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The Effect of the Timing of Manure Application in Combination with Mineral Fertilizers and Planting Density on the Weediness of Potato Plantings

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Abstract. Potatoes are one of the most responsive crops for grooming techniques since in the period from seedlings before closing rows are easily suppressed by weeds that take away nutrients, water, light from it. The factor that causes high harm to potatoes is weed. By absorbing a large number of nutrients and moisture from the soil, weeds inhibit the growth and development of plants, reducing their potential productivity. The purpose of the study was to establish the effect of the timing of the introduction of bedding manure in conjunction with mineral fertilizers and planting density on the weediness of potato plantings. Studies were provided to identify the impact of the timing of bedding manure together with mineral fertilizers and planting density for weed planting potatoes. Experiments were laid by the systematic method with a tiered arrangement of variants in the experiment with a 3-fold repetition. We used cattle manure on straw bedding for autumn-winter harvesting. The following types of fertilizers were used: ammonium nitrate, double superphosphate, potassium chloride. Determination of the amount and biomass of weeds in potato plantings was carried out in the flowering phase and before harvesting. The application of manure was accompanied by an increase in the number and weight of weeds. Annual weeds predominated in potato plantings: *Amaranthus retroflexus* L., 1753 and *Amaranthus blitoides* S. Watson, 1877, *Chenopodium album* L. Chenopodium album L., 1753, *Setaria* P. Beauv, 1812 and *Setaria viridis* (L.) P. Beauv, 1812, *Echinochloa crus-galli* (L.) BEAUV., 1812 and others, perennials included *Cirsium arvense* (L.) SCOP. 1772 and *Sonchus arvensis* L., 1753, (*Elytrigia repens* (L.) DESV. ex NEVSKI, 1933 and others. Planting density also has a definite effect on the development of weeds. When manure was applied in autumn under the plow, the number of weeds increased in comparison with other options, where only mineral fertilizers were applied. The application of manure over frozen plow and in winter over snow leads to a slight decrease (2.3-2.5 pcs/m^2) of weeds. The greatest number of weeds is observed during the spring application of manure for plowing the fall plow. Nevertheless, studies aimed at clarifying the composition and structure of weediness, the number and weight of weeds in potato plantings are of great practical importance for local agricultural producers. These data should contribute to the development of an effective weed control system and high yields of potatoes in the region

Keywords: quantity and weight of weeds, annual and perennial weeds, weed planting of potatoes, manure and mineral fertilizers

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INTRODUCTION

Preservation and improvement of soil fertility is the main part of the general problem of rational use of land resources, increasing productivity, and improving the soil ecology of agricultural landscapes [1; 2]. One of the most effective factors affecting plant growth and productivity, is mineral nutrition. By regulating the intensity of nutrient supply to plants by applying fertilizers, it means changing the activity, and even the direction of biochemical reactions, which, ultimately, will significantly increase the efficiency of the fertilizers used and use the potential of the crop or varieties [3].

Some authors [4] found the use of mineral fertilizers, especially nitrogen, in moderate doses in combination with phosphorus, significantly improved the nutrient regime of the studied crops during their vegetation.

Potatoes are one of the most responsive crops for grooming techniques since in the period from seedlings before closing rows are easily suppressed by weeds that take away nutrients, water, light from it. The factor that causes high harm to potatoes is weed. The presence of weeds on the field leads to a dramatic decrease in the productivity of land and the marketability of tubers. By absorbing a large number of nutrients and moisture from the soil, weeds inhibit the growth and development of plants, reducing their potential productivity. Caring for potato plantings and harvesting tubers infested with weeds is difficult, therefore total costs also increase. After planting, tubers germinate slowly while weeds grow fast. In addition, the non-simultaneous germination of weeds complicates their elimination in the field. Weeds generally absorb moisture and nutrients by growing in potato plantings. Thereby they reduce the moisture and nutrient content of the soil.

Strong weeds *Amaranthus*, *Sonchus arvensis* L., *Echinochloa crus-galli* (L.) Beauv, various species of *Polygonum* (L.) have a negative effect not only on the potato yield, but also on the size tubers which reduces them marketability complicate mechanized harvesting, increases storage losses [5]. Weed control is a necessary condition for increasing the yield of potatoes, improving their quality, and reducing labor costs [6]. B.A. Pisarev [7], and N.M. Nenakhova [8] argue that it is difficult to get rid of weeds sprouting in the second half of the summer, after closing the tops on heavily weedy potato plantings, even with frequent mechanical treatments, especially with frequent rains or irrigation.

