Mostyakova[2,*], Natalya Vladimirovna Sitnikova[2]

[1]Kazan State Agrarian University, 65, Karl Marx Street, Kazan, 420015, Russian Federation.
Kazan (Volga region) Federal University, 18, Kremlevskaya Street, Kazan, 420008, Russian Federation.

***Corresponding author**

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Abstract

Efficiency of fertilizers calculated doses application on planned harvest of early ripening varieties of potato has been studied. The study of potato leaves surface formation, leaf photosynthetic potential, photosynthetic active radiation use factor dynamics on grey forest soils of Middle Volga region forest-steppe showed its dependence on mineral nutrition level. Fertilizers effect on productivity and tubers quality of Sprint and Zhukovsky early ripening varieties of potato is established.

Keywords: Potato; leaves surface; photosynthetic potential (PP); PAR use factor; productivity; starch; vitamin C; nitrates.

Introduction

Among factors that influence the growth and development of plants, solar radiation is the hardest to control. That is why identification of ecological basis and possibilities of crop producing power growth by increased use of solar radiation in photosynthesis process is one of the key problems in modern agriculture. Radiation is the energy source for photosynthesis and water-and-thermal regime of plants; it influences the photosynthesis dynamics, growth of certain plant organs, and harvest formation by crop architectonics dynamics and light adaptation [1,2].

An organic matter is created as a result of productional process. Photosynthesis and mineral nutrition can be considered as processes, by which plant interacts with environment and extracts energy and matter from surroundings, and breathing can be considered as a process of their transformation. Mineral nutrition elements influence the photosynthesis mostly at structures and substances formation of pigments and enzymes and define the activity of the latter. The life span of leaves depends on nutrition elements content in plants. A productional process as a whole more or less depends on these indicators [3].

To increase the photosynthetic active radiation (PAR) utilization factor the development and adoption of new methods of crop producing power growth are necessary. One of these methods is cultivation of planned harvest that provides for development of complex of cultivation technology interrelated elements that provide achievement of predicted harvest level, if timely implemented.

From our point of view, growing of planted harvest can be considered a maximal productivity type of agriculture. This type of agriculture means provision of maximal of potatoes and sorts at given soil and climate conditions. Estimations show that in Republic of Tatarstan combined influence of solar radiation and water-and-thermal regime allow of obtaining 36.26-54.39 ton/ha of potato tubers per year with average humidification [4].

According to data by Kazan Federal University, 2.93 billions of kcal of PAR are radiated on each hectare of Tatarstan territory during vegetation period: 0.61 billions of kcal in May, 0.71 – in June, 0.69 – in July, and 0.89 during August and September. If 3-4% of PAR is used on photosynthesis, then the harvest will be around 15-20 ton of dry biomass or 45-60 ton/ha of potato tubers.

Active photosynthetic surface of crop is mainly defined by leaves surface. Leaf is a main photosynthetic organ [5,6]. 80-90% of all consumed solar radiation and 60-95% of organic matter created in photosynthesis fall to its share [7].

Most of the researchers arrived at a conclusion that crop's optimal leaves surface varies in the range of 20-70 thousand m^2/ha [8-16].

It is established that as leaves surface rises to 30-40 thousand m^2/ha an amount of consumed energy rises significantly. The most favorable leaves surface is 40-50 thousand m^2/ha, its active preservation until the end of productional process and fast decrease or full extinction of agrocenosis by the end of vegetation. Further increase in leaves surface leads to decrease in harvest accumulation per surface unit area of leaves due to optical density of crop [4,17-19].

Therefore, crop leaves surface and net productivity of photosynthesis are the main factors, defining agrocenosis biomass harvest level.

Many authors note it is appropriate to assume the measures to make leaf area reach the biggest size as soon as possible to use the intake of PAR with maximal efficiency. The main measures to make maximal leaf area coincide with maximal radiation intake are optimally early planting and choice of sorts with intensive growth during initial phase of development [18,21-22].

According to Allen and Scott [23], a potential productivity of med-season and full-season variety of potatoes in Western Europe is 90-100 ton/ha, in Eastern Europe – 60-80 ton/ha. At the same time, potatoes productivity in Russia is still low. In 2007-2011, average productivity of this crop was 13.1 ton/ha.

