

INFLUENCE OF FERTILIZATION LEVEL AND SOWING TERMS ON ACCUMULATION OF BASIC NUTRITION ELEMENTS IN PLANTS AND YIELD OF WINTER RAPE CULTIVATORS

The article presents the results of a study on the nitrogen, phosphorus and potassium accretion by plants in dynamics of the main phases of development and its effect on the seed yield of winter rape under the conditions of Western Polesye in Ukraine. High seed yield was provided by Dembo and Champion of Ukraine breeds using the fertilization program $N_{30}P_{90}K_{120} + N_{60(III)} + N_{60(VII)}$. Seeding time can be from August 20 to September 10 depending on the breed. Thus the Dembo breed provided high seed yield for earlier seeding time and breeds Champion of Ukraine and Black Giant for later seeding time.

Key words: winter rape, sowing term, cultivators, gross amount of NPK, NPK accumulation, phases of growth and development, yield.

Introduction. Among the tasks intended for improvement of agricultural sector of Ukrainian economy, further enhancement of oil plants production is of large importance. Special place is taken by the rape, which oil, due to its unique biological and chemical properties, finds broader application in human ration and in many branches of the national economy [1].

Use of mineral fertilizers during the main introduction promotes better development of the plants in autumn and improves their over-winter and root system development [5]. Winter hardness of the plants, their hardness to diseases and blasts and, eventually, seeds yield depend on provision of the rape with nutrients [3, 6].

The period from vegetation recovery till blossoming is marked with a very active accumulation of dry matter. This is an important period for taking mineral elements. Development of leaves and leaf surface per unit area of soil are key factors in determination of yield [7].

In recent years winter rape crop area is growing rapidly, especially in western region of Ukraine. This crop is very demanding on mineral nutrition [1, 2, 3, 4] and seeding time [8, 9, 10]. Thus, winter rape responds positively to application of mineral fertilizers by high increase in crop yield. However, too high amount of fertilizer does not provide an expected result. Rape overwintering depends on the seeding time: early crops overgrow and lose their hardness, and later crops are underdeveloped at the beginning of the winter. Studies on winter rape are conducted mainly in the forest-steppe zone, so it is important to improve the cultivation technology of winter rape in other regions including Western Polesye.

The aim of the research was to study accumulation of basic nutrition elements (NPK) by winter rape plants within the main phases of the winter rape development depending on the fertilization program, sowing terms and cultivator in conditions of Western Polissya of Ukraine and its impact on the seeds yield.

Materials and methods. To achieve this aim during 2009 – 2012 a temporary experiment was carried out in Volyn SARS AIWP NAAS. The area of accounted plots is 30 m² at 4 time replications. Predecessor was winter wheat. Soil was sod-podzolic gley sandy-loam one.

The research was conducted under the following scheme: cultivator: Champion of Ukraine, Black giant, Dembo; dose of fertilizers: without fertilizers (control), recommended for zone of Polissya $N_{30}P_{60}K_{90} + N_{30(III)} + N_{60(VII)}$, $N_{30}P_{90}K_{120} + N_{60(III)} + N_{60(VII)}$, $N_{30}P_{60}K_{90} + N_{60(III)} + N_{30(VII)}$, $N_{90}P_{45}K_{60} + N_{30(III)} + N_{30(VII)}$; sowing term: August 20, September 1, September 10.

Diagnostics of winter rape plants for NPK accumulation was carried out in dynamics.

The experiment was started according to Dospekhov method of field studies [11]. The harvest of winter rape seeds was determined by continuous threshing and weighing of the seed.

Accumulation of NPK in plants was determined according to the formula [1]:

$$A = \frac{DVW \times GC}{100\%}, \text{ where} \quad [1]$$

A – accumulation of one of the nutrition elements, kg/ha,

DVW – dry vegetative weight of entire plants, kg/ha,

GC – gross content of one of the nutrition elements.

Gross content of NPK can be determined by standard methods [12, 13].

Results and discussion. Accumulation of basic nutrition elements in dry vegetative mass of plants in the phase of autumn rosette depended on all factors being researched and specially - on fertilizers dose and sowing term. As far as the maximum vegetative mass of plants was formed in the period of sowing on August 20, so respectively in this period there was the maximum accumulation of NPK in plants (Table 1).

Maximum indices of nitrogen accumulation by plants were reached during introduction of N₃₀P₉₀K₁₂₀. Thus, in the period of sowing on August 20 it made 115.7-134.8 kg/ha, on September 01 – 60.7-74.2 kg/ha and on September 10 – 27.8-32.9 kg/ha depending on the cultivator type. Cultivator Black giant formed higher indices. Cultivators Dembo and Black giant showed rather high level of nitrogen accumulation in the plant when variant N₃₀P₄₅K₆₀ was introduced.