According to A.M. Shpanev and others [9], the results of the research have revealed general positive effect of the mineral fertilizer application and protective measures on weed infestation and potato yield. This effect was developed on the second half of the vegetation and expressed in stronger inhibition of plant development (from 36.6 to 20.4 and 11.1 g/m^2 on low, medium, and high levels of mineral nutrition, respectively), in the reduction of species diversity (from 12 to 10 and 10 species/m^2) and number (from 69 to 42 and 32 species/m^2) of weeds. The highest biological (biomass reduction – 95.3%, the number of weeds – 79%) and economic (yield increase – 228 c/ha or 107%) effect was achieved by a high rates of mineral fertilizer application with combined protective measures of potato crops from weeds. In addition, this option was characterized by the greatest profitability (125.3%), whereas chemical protection, providing double treatment of potato plantings with herbicides, even at the middle and high level of mineral nutrition was less effective (102.6 and 109%) in economic terms.

J.V. Aspidova, M.S. Galiev [10] note that a high degree of weed infestation in the field reduces the productivity of harvesting machines by 50%, increases potato damage by 70%, and reduces the yield by 25%.

Some researchers [11] proved that the qualitative characteristics of potato weediness also changed significantly, whereas mechanical treatment of the control variant contributed to the preservation of the number of species of the weed component of the agrocenosis at a high level – 10 species/m^2 before hilling. In the studies of a number of authors [12], the use of the albite complex drugs in a tank mixture with the herbicide lapis lazuli, SP, in comparison with the treatment of plantings with herbicide only, increased the yield of potato tubers to 4.5 t/ha (by 19%) and tops to 0.6 t/ha (by 8%).

It is certain that in the presence of 10 weeds/m^2 before flowering, the productivity of plants decreases by 75.2 g, that is, each weed reduces the average yield of tubers by 4.5 g/m^2 [13]. For the Non-Black Earth Zone of Russia, the presence of 5 *Chenopodium album* L. plants per 1 m^2 reduces the yield by 43%. 40 plants – up to 74% [14]. Therefore, an analysis of research data carried out in a wide variety of soil and climatic zones shows that fertilizers and planting density have a certain effect on the weediness of the planting, which ultimately affects the yield and quality of potato tubers.

The purpose of the study was to establish the effect of the timing of the introduction of bedding manure in conjunction with mineral fertilizers and planting density on the weediness of potato plantings.

MATERIALS AND METHODS

The experiment scheme:

1. $N_{60}P_{120}K_{60}$
2. $N_{90}P_{120}K_{60}$
3. 40 t of manure for wintering + $N_{60}P_{120}K_{60}$
4. 40 t of manure for wintering + $N_{90}P_{120}K_{60}$
5. 40 t of manure on frozen plow + $N_{60}P_{120}K_{60}$
6. 40 t of manure on frozen plow + $N_{90}P_{120}K_{60}$
7. 40 t of manure in winter on snow + $N_{60}P_{120}K_{60}$
8. 40 t of manure in winter on snow + $N_{90}P_{120}K_{60}$
9. 40 t of manure for plowing + $N_{60}P_{120}K_{60}$
10. 40 t of manure for plowing + $N_{90}P_{120}K_{60}$

Landing scheme: 70x25 cm and 70x25 cm. The research was carried out peasant farm "Tuatay" Chingirlau

district of West Kazakhstan region of the Republic of Kazakhstan in 2017-2019.

Soil dark chestnut, medium loamy [15]. The humus content in the arable horizon is from 2.6 to 3.4%, the thickness of the humus horizons is 45-55 cm, effervescence from 45-50 cm. In terms of the content of total nitrogen, phosphorus and potassium, as well as in terms of soil pH, experimental crop rotation fields were relatively homogeneous: total nitrogen content – 0.292-0.356%; P_2O_5 – 2,6-3,5 and K_2O – 45,8-52,0% mg per 100 g of soil; pH – 7.2-7.3 aqueous extract.

The experiments were laid by the systematic method with a tiered arrangement of variants in the experiment. The total area of the plot is 84 m^2, the counting area is 56 m^2, the replication is 3 times. The experimental plot was divided into plots in the fall. The experiments were carried out in an irrigated area. The moisture content of the soil was maintained by irrigation in the range of 75-85% of the lowest moisture capacity of the soil.

