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The role of organic farming in the formation of the harvest and the nutrition value of potatoes on unused arable lands and fallow lands of Altay Region (Western Siberia)

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In the article, a comprehensive evaluation of the role of organic farming in the formation of the crop and the nutritional value of perspective varieties cultivated within the climatic zone of Western Siberia is considered. The most favorable conditions for growing potatoes in the Altai Region of the Western Siberia are compared with other regions of Russia and those of foreign countries.

In the southern and southeastern regions of the Altai region, where the formation of tubers coincides with the hot period of the first half of summer, the high soil temperature negatively affects the eyes of the tubers. Therefore, the seed material here rapidly degenerates. To avoid this, summer potatoes are planted. Irrigation ensures high and stable potato yields irrespective of weather conditions. Moisture content of soil during the period from planting potatoes to shoots should be maintained at the level of 65-70 per cent, in the budding and flowering phases - of 75-85 per cent and during the period from the beginning of wilting of potato tops – of 60-65 per cent. The number of irrigations, their terms and standards, are determined by taking into account soil-climatic conditions, the phase of plant development and the application area of a crop.

The most effective irrigation method is sprinkling. The irrigation norm ranges from 500 to 800 m3 per hectare. On irrigated lands, plowing of potato fields is carried out necessarily with a soil cultivator, preventing the formation of a plow pan. Rows are located across the slope, or angle-wise. After watering space between rows are loosened (on heavy soils also before watering). During irrigation process it is necessary to apply higher quantities of organic and mineral fertilizers and to carry out a set of measures to control weeds, pests and diseases of potatoes.

Key words: organic farming; potatoes; land allocation; temperature; humidity; tuber formation; favorable temperature; Western Siberia; arable and fallow lands; crop rotation; flowering; starch; proteins; carbohydrates; vitamins

Introduction

All the lands in our country are divided into agricultural and nonagricultural ones. Depending on climatic parameters, a method of land use and soil quality indicators, the subspecies of these two groups are also emphasized. What is agricultural land? The definition of this concept is quite specific (in contrast to the categories). Agricultural lands are called lands intended for growing cultivated plants, breeding livestock and performing related works. Each such plot is characterized by closed boundaries and a certain location. Agricultural lands include the following groups of allotments: arable land, pasture fields, hayfields, perennial plantations, fallow lands. One subspecies can be transferred to another in the process of performing any agricultural activity. But this happens very occasionally. Most of the agricultural lands are plots intended for sowing cultivated plants. Such allotments are referred to arable lands, but only if they are systematically cultivated. In addition to fields with cultivated plants, this group includes sowing of perennial grasses in the areas of crop rotation, excretory fields and pure vapors. The total area of all the Earth's farm fields today is about 1.3 billion hectares. This amounts to about 3 per cent of the land surface. The total area of farmland in Russia amounts to 2434.6 thousand hectares. At the same time, arable land amounts to 60 per cent of all lands. As fallow lands, the areas are qualified which have been plowed previously, but not used for growing plants for more than a year, and which are also not resting. Perennial plantations are lands planted artificially with trees, bushes and perennial grasses. This group includes, for example, berries, orchards, vineyards, hops, tea plantations, etc.

Agricultural lands may be used in a variety of ways. However, fertility appears as the main indicator of their quality. Rational use of agricultural lands is defined as this one leading to obtaining maximum yields without reducing this indicator. The current legislation in Russia provides economic incentives for land users, landowners and tenants to apply such farm practices, which

do not decrease the fertility of plots, but increase it at every possible way. In addition to deteriorating the composition and structure of lands, land misuse can lead to their contamination and flooding. To avoid soil degradation, it is necessary to observe a crop rotation, to use heavy equipment competently (to avoid land reconsolidation), to apply correct quantities of mineral fertilizers and time of their application, to make liming, etc. (Production of vegetables and potatoes..., 1985).

Discussion

In our country, potato is of a great, multifaceted significance. It is used as a food, technical and forage crop (Miakisheva, Tavartkiladze, Durnikin, 2016). Potato tubers contain about 25 per cent of dry matter, including 12-22 per cent of starch, 1.4-3 per cent of protein, and 0.8-1 per cent of ash substances. They contain a variety of vitamins: C, B, PP, K and carotenoids (Miakisheva, Durnikin, Tavartkiladze, 2016). Potato as a technical crop is also of great significance. It may be used as the raw material in production of starch, molasses, dextrin, glucose, alcohol, etc. Potato is widely used for forage purposes. It is especially valuable for pigs and dairy cattle. Tubers, tops and products of industrial processing of potatoes (distiller's wash, pulp) are used up on feeding live-stock animals. Nutritive value of 100 kg of tubers amounts to 20-30 fodder units, tops silage - to 8.5-9, fresh pulp – to 13.2, fresh distiller's wash - to 4 fodder units The total output of forage units amounts to about 5.5 thousand subject to output yield of tubers amounting to 15 tons per hectare and that one of tops amounting to 8 tons per hectare.