An important factor in development of optimal technologies of crop cultivation is estimation of arable land productivity with consideration for efficient soil fertility, plants provision with mineral fertilizers and detection of dependency between these constituents.

One of the ways to increase the potato agrocenosis productivity is plants mineral nutrition control by use of balanced doses of fertilizers. Nutrients must be easy accessible for plants and in required quantity and form in order to obtain high harvest with good tuber quality [5,24-27].

The aim of this study is to ground a fertilizers rate for planned harvest at 25.0-40.0 ton/ha of early ripening potato varieties tubers (Sprint and Zhukovsky early) on grey forest soils of Republic of Tatarstan.

Materials and Methods

The research was conducted in field experiment in 2011-2013 on grey forest soil of Kazan State Agrarian University testing field. The relief of testing field was smooth. Topsoil thickness was 24-26 sm, pH of salt extract was 5.5-5.6, content of easy-hydrolyzable nitrogen was 110-122 mg/kg, humus content (using the Turin method) was 3.15-3.22%, movable phosphorus content was 119-123 and metabolic potassium content was 140-152 mg per 1 kg of soil, hydrolytic acidity was 5.28-5.36 eq.mg per 100 g of soil, amount of absorbed bases 25.39-25.48 eq.mg per 100 g of soil.

Total acres of plot of land was 72.0 m^2, discount area was 60.0 m^2. Occupancy of samples was sequential. Experiment repeatability was triple. Predecessor was a winter wheat. Planting depth was 8-10 sm. Tubers of medium fraction (60-65 g) were planted. Tubers were of first reproduction, planting density was 53.5 thousand items per hectare.

Fertilizers were applied in accordance to obtain harvest of 25-40 ton/ha. Organic fertilizers were applied before Autumn ploughing, mineral fertilizers were applied at planting. Actual doses of fertilizers are as follows:

1. Estimation for productivity at 25 ton/ha ($N_{37-58}P_{55-60}K_{121-165}$). 2. Estimation for productivity at 30 ton/ha (manure 20 ton/ha + $N_{37-58}P_{35-40}K_{93-137}$). 3. Estimation for productivity at 35 ton/ha (manure 25 ton/ha + $N_{75-96}P_{70-75}K_{128-172}$). 4. Estimation for productivity at 40 ton/ha (manure 30 ton/ha + $N_{112-133}P_{105-110}K_{164-208}$).

Results and Discussion

Meteorological conditions during experimental years were stable and quite favorable for growth and development of potato plants. Due to use of irrigation, plants were well moistened during vegetation period.

Planting of both varieties of potatoes took place at 10th of May in 2011, 8th of May in 2012, and 12th of May in 2013. The shoots appeared at the same time in all experiments. Phases of buds formation, blossoming, and fading of top depend on mineral nutrition level. Increase of nutrition caused certain delay in the beginning of phases of development for both varieties.

Potato productivity depends greatly on a number of plants per unit of area. In consideration of that, we defined plants number at shoots phase, blossoming phase, and before harvest. At shoots phase, Sprint plants number was from 52.65 thousand per hectare in control sample to 52.82 thousand per hectare in sample, fertilized for productivity at 40 ton/ha.

Zhukovsky early variety potato had these characteristics at 52.59 and 52.85 thousand plants per hectare. A number of plants decreased a little by the harvest time. Sprint variety decrease was at 0.38-0.55%, and Zhukovsky early variety decrease was 0.40-0.54%.

Fertilizers are very important for plants fungus, bacteria, and virus resistance. Early ripening potato varieties use productive moisture in full, which increase photosynthesis and accelerate harvest accumulation before late blight of potato spreads. Favorable combination of mineral nutrition and chemical plant protection in our research significantly decreased injuriousness of late blight of potato.

It is established that application of fertilizers for productivity at 25 and 30 ton/ha lowered late blight development for both potato varieties. Thus, when in Sprint control sample a number of plants with late blight was 6.43%, in samples for productivity at 25 and 30 ton/ha it was 0.66 and 0.46% lower. Increased nutrition under fertilization for productivity at 25 and 30 ton/ha boosted late blight development by 0.04 and 0.37%.