The potatoes were placed in the vegetable crop rotation after the cucumbers. Winter plowing was carried out at the beginning of September to a depth of 27-30 cm. The selection of medium sized tubers (50-80 g) for the establishment of experiments was carried out in early spring. In the experiments, we used the zoned medium-early variety Nevsky. Planting was carried out with tubers germinated in the light.

Cattle manure on straw bedding was used for establishing the trial for the autumn-winter harvesting. Manure was obtained by bedding 5 kg of straw per 1 head of cattle with daily harvesting and storage in a pile on a concrete area. The characteristics of manure were as follows: humidity: 58-62%, pH: 7.5-8.0, total nitrogen: 0.50-0.55, phosphorus: 0.22-0.25, potassium: 0.58-0.62, ash: 12-14%. The composition of the manure differed little over the years. The following types of mineral fertilizers were used: ammonium nitrate, double superphosphate, potassium chloride.

Before the potatoes were planted in spring the soil was prepared in early-spring by plowing with fertilizer and harrowing.

Determination of the number and weight of weeds in potato plantings was carried out in the flowering phase and before harvesting.

RESULTS AND DISCUSSION

The application of bedding manure was accompanied by an increase in the number and biomass of weeds (Table 1). The data show that the number and weight of weeds varied both by year and by variant. Irrigated lands West Kazakhstan region are littered with *Amaranthus retroflexus* L., 1753 and *Amaranthus blitoides* S. Watson, 1877, *Chenopodium album* L., 1753, *Xanthium strumarium* L., 1753, *Solanum nigrum* L., 1777, *Setaria* P.Beauv, 1812 and *Setaria viridis* (L.) P.Beauv, 1812, *Convolvulus arvensis* L., 1753, *Barbarea vulgaris* W.T.Aiton. 1812, *Echinochloa crus-galli* (L.) Beauv, 1812 and others.

In field experiments Z.P. Okazova [16], it was found that the main weeds of potato seeding are: *Galinsoga parviflora* (Cav.), 1795, *Artemisia vulgaris* L., 1753, *Ambrosia* L., 1753, *Panicum capillare* L., 1753, *Centaurea cyanus* L., 1753, *Papaver* L., 1753, *Atriplex* L., 1753, *Convolvulus arvensis* L., 1753, *Girsium arvense* L., 1753, *Melandrium album* L., 1789, *Erigeron canadensis* L., 1753, *Digitaria sanguinatis* L., 1753, *Cirsium arvense* (L.) SCOP., 1772 *Capsella bursa-pastoris* L., 1792, *Helianthus tuberosus* L., 1753.

Table 1. *Influence of the timing of the introduction of manure on the weediness of potato plantings*

Landing scheme	Terms of application of manure	The number and weight of weeds															
		2017				2018				2019				Average over 3 years			
		Flowering phase		Before cleaning		Flowering phase		Before cleaning		Flowering phase		Before cleaning		Flowering phase		Before cleaning	
		pcs/m^2	g/m^2	pcs/m^2	g/m^2	pcs/m^2	g/m^2	pcs/m^2	g/m^2	pcs/m^2	g/m^2	pcs/m^2	g/m^2	pcs/m^2	g/m^2	pcs/m^2	g/m^2
70x25 cm	$N_{60}P_{120}K_{60}$	7.9	35.5	11.7	104.9	9.8	125.1	12.2	150.9	10.3	51.5	13.3	226.1	9.3	70.7	12.4	160.6
	$N_{90}P_{120}K_{60}$	9.0	41.7	12.8	106.7	10.1	127.4	12.6	157.6	11.3	61.2	13.4	231.4	10.1	76.7	12.9	165.2
	40 t of manure for wintering + $N_{60}P_{120}K_{60}$	15.9	65.8	18.2	174.6	14.2	140.2	15.2	184.3	12.0	142.2	14.4	237.4	14.0	116.0	15.9	198.7
	40 t of manure for wintering + $N_{90}P_{120}K_{60}$	15.9	65.6	18.2	184.6	14.6	147.3	15.6	187.1	12.3	144.4	14.4	238.6	14.2	119.1	16.0	203.4
	40 t of manure on frozen plow + $N_{60}P_{120}K_{60}$	18.2	72.8	24.5	305.2	14.9	151.2	16.2	191.2	13.2	145.4	14.6	282.2	15.4	123.1	18.4	259.5
	40 t of manure on frozen plow + $N_{90}P_{120}K_{60}$	18.8	86.9	25.5	322.2	15.0	152.6	16.4	191.9	13.4	145.5	15.5	246.3	15.7	128.3	19.1	253.4