As an arable crop, potato is a good precursor of spring crops (spring wheat, corn, beet, barley, millet, etc.). Early potato varieties are effective in a seeded fallow.

Potato is a crop of temperate climate. Tubers usually start germinating when a soil temperature reaches 7-12°C, and the eyes are awakened at a temperature of 3-6°C. The tubers grow most rapidly at a soil temperature of about 20° C. The potato roots are formed at a temperature of at least 7 ° C. Favorable soil temperature for growth of tops and tubers formation is 15-20°C, raising it to 30°C inhibits the growth of potato plants. At an air temperature above 42 ° C, the tops cease to grow, as the plant spends more assimilation products on respiration than their leaves accumulate during photosynthesis. The tops can withstand only a short-term drop in soil temperature to minus 1-1.5°C, its growth stops at temperatures below 7°C. Long-term action of low temperatures kills seedlings, but they can reappear if tubers of a not very small size were used for planting. Intensive growth of tubers is observed when the soil gets warmed up to 6-7°C, and a temperature increase up to 23-25°C delays their growth, and at a temperature of 29-30°C tubers formation practically ceases, in this case irrigation is necessary.

Potato is a light demander. Under insufficient light, the plant forms few tubers of poor quality. Therefore, it is very important to arrange the rows of potatoes properly. When located from north to south, the rows of plants are illuminated more evenly than those located from west to east.

Potatoes have the highest demand for the soil moisture (Scugina, 1984). Their transpiration coefficient amounts to 400-550, though it varies ranging from 170 to 660 depending on the growth conditions. The need for moisture varies in relation to their growth phases. At the first phase of their growth, potatoes can take up moisture reserves available in the mother tuber.

The critical period is the phase between the beginning of flowering and the termination of the tops growth. The lack of moisture in the soil during this period leads to a significant diminishing of tubers yield. The transpiration coefficient, or the amount of water expended by the plant to form a dry matter unit, is about 400-500 (Zimmert, 2000) and varies between 230 and 700 depending on the growth conditions. The most favorable conditions for the growth of potatoes and the formation of a heavy yield of tubers are provided when the soil moisture accounts for 70-80% of the total field moisture capacity in the zone where the main mass of roots is spread during flowering and tuber formation, and for 60-65% - during the top necrosis and starch accretion in the tubers.

In Western Siberia, heavy potato yields are obtained when the total amount of precipitation during the vegetation period is no less than 300 mm with higher intensity in June-July and August. Water saturation reduces the yield of tubers and the starch content in them significantly. Potatoes take up atmospheric moisture better than other crops. Potatoes absorb dew or fog drops falling on the leaves with grandular hairs.

Potatoes grow in different soils, but the greatest crops are secured on well-cultivated sandy and medium-textured loams. The less the soil density around the area of the tuber formation and the better supply of the root system with atmospheric oxygen, the higher the yield. For potatoes, loamy soils with a bulk density of 0.9-1.2 g / cm3 are considered optimal. In firm soils potato sprouts begin to emerge later, and in some cases potato tubers putrefy. Therefore, it is important to maintain the soil in a friable state throughout the whole vegetative period of plants. For the growing of seed material, the most suitable soils are peatlands that have potentially high fertility and favorable physical properties (optimal porosity, moisture capacity, and low soil density). Potatoes grow best in acidic soils with a pH of 4.5 to 5. Nutrients in large amounts are required for the growth and development of potatoes. When 10 tons of tubers are formed, potato plants absorb about 50 kg of nitrogen, 20 kg of phosphorus, 90 kg of potassium, about 40 kg of calcium, 20 kg of magnesium from the soil.

In Western Siberia, potatoes are planted after perennial grasses (by furrow slice and its overturning), winter crops, legumes, annual grasses and flax, in sandy soils after lupine. In Ukraine and the North Caucasus, in the Volga region and Central Asia, the best predecessors of this crop are winter crops, corn, and annual grasses. Potato belongs to a few crops that are able to produce heavy yields while subjecting to longtime re-cultivation in the same place under conditions of good soil treatment and proper application of fertilizers. This, in particular, is evidenced by the practice of collective and state farms located in suburban areas. When growing potatoes in fertile areas with a high level of agrotechnics, absence of diseases, forced change of planting material, repeated planting on the same sites within the period of 2-3 years is permissible. However, rotations for seed potatoes

should have such a shift of crops, when the potatoes return to their original place in no earlier than 3-4 years. Early potatoes are usually placed in a steam field. Applying organic and mineral fertilizers leads to high yields of potatoes and winter crops sown after it (System of reference ..., 1987).