Similar situation was observed with Zhukovsky early variety, but this type of plants was more exposed to late blight than Sprint plants. On average during three years 6.93% of Zhukovsky early plants in control sample and 8.00% of plants in fertilized for productivity at 40 ton/ha sample developed late blight.

Growth of potatoes can be divided into three periods: (1) from planting to depletion of mother tuber reserves; (2) growth of plant tops; (3) growth of tubers. These periods partially overlap. In our experiments tops growth began with emergence of seedlings and ended with beginning of intensive tuber formation. Depending on variety, year, and nutrition, simultaneous tops growth and tubers formation occurred for 37-45 days. In the beginning, top growth took place on account of photosynthesis and mother tuber's reserves. Increment of leaves stopped with beginning of intensive tuber formation. During this period, tubers growth occurred on account of photosynthesis and assimilates intake from aging leaves and stem organs. Length of period from tubers formation to their intensive growth varied for different samples.

Study of leaves assimilation surface growth dynamics showed that fertilizers had a great influence on leaves surface and their vital activity during vegetation period. It was considerably higher in fertilized samples at all control dates, except for shoots period.

With insignificant changes during shoots period, in buds formation phase leaves surface increased (depending on nutrition) by 2.6-3.1 times in comparison to previous phase. In control sample leaves surface was 27.4 thousand m^2/ha for Sprint and 25.2 thousand m^2/ha for Zhukovsky early variety.

Leaves surface reached its maximum in blossoming phase regardless of nutrition. In control sample without fertilization, maximal leaves surface of Sprint variety reached 30.0 thousand m^2/ha. Under fertilization for productivity at 25 ton/ha, it increased by 1.12 times, under fertilization for productivity at 40 ton/ha it increased by 1.51 times in comparison to control sample. By the harvest time a significant dying-off of leaves and decrease in their photosynthetic activity occurred. The same situation was observed with Zhukovsky early variety.

Photosynthetic activity is not enough to receive high harvest. The most important factor of productional process is a photosynthetic potential of crops. It represents assimilation surface strength during vegetation period and interface periods. Photosynthetic potential was insignificant at the beginning of vegetation, but, as leaves surface raised, it increased and has reached its maximum at period of blossoming phase to the beginning of tops dying-off, i.e., at intensive tuber growth period.

In control sample without fertilizers, total leaf photosynthetic potential (LPP) of Sprint variety during vegetation period reached 2,161 thousand $m^2 \times$ day per hectare (hereinafter referred to as units), in 25 ton/ha – 2,475 thousand units, in 30 ton/ha – 2,821 thousand units, 35 ton/ha – 3,132 thousand units, 40 ton/ha – 3,413 thousand units, i.e., this indicator raised as the natural result of increase in nutrition. Difference in extreme samples was 1.58 times.

Zhukovsky early variety showed the same pattern during 3 yrs; total LPP during vegetation period reached 2,236 thousand $m^2 \times$ day per hectare for control sample and

3,434 thousand $m^2 \times$ day per hectare in fertilized for 40 ton/ha sample.

The results of studied techniques influence on main photosynthetic process parameters determination showed that fertilizers significantly raised photosynthesis productivity indicators for both potato varieties.

Studies showed that growth of tops goes from phase to phase unevenly. During period from buds formation to blossoming tops dry matter weight raised significantly during short time interval toward dry matter weight in buds formation phase.

Accumulation of tops dry matter weight ended in blossoming phase. Percentage of air-dry matter in plant tops was lower in fertilized samples than in control sample. This is fair for both varieties of potato.

Intensive growth of total potato plants dry matter weight continued until harvest; in second half of vegetation it occurred mostly due to tubers growth.

Provision with mineral nutrition elements significantly raised the use of PAR by plants. In this case, dry biomass harvest for Sprint variety, fertilized for productivity at 40 ton/ha was 13.01 ton/ha and for Zhukovsky early variety – 12.96 ton/ha (6.22 ton/ha and 5.75 ton/ha higher).