Table 1, Continued

Landing scheme	Terms of application of manure	The number and weight of weeds															
		2017				2018				2019				Average over 3 years			
		Flowering phase		Before cleaning		Flowering phase		Before cleaning		Flowering phase		Before cleaning		Flowering phase		Before cleaning	
		pcs/m^2	g/m^2	pcs/m^2	g/m^2	pcs/m^2	g/m^2	pcs/m^2	g/m^2	pcs/m^2	g/m^2	pcs/m^2	g/m^2	pcs/m^2	g/m^2	pcs/m^2	g/m^2
70x25 cm	40 t of manure in winter on snow + $N_{60}P_{120}K_{60}$	19.2	94.6	24.6	300.6	14.5	150.2	16.4	192.5	13.2	144.9	14.5	240.7	15.6	129.9	18.5	244.6
	40 t of manure in winter on snow + $N_{90}P_{120}K_{60}$	20.5	101.4	25.0	308.2	14.9	151.7	16.5	192.7	13.2	145.0	14.8	243.2	16.2	132.7	18.7	248.0
	40 t of manure for plowing + $N_{60}P_{120}K_{60}$	24.5	128.5	27.4	328.2	15.4	157.2	17.8	195.2	13.9	148.4	15.3	248.2	17.9	144.7	20.1	257.2
	40 t of manure for plowing + $N_{90}P_{120}K_{60}$	25.6	134.6	28.1	333.6	15.7	161.4	18.1	198.2	14.0	148.8	15.4	252.3	18.4	148.2	20.5	261.3
70x35 cm	$N_{60}P_{120}K_{60}$	10.8	42.4	13.4	216.4	10.4	122.4	12.6	152.4	10.9	58.3	13.7	244.1	10.7	74.3	13.2	204.3
	$N_{90}P_{120}K_{60}$	12.4	44.6	14.1	218.6	11.3	129.1	13.4	158.1	11.6	67.1	15.1	249.7	11.7	80.2	14.2	208.9
	40 t of manure for wintering + $N_{60}P_{120}K_{60}$	16.6	78.4	22.2	372.8	15.2	134.2	19.1	224.2	13.3	150.7	16.7	252.6	15.0	121.1	19.3	283.2
	40 t of manure for wintering + $N_{90}P_{120}K_{60}$	19.8	82.8	23.2	384.5	15.4	134.9	19.2	225.2	13.6	159.4	17.5	257.9	16.2	125,7	19.9	289.2
	40 t of manure on frozen plow + $N_{60}P_{120}K_{60}$	22.4	98.4	22.0	364.6	15.7	139.3	19.4	225.6	13.7	161.3	17.6	263.2	17.2	133.0	19.6	284.4
	40 t of manure on frozen plow + $N_{90}P_{120}K_{60}$	23.1	104.5	22.8	369.1	15.9	141.1	19.5	226.3	13.9	162.2	17.8	264.1	17.6	136.0	20.0	286.5
	40 t of manure in winter on snow + $N_{60}P_{120}K_{60}$	22.8	136.6	21.8	351.4	15.3	154.1	19.0	225.2	13.4	153.3	17.1	248.2	17.1	148.0	19.3	274.9
	40 t of manure in winter on snow + $N_{90}P_{120}K_{60}$	23.4	137.4	22.2	371.2	15.6	157.2	19.1	224.9	13.5	157.2	17.3	249.1	17.5	150.6	19.5	281.7
	40 t of manure for plowing + $N_{60}P_{120}K_{60}$	28.4	211.6	29.5	394.6	17.2	167.6	20.2	251.2	14.4	171.8	19.1	283.2	20.0	183.4	22.9	309.6
	40 t of manure for plowing + $N_{90}P_{120}K_{60}$	29.6	244.4	30.4	401.4	18.2	172.1	21.1	256.3	14.7	178.3	19.7	286.3	21.1	198.2	23.7	314.6

***Source**: compiled by the authors*

The development and predominance of certain weed plants determined their different number and weight. The experimental plot was dominated by annual weeds: *Amaranthus retroflexus* L., 1753 and *Amaranthus blitoides* S. Watson, 1877, *Chenopodium album* L. Chenopodium album L., 1753, *Setaria* P.Beauv, 1812 and *Setaria viridis* (L.) P. Beauv, 1812, *Echinochloa crus-galli* (L.) BEAUV., 1812 and others, perennials included *Cirsium arvense* (L.) SCOP., 1772 and *Sonchus arvensis* L., 1753, (*Elytrigia repens* (L.) DESV. ex NEVSKI, 1933 and others.