Soil nutrition is the most critical parameter for growing potatoes. Potato plants take up large quantities of potassium, then nitrogen and smaller amounts of phosphorus. Considerable quantities of organic fertilizers (50-80 tons per hectare) benefit the soil and improve its physical properties. Clay and loamy soils become less cohesive, which is especially important for mechanized harvest, sandy and sandy loam soils lock in moisture better. Organic fertilizers increase potato yield, and starch content in tubers. In the areas of the Central Russia, the North-West, the Urals, and Western Siberia, 30-40 tons of organic fertilizers are applied; in the North 40-60 tons, in the Central Black Earth region, the Volga region, in the North Caucasus - 20-30 tons and on irrigated lands of the South - 15-20 tons per hectare (Vereshchagin, Levshin, Skorokhodov, 2003). The amount of manure is increased to 60-80 tons per hectare for poorly cultivated soils. Its quantity depends on the presence in the crop rotation of perennial grasses, green manure crops, and stubble crops. The best fertilizers for potatoes are partially decomposed manure, peat-manure composts, and also green manure, which can be obtained by sowing serradella and lupine under winter grains, or stubble crops of lupine. Sour soils must be chalked. Organic fertilizers and lime are best to apply during the autumn plowing of the soil or under the precursor. The introduction of organic fertilizers in the spring leads to soil compaction, the spread of weeds, and often to a prolongation of the planting time. Mineral fertilizers are applied together with organic fertilizers. In Western Siberia, nitrogen fertilizers in combination with phosphorus and potash fertilizers are of higher value. Ammonium nitrate should be introduced primarily. In the Central Black Earth zone, phosphoric fertilizers (superphosphate, and phosphorite meal applied in sour soils) work for higher productivity, and potash fertilizers are most effective when applied in sandy soils and loamy sands. As for potassium fertilizers they should be either chlorine free or poor in chlorine when applied for potatoes. A large quantity of chloride salts in the soil inhibits the starch accumulation in tubers. Fertilizer rates depend on the amount of the crop planned and on the soil type (System of Measures ..., 1997; Scholz, 1990).

Phosphate and potash fertilizers are introduced in autumn during deep plowing or in spring under replowing, nitrogen fertilizers are applied in spring due to nitrate leaching risk. Good results are obtained by adding ammonium nitrate and granulated superphosphate to the nests or furrows when planting potatoes. In light soils, magnesium fertilizers are applied in amounts of 40-50 kg per hectare or 0.25-0.3 tons of dolomite meal; in marshy soils the quantity of copper sulfate applied amounts to 5-6 kg (when planting potatoes). In soddy-podzolic soils, boric, zinc and molybdenum fertilizers should also be applied.

Potatoes are highly demanding for soil aeration. For a good development of roots, stolons, tubers, it requires deep tillage. In autumn, after harvesting the predecessor, the stubble on the field should be broken once or twice, depending on the weed infestation, then in 2-3 weeks winter tillage should be processed: soils with a deep humus-accumulated horizon are plowed by an ordinary plow at a depth 28-30 cm, soddy-podzolic, gray forest and other soils with plough horizon at a depth of 19-22 cm are tilled with a subsoil plow or noninversing plow without overturning the subsurface layer. When cultivating the soil for potatoes, it is possible to deepen the arable layer by 2-3 cm. In the northeastern regions of Western Siberia, where the post-harvest period is rather short, fields should be plowed immediately after harvesting the predecessor to full depth, and then, if the weed seeds germinate, tilling should be carried out or the stubble on the field should be broken. A layer of perennial grasses is preliminarily cultivated with a disk harrow in two directions, and then plowed with a plow with a skim colter. The stubble on cultivated peat bogs and swampy soils should be removed to a depth of 6-10 cm by heavy disc harrows, and then they should be plowed to a depth of 30 cm. If weeds appear, the field is treated 1-2 times with disc stubble breakers. In light sandy loamy soils fall-plowing can be replaced by tillage in autumn to 14-16 cm. Additional soil preparation is essential in spring in order to create a deep broken arable layer required for good growth and development of plants. It starts with early spring single-cut or tandem disc harrowing. When growing potatoes in light soil after early spring harrowing, the field is plowed to a depth of 16-18 cm. If organic fertilizers are introduced in autumn, fall-plowing can be replaced by complete cultivation up to 12-14 cm. In the northwestern and northern regions of Western Siberia with excessive moistening, the field should be replowed to 18-20 cm by single-furrow plows with skimmers and subsoil disrupturers. In areas with insufficient moistening, subsurface loosening is carried out. When organic fertilizers are applied in spring, plows are used on which the hulls are installed for nonmouldboard cultivation instead of the moulboards, and the skimmers are buried under 12-14 cm. In Western Siberia, the depth of the nonmouldboard cultivation should be about 27-30 cm. On cultivated peat bogs and marsh soils, spring cultivation is started with single-cut or tandem disc harrowing by thawing of soil to 10-15 cm. Before planting the potatoes, the field is repeatedly cultivated with a disc harrow and rammed with water-filled rollers. In some areas, pre-planting ridge tillage is effective. Depending on weather and soil, the ridges are cut (instead of pre-planting cultivation) a few days before or on the day of planting with a cultivator equipped with tier hilling plows. In sandy loamy soils, the cutting of the ridges can in some cases replace even the spring plowing of the winter tillage. While cutting ridges, mineral fertilizers are introduced, excluding this operation when planting potatoes. Harrowing is an essential part of a spring soil cultivation (Sands, 1990).