Solar radiant energy use factor is very important characteristic of plants vital activity. PAR use factor also depended on nutrition. As nutrition increased, so did the PAR use factor for both varieties of potato. On average during 3 yrs PAR use factor for Sprint variety, fertilized for productivity at 40 ton/ha, was 2.67% and for Zhukovsky early – 2.63%, that is by 1.28 and 1.17% higher than for control sample (Table 1).

Leaves work productivity (LWP) is a tuber output per 1 thousand units of photosynthetic potential (PP). In control sample, Sprint variety plants formed 7.65 kg tubers per PP thousand units, and Zhukovsky early plants – 8.43 kg. In second sample (for productivity at 25 ton/ha) – 10.87 and 11.16 kg; in third sample – 11.68 and 12.10 kg; in fourth sample – 11.51 and 11.73 kg; and in fifth sample – 11.21 and 12.20 kg. Zhukovsky early plants showed similar results, though they differed significantly from year to year.

Decrease in 1 thousand of PP in Sprint variety samples for productivities at 35.0 and 40.0 ton/ha in comparison to 30.0 ton/ha sample can be explained by development of bigger leaves surface and shading of lower levels by higher levels leaves. Zhukovsky early variety plants did not show this pattern over 3 yrs.

One can influence the yield greatly by ratio control between different elements of mineral nutrition by application of different fertilizer doses, estimated for different harvest levels. However, introduction of certain amount of fertilizers into soil does not always provide formation of desired tuber harvest, since there are many factors that influence the mineral nutrition process and, therefore, the efficiency of fertilizers. These factors must be considered in estimation of planned harvest. Among these factors are: climate and weather conditions, soil fertility, biological specifics of plant variety, etc.

In our research application of fertilizers, calculated with the balance method for achievement of harvest at 25-40 ton/ha, significantly increased the yield of both potato varieties (Table 2).

Table 1. Productivity indicators of Sprint variety potato plants depending on nutrition, 2011-2013.

Variety	Planned harvest (ton/ha)	Dry biomass harvest (ton/ha)	Average daily dry biomass intake (kg/ha)	LWP (tuber kg per 1 thousand PP units)	PAR use factor (%)
Sprint	Without fertilizers	6.79	71.2	7.65	1.39
	25	9.47	99.4	10.87	1.94
	30	11.21	117.6	11.68	2.30
	35	12.24	128.4	11.51	2.51
	40	13.01	136.5	11.21	2.67
Zhukovsky early	Without fertilizers	7.21	76.5	8.43	1.46
	25	9.50	100.7	11.16	1.93
	30	11.04	117.1	12.10	2.24
	35	11.86	125.7	11.73	2.41
	40	12.96	137.4	12.20	2.63

Table 2. Yield of early ripening varieties of potato depending on nutrition, ton/ha 2011-2013.

Variety	Planned harvest (ton/ha)	Yield (ton/ha)				Departure from planned (±)	
		2011 Г	2012 Г	2013 Г	Average	Ton/ha	%
Sprint	Without fertilizers	16.12	14.60	15.11	15.53	–	–
	25	28.65	22.10	26.10	25.62	+0.62	+2.48
	30	33.45	30.41	31.25	31.70	+1.93	+5.67
	35	36.08	33.65	34.65	34.79	– 0.21	– 0.60
	40	38.36	35.45	37.12	36.98	– 3.02	– 7.55
Zhukovsky early	Without fertilizers	18.10	16.83	17.36	17.43	–	–
	25	29.65	25.14	28.10	27.63	+2.63	+10.52
	30	34.45	32.42	33.40	33.42	+3.42	+11.40
	35	38.30	34.65	36.24	36.40	+1.40	+4.00
	40	42.21	38.45	40.65	40.44	+0.44	+1.10

According to efficient fertility, yield of Sprint tubers is 15.53 ton/ha; of Zhukovsky early tubers – 17.43 ton/ha. Applied fertilizers for productivity at 25, 30, and 35 ton/ha almost provided that harvest for both varieties. Harvest of tubers at 40 ton/ha productivity was achieved with Zhukovsky early over 3 yrs, and Sprint variety had a shortage of 7.55%.

Application of different calculated by balance method for various harvest levels doses of fertilizers may have a great influence on accumulation of starch, vitamins, and other substances.