In the field experiments A.A. Samarkin [17], by the time of harvesting, perennial weeds that were remained are: *Cirsiuem arocusa* (L.) Scop, 1772, *Soulus arocusis* L., 1753, of juvenile spring weeds met *Raphanus aphanis-fmen* L., 1753, as well *Chenopodium alhem* L., 1753, among wintering ones - *Cenfaupea cuames* L., 1753, and *Capselle bursa - pasfonis* L., 1792.

The largest number of weeds was recorded in 2017. It was also noted that an increase in nitrogen in mineral fertilizer from N_{60} to N_{90} promotes an increase

in weeds in different variants from 0.6 to 3.2 weeds per square meter. This trend was observed in all years of research (Table 1).

Such data were also shown by A.A. Skryabin [18], where the highest percentage of weeds was observed during the use of nitrogen fertilizers at a dose of 90 kg (35 kg dry matter), the smallest 201 kg dry matter – at the introduction of 120 kg of a.s. of nitrogen.

With the introduction of bedding manure in the fall under the fall, the number of weeds increased in comparison with other options where only mineral fertilizers were applied, in 2017 by 6.9-8.0 pieces, in 2018 – by 4.4-4.5, in 2019 – by 1.0-1.1 pcs, and the weight, respectively, by 23.9-30.3; 15.1-19.9 and 83.2-90.7 grams in the flowering phase and 69.7-77.9; 29.5-33.4 and 7.2-11.3 g before harvesting.

In the studies of A.V. Ivenin [19], weed control reduces the level of weed infestation at the beginning of the growing season (after germination) to 7.1-8.2 weeds/m², including 0.7-1.6 weeds/m² of perennials. In the option of the field experiment with autumn tillage use, the amount of weeds is lower than in the option without it. By the end of the growing season of potatoes, the infestation of annual weeds increases and reaches 8.0-8.9 pcs/m².

The application of manure over frozen plow and in winter over snow leads to a slight decrease (2.3-2.5 pcs/m²) of weeds. The greatest number of weeds is observed during the spring application of manure for plowing the plow (Fig. 1). Such data were also shown in the experiments of A.A. Vasiliev [20], that in the South Urals the infestation of potato plantings with wheatgrass is low (0.2 pcs/m²). Steaming with the use of spring rape resulted in a 4-fold decrease in this indicator, and a 2-fold decrease in the vetch-oat mixture, compared with black fallow.