Preparation of planting material starts in autumn. During the harvesting of potatoes, healthy and whole tubers weighing 50-80 g are taken for seeds. In spring, the preparation of tubers for planting includes unloading from storage facilities, removal of impurities and defective tubers, calibration, heating, disinfection. Calibration of seed potatoes is carried out at stationary points or by mobile machines. To produce an early harvest, the tubers are germinated. This method is obligate in areas with short summers and early autumn frosts. Germination of tubers is also used in the humid western and north-western regions, where potatoes are strongly affected by potato blight in autumn (Ivenin, 2015). Potatoes should be planted within short time-frames in accordance with the prescribed planting rate and planting depth. The tubers are planted when the soil at a depth of 10 cm warms up to 6-8 °C, in light soils even somewhat earlier. First of all, potatoes are planted in seed fallow and on plots for summer harvesting. The time of planting potatoes in areas with a short crop season where tubers may not ripen until autumn frosts

should not be delayed. However, when planting potatoes, not only the temperature, but also the workability of soils should be taken into account especially where soils are loamy. In Western Siberia, ridge planting is carried out, and the tubers are plowed under a depth of 8-10 cm. In the area of insufficient moistening and on light soils of the Non-Black Earth Region, the depth of planting is increased up to 10-12 cm; in the northern regions and in areas with a high groundwater level, the ridge planting of potatoes is used. The soil in the ridges is warming up faster; the relevant water-air and thermal regimes are created. In areas with insufficient moistening of the steppe part of Western and Eastern Siberia, planting is carried out only on level stretches (Yashina, 2010).

Small seeds are sown closer than medium and large ones. Optimal density of planting while using tubers weighing 50-80 g amounts to 45-55 thousand bushes per 1 hectare (45 thousand - in sandy and sandy-loam soils and 50-55 thousand - in loamy soils). With irrigation, the planting density is increased to 50-60 thousand, in seed plots up to 60-70 thousand shrubs per 1 hectare (Pisarev, 1990).

Sprouts appear in 13-20 days after planting. During this time, weeds can grow, a soil crust may appear which hinders the sprouts emergence and causes the soil to dry out, and in the case of a cold long spring, the shoots can be affected by rhizoctonia disease, which leads to a blindness in seedlings. Therefore, the fields are harrowed several times before and after sprouts emergence, in particular on heavy cohesive soils up to 2-3 times (last time on shoots). For this process, light harrows are applied because heavy harrows can turn the tubers to the surface. Further care for potatoes is reduced to a systematic (as weeds grow) bursting of potato rows until closing of crop. For bursting of light soils, cultivators are used, and for heavy soils cultivators and then hilling plows are applied when sprouts grow to 18-20 cm. For the second time, potatoes are hilled up 10-15 days after the first hilling-up procedure. The hilling-up of potatoes is of great agrotechnical importance. It allows expanding a loose soil layer around the plants, which creates conditions for the formation of additional underground stems and new tubers (Nikulin, Kosyanchuk, Kuvshinov, 1994). When soil moisture exceeds 80%, the formation of tubers stops, and after 3-5 days formed tubers start to rot (Cheremisin, 2014). To prevent water saturation, high ridges should be arranged and repeated bursting and hilling should be carried out. Under dryland conditions, hilling can cause the soil to dry out, so it is better not to process it. For protection against diseases and pests, potatoes are sprayed 4-5 times with pesticides, including 2-3 times simultaneously against late blight and Colorado beetle. For the control of weeds, potato plants are treated with herbicides.

Conclusions

In the southern and southeastern regions of the Altai region, where the formation of tubers coincides with the hot period of the first half of summer, the high soil temperature negatively affects the eyes of the tubers. Therefore, the seed material here rapidly degenerates. To avoid this, summer potatoes are planted. Irrigation ensures high and stable potato yields irrespective of weather conditions. Moisture content of soil during the period from planting potatoes to shoots should be maintained at the level of 65-70 per cent, in the budding and flowering phases - of 75-85 per cent and during the period from the beginning of wilting of potato tops – of 60-65 per cent. The number of irrigations, their terms and standards, are determined by taking into account soil-climatic conditions, the phase of plant development and the application area of a crop.

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