Analysis of these tuber quality indicators showed that increase in fertilizer doses did not have a significant effect on starch content in tubers. Application of fertilizers for productivity at 25 and 30 ton/ha increased starch content in comparison to control sample for both varieties of potato. Only doses for productivity at 35 and 40 ton/ha slightly lowered the starch level in tubers (Table 3).

Fertilizers promoted the increase in vitamin C in tubers of both varieties, especially with combined introduction of organic and mineral fertilizers, except for doses for productivity at 40 ton/ha.

All samples had nitrate content in tubers lower than MPC. However, the increase of fertilizer doses caused the increase in nitrate amount in tubers. Control sample of Sprint variety had 28.6 mg/kg of nitrates, second sample – 40.5, third sample – 49.0, fourth sample – 52.9, and fifth sample had 61.9 mg/kg, i.e., nitrate content increased by 11.9-33.3 mg/kg in comparison to control sample. The same goes for Zhukovsky early variety.

Table 3. Potato tuber quality indicators depending on nutrition, %, 2011-2013.

Variety	Planned harvest (ton/ha)	Tuber quality indicators				
		Starch content (%)	Vitamin C content (mg%)	Nitrate content (mg/kg)	Marketability of harvest (%)	Starch collection (ton/ha)
Sprint	Without fertilizers	19.1	21.2	28.6	83.6	2.97
	25	19.3	21.5	40.5	85.2	5.02
	30	19.4	21.7	49.0	87.6	6.15
	35	18.9	21.5	52.9	89.7	6.57
	40	18.7	20.9	61.9	91.6	6.92
Zhukovsky early	Without fertilizers	13.2	23.7	26.9	86.1	2.49
	25	13.4	24.4	38.7	88.8	3.70
	30	13.3	24.7	46.8	90.1	4.44
	35	12.2	24.4	50.6	92.0	4.62
	40	11.8	22.2	59.4	93.0	4.94

Fertilizers had a great influence on the output of marketable tubers in harvest. Marketability of Sprint control sample was 83.6% and as nutrition increased, so did marketability by 1.6-8.0%. Zhukovsky early had harvest marketability at 1.4-3.6% higher in comparison to Sprint variety.

Conclusions

1. According to efficient fertility of grey forest soils of testing fields, yield of Sprint tubers is 15.53 ton/ha, yield of Zhukovsky early tubers is 17.43 ton/ha; application of calculated by balance method doses of fertilizers provided obtaining harvests of early ripening Sprint and Zhukovsky early potato varieties at 25-35 ton/ha.
2. Fertilizers, applied for productivity at 25-40 ton/ha, significantly increased photosynthetic activity of potato plants of both varieties. Leaves surface of Sprint plants was increased by 3.6-15.4 thousand m^2/ha, of Zhukovsky early plants – by 3.9-15.9 thousand m^2/ha, total leaf photosynthetic potential raised by 314-1252 and 359-1198 thousand $m^2 \times$ day per hectare during vegetation, PAR use factor increased by 0.55-1.28 and 0.47-1.17%.
3. Starch content changed slightly with application of fertilizers. Maximal starch content in Sprint plants (19.4%) was obtained under fertilization for productivity at 30 ton/ha, in Zhukovsky early plants (13.4%) – under fertilization for productivity at 25 ton/ha.
4. Nitrate content in all samples was lower than MPC. However, increase in fertilizer doses caused increase of nitrate content for Sprint plants by 11.9-33.3 mg/kg and for Zhukovsky early plants – by 11.8-32.5 mg/kg in comparison to control samples. Marketability of Sprint variety of potato raised by 1.6-8.0% and of Zhukovsky early variety – by 2.7-6.9% with increase in nutrition.