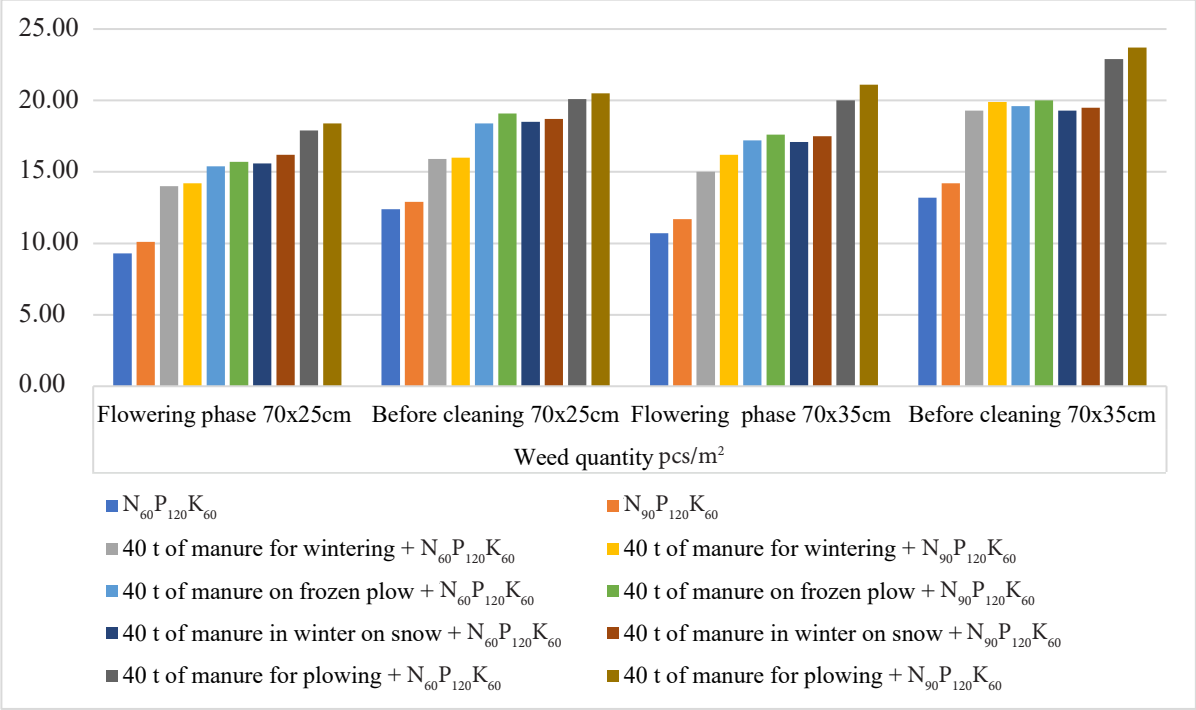

Figure 1. *Influence of the timing of the introduction of manure on the weediness of potato plantings, pcs/m²*
Source: *compiled by the authors*

In the flowering phase, on average for 3 years in this variant, there were 20 weeds against the background of $N_{60}P_{120}K_{60}$ and 21.1 weeds against the background of $N_{90}P_{120}K_{60}$ with a planting of 70x35 cm and 17.9 and 18.4, respectively. when planting 70x25 cm, before harvesting – respectively 22.9; 23.7; 20.1 and 20.5, which is 7.6-7.7 tons more than on the variants without manure application 9.5-9.7 weeds before harvesting, and in comparison with the flowering phase – by 8.3-8, 6 when planting 70x25 cm and by 9.3-9.4 (when planting 70x35 cm), and their mass increased, respectively, in the flowering phase by 2.47; 1.93-2.05 times, before harvesting – 1.50-1.51 and 1.58-1.60 times (Fig. 2).

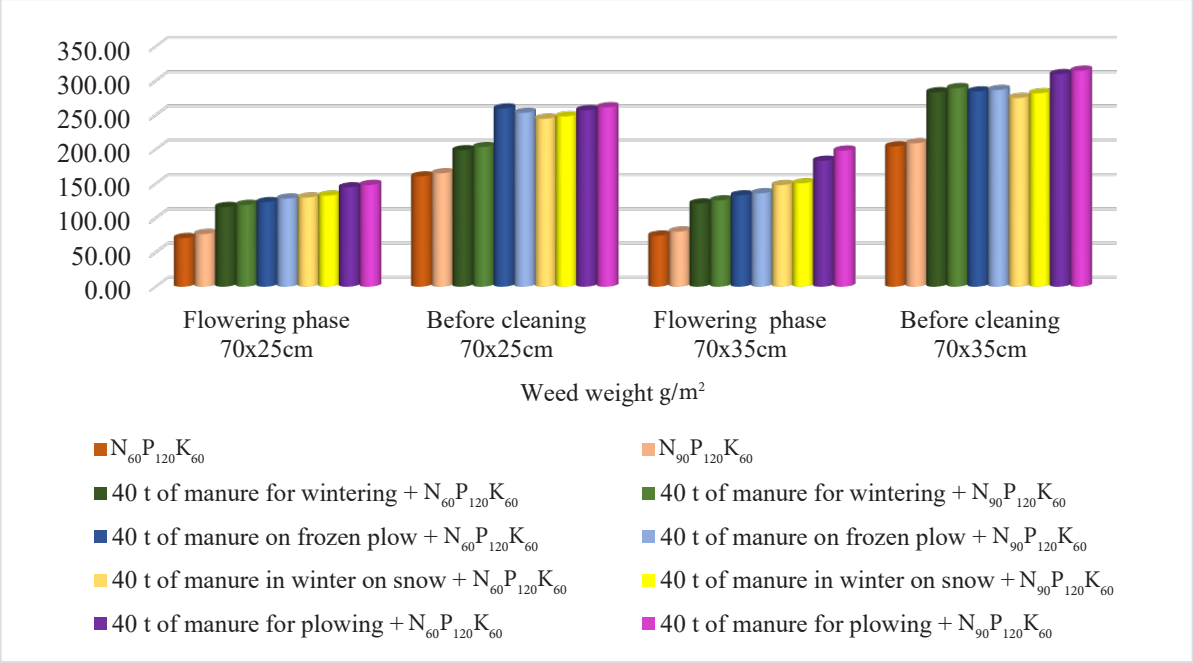

***Figure 2**. Influence of the timing of manure application on the weight of weeds, g/m²*
***Source**: compiled by the authors*