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References

1. Budyko MI, Efimova NA (1968) Use of solar energy by nature plant cover on USSR territories. Botanical Journal 53(10): 1384-1389.
2. Dadykin VP (1975) Accumulation of solar energy in phytomass under different conditions. In Problems of Photovoltaic Energetic of Plants, Kiev: Naukova dumka, pp. 13-14.
3. Kuperman IA, Hitrovo EV (1980) Respiratory metabolism and productivity of agrophytocenosis. Agricultural Biology 15(2): 278-284.
4. Vladimirov VP (2006) Potato in Forest-Steppe of Volga Region. Kazan: Center of Innovative Technologies, p. 307.
5. Gifford RM, Jenkins LD (1987) Use of scientific progress in photosynthesis to increase a productivity of cultivated plants. In Photosynthesis, Govindjee (Ed), Moscow: Mir, Vol. 2, pp. 365-410.
6. Ross YuK (1975) Radiation Mode and Agrotechnology of Plant Cover. Leningrad: Gidrometeoizdat, p. 342.
7. Vavilov PP, Medintsev IP, Postnikov AN (1981) Influence of retardants on level and structure of potato harvest. Proceeding TAA 6: 31-36.
8. Blackman GE (1968) The application of the concepts of growth analysis to the assessment of productivity. In Funct. Terrestr. Ecosyst. Primary Prod. Level. Paris, pp. 243-259.
9. Buttery BR (1970) Effects of variation in leaf area index on growth of maize and soybeans. Crop Science 10(1): 9-13.
10. Donald CM (1961) Competition for light in crops and pastures. Symp. Soc. Exp. Biol. 15: 282-313.
11. Donald CM (1963) Competition among crop and pasture plants. Advances in Agron 15: 1-114.
12. Hiroi T, Monsi M (1966) Dry matter economy of Helianthus annuus communities grown at varying densities and light intensities. J. Fac. Sci. Univ. Tokyo III, 9: 241-285.
13. Hodanova D (1972) Structure and development of sugar beet canopy. I. Leaf area – leaf angle relations. Photosynthetica 6(4): 401-409.
14. Okubo T, Oizumi K, HoshIno M (1969) An observation on solar energy conversion in primary

canopies of forage crops. In Photosynthesis and Utilization of Solar Energy. Level III Experiments. Tokyo, pp. 37-39.

15. Stern WR, Donald CM (1961) Relationship of radiation, leaf area index and crop growth rate. Nature 189(4764): 597-598.

16. Takeda T (1961) Studies on the photosynthesis and production of dry matter in the community of rice plants. Japanese Journal of Botany 17(3): 403-437.

17. Maltcev VF, Kayumov MK (2002) System of Agriculture Biologization in Non-Black Soil Area of Russia. Moscow: FSSI Rosinformagrotech, Vol. 2, p. 574.

18. Nichiporovitch AA (1963) Of ways to increase photosynthesis productivity of plants in crops. In Photosynthesis and Plants Productivity Issues. Moscow: Publisher USSR Academy of Sciences, pp: 5-36.

19. Ustenko GP (1963) Photosynthetic activity of plants in crops as base of harvest formation. In Photosynthesis and Plants Productivity Issues. Moscow: Publisher USSR Academy of Sciences, pp. 37-70.

20. Tooming HG (1977) Solar Radiation and Harvest Formation. Leningrad: Gidrometeoizdat, p. 200.

21. Tooming HG, Callis AG (1972) Calculations of productivity and growth of plant cover. In Solar Radiation and Productivity of Plant Cover. Tartu: IFA ESSR Academy Sciences, pp. 5-121.

22. Shvetcova VM (1987) Photosynthesis and Productivity of Agricultural Plants in the North. Leningrad: Science, p. 95.

23. Allen EA, Scott RK (1980) An analysis of growth of the potato crop. Journal of Agricultural Science Cambridge 9: 583-606.

24. Burmistrova TI, Sysoeva LN, Alekseyeva TP (2012) Study of organic-mineral fertilizers efficiency on growing of potato. Advances in Science and Technology in ACS 5: 32-33.

25. Vasilyev AA (2013) Balance of mineral nutrition defines productivity and quality of potato. Russian Academy of Agricultural Sciences Bulletin 4: 21-23.

26. Vladimirov SV (2013) Formation of potato harvest depending on mineral nutrition level on grey forest soil of forest-steppe of Middle Volga region. Kazan State Agricultural University Bulletin 2(28): 110-114.

27. Shabanov AE, Kiselev AI, Zebrin SN (2011) Productivity and quality of new varieties of potato depending on agrotechnology techniques. Advances in Science and Technology in ACS 1: 30-31.