The planting density of potatoes also has a definite effect on the development of weeds. So, when applying only mineral fertilizers in doses of $N_{60}P_{120}K_{60}$ and $N_{90}P_{120}K_{60}$and when planting 70x25 cm, the number of weeds on average for 3 years was, respectively, in the flowering phase 12.4 and 12.9 per 1 m², when planting 70x35 cm – 13.2 and 14.2 pcs/m², and their weight increased by 38.1-96.6 g/m², before harvesting – by 70.6-105.7 g/m².

CONCLUSIONS

Thus, the introduction of bedding cattle manure increases the number of weeds on plantings and their weight:

– an increase in nitrogen in mineral fertilizers from N_{60} to N_{90} promotes an increase in weeds;

– a certain influence on the development of weeds is also exerted by the planting density of potatoes;

– with the introduction of bedding manure in autumn under the winter plow, the number of weeds increased in comparison with other options;

– application of manure over frozen plow and in winter over snow leads to a slight decrease in weeds.

– the greatest number of weeds is observed during the spring application of manure for plowing the fall plow.

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Вплив термінів внесення гною у поєднанні з мінеральними добривами та густоти посадки на засміченість посадок картоплі

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Анотація. Картопля є одним з найбільш чуйних культур на прийоми догляду, оскільки в період від сходів до змикання рядів легко пригнічується бур'янами, які відбирають у неї живильні речовини, воду, світло. Велику шкоду картоплі завдають бур'яни. Наявність на полі бур'янів сприяє сильному зниженню врожайності та товарних якостей бульб. Поглинаючи з ґрунту велику кількість поживних речовин та вологи, бур'яни пригнічують ріст і розвиток рослин, знижуючи їхню потенційну продуктивність. Дослідження проводилися для виявлення впливу термінів внесення підстилкового гною разом із мінеральними добривами і густоти посадки на засміченість посадок картоплі. Досліди закладалися системним методом з ярусним розташуванням варіантів в досліді, повторність 3-кратна. Використовували гній великої рогатої худоби на солом'яній підстилці осінньо-зимової заготівлі. Застосовували такі види добрив: аміачну селітру, подвійний суперфосфат, хлористий калій. Визначення кількості та біомасу бур'янів у посадках картоплі проводили у фазі цвітіння та перед збиранням урожаю. Внесення гною супроводжувалося збільшенням кількості та маси бур'янів. У посадках картоплі переважали однорічні бур'яни: *Amaranthus retroflexus* L., 1753 і *Amaranthus blitoides* S. Watson, 1877, *Chenopodium album* L., 1753, *Setaria* P. Beauv, 1812 і *Setaria viridis* (L.) P. Beauv, 1812, *Echinochloa crus-galli* (L.) BEAUV., 1812 та ін., з багаторічних зустрічалися *Cirsium arvense* (L.) SCOP., 1772 і *Sonchus arvensis* L., 1753, (*Elytrigia repens* (L.) DESV. ex NEVSKI, 1933 та ін. Певний вплив на розвиток бур'янів і густота посадки. При внесенні гною восени під зяб кількість бур'янів зростала порівняно з іншими варіантами, де вносилися тільки мінеральні добрива. Внесення гною по замерзлому зябу і взимку по снігу призводить до незначного зниження (2,3–2,5 шт./м^2) бур'янів. Найбільша кількість бур'янів відзначається при весняному внесенні гною під переорювання зябу. Тим не менш, для місцевих сільгоспвиробників велику практичну значущість мають дослідження, націлені на уточнення складу та структури засміченості, кількості та маси бур'янів у посадках картоплі. Ці дані мають сприяти виробленню ефективної системи боротьби з бур'яном і отриманню високих урожаїв картоплі в регіоні

Ключові слова: кількість та маса бур›янів, однорічні та багаторічні бур›яни, засміченість посадок, гній та мінеральні добрива