Table 1

Accumulation of basic nutrition elements in dry vegetative mass of winter rape plants in the phase of autumn rosette (end of autumn vegetation), kg/ha

Cultivator	Fertilization program	N			P ₂ O ₅			K ₂ O		
		Sowing terms								
		20.08	1.09	10.09	20.08	1.09	10.09	20.08	1.09	10.09
Champion of Ukraine	without fertilizers (control)	61.1	32.1	24.0	25.1	13.2	8.2	50.12	27.3	16.5
	N ₃₀ P ₆₀ K ₉₀ +N ₃₀ +N ₆₀	86.5	54.7	32.0	34.6	19.4	10.6	69.6	37.7	24.9
	N ₃₀ P ₉₀ K ₁₂₀ +N ₆₀ +N ₆₀	119.2	73.1	33.9	50.6	26.8	11.6	113.7	53.0	27.1
	N ₃₀ P ₆₀ K ₉₀ +N ₆₀ +N ₃₀	108.3	44.4	28.6	44.0	16.2	9.9	93.4	37.8	23.8
	N ₃₀ P ₄₅ K ₆₀ +N ₃₀ +N ₃₀	116.7	56.1	36.7	43.8	19.0	12.5	93.5	43.9	29.9
Dembo	without fertilizers (control)	63.2	38.6	18.6	27.0	13.7	6.2	52.8	27.7	14.3
	N ₃₀ P ₆₀ K ₉₀ +N ₃₀ +N ₆₀	83.3	49.2	32.2	30.3	18.0	10.9	65.3	40.6	25.7
	N ₃₀ P ₉₀ K ₁₂₀ +N ₆₀ +N ₆₀	115.7	60.7	27.8	38.9	22.5	10.0	87.5	48.4	22.7
	N ₃₀ P ₆₀ K ₉₀ +N ₆₀ +N ₃₀	89.1	45.4	31.4	34.2	16.4	10.4	77.3	36.7	23.9
	N ₃₀ P ₄₅ K ₆₀ +N ₃₀ +N ₃₀	85.9	48.9	25.2	31.8	17.1	8.5	66.0	36.6	20.53
Black giant	without fertilizers (control)	71.3	42.5	20.1	28.1	15.7	7.1	57.0	36.9	16.7
	N ₃₀ P ₆₀ K ₉₀ +N ₃₀ +N ₆₀	101.3	62.2	27.7	37.5	22.5	9.4	80.1	54.5	22.7
	N ₃₀ P ₉₀ K ₁₂₀ +N ₆₀ +N ₆₀	134.8	74.2	32.9	50.9	30.5	10.7	116.0	73.2	26.8
	N ₃₀ P ₆₀ K ₉₀ +N ₆₀ +N ₃₀	100.0	86.7	27.8	41.7	29.5	9.5	97.2	69.5	21.8
	N ₃₀ P ₄₅ K ₆₀ +N ₃₀ +N ₃₀	84.8	56.3	25.2	35.6	20.0	9.4	78.7	49.5	22.9

Accumulation of phosphorus by winter rape plants was two - three times less than of nitrogen and reached of up to 50.9 kg/ha. During sowing on August 20 phosphorous accumulation by the plants was 25.1-28.1 kg/ha on control variants and reached of up to 38.9-50.9 kg/ha when introducing N₃₀P₉₀K₁₂₀. This index was higher for cultivators Black giant (50.9 kg/ha) and Champion of Ukraine (50.6 kg/ha) and lower for cultivator Dembo (38.9 kg/ha). During sowing on September 01 this index reached of up to 22.5-30.5 kg/ha when fertilizing with N₃₀P₉₀K₁₂₀, which exceeded the control one by 8.8-14.8 kg/ha depending on the cultivator. As well as during the previous sowing term cultivators Black giant and Champion of Ukraine accumulated more phosphorus. The rape plants sown on September 10 accumulated the least amount of phosphorus, at that the difference between fertilization programs was insignificant. This index was 6.2-11.6 kg/ha.

During the phase of autumn rosette the winter rape plants accumulated slightly less potassium than nitrogen. During sowing on August 20 the maximum indices made 87.5-116.0 kg/ha, on

September 01 – 48.4-73.2 kg/ha and on September 10 – 22.73-27.14 kg/ha against the background of mineral nutrition $N_{30}P_{90}K_{120}$.

Consequently, in the phase of autumn rosette there is the highest accumulation of basic nutrition elements in vegetative mass from soil when sowing on August 20 and it significantly reduces during subsequent sowing terms due to much less dry vegetative weight of the plants. Maximum indices are remarked against the background of the mineral nutrition $N_{30}P_{90}K_{120}$. During this phase cultivators Black giant and Champion of Ukraine form larger dry vegetative mass, that's why they have accumulated more NPK in plants than Dembo.

In the period from the phase of rosette till budding an intensive accumulation of dry vegetative mass has been taking place and respectively of NPK. In comparison with the phase of autumn rosette, until budding the content of basic elements in plants has increased up to 3.3 times while sowing on August 20 and up to 10.8 times while sowing on September 10. Content of phosphorus and potassium was increasing especially intensively (Table 2).

Table 2

Accumulation of basic nutrition elements in dry vegetative mass of winter rape plants in the phase of budding, kg/ha

Cultivator	Fertilization program	N			P ₂ O ₅			K ₂ O		
		Sowing terms								
		08.20	09.01	09.10	08.20	09.01	09.10	08.20	09.01	09.10
Champion of Ukraine	without fertilizers (control)	66.6	58.0	86.3	40.6	35.5	54.5	101.1	94.9	109.4
	$N_{30}P_{60}K_{90} + N_{30} + N_{60}$	121.3	155.4	134.0	71.5	85.7	71.3	173.6	193.9	184.8
	$N_{30}P_{90}K_{120} + N_{60} + N_{60}$	202.5	178.6	173.4	124.3	92.2	91.6	332.2	228.7	232.2
	$N_{30}P_{60}K_{90} + N_{60} + N_{30}$	230.8	178.0	132.8	115.9	98.0	68.6	305.3	235.7	172.8
	$N_{30}P_{45}K_{60} + N_{30} + N_{30}$	144.9	113.7	122.6	92.0	69.1	75.2	205.8	162.8	169.6
Dembo	without fertilizers (control)	67.5	51.2	77.7	45.4	37.2	49.5	97.2	81.8	110.4
	$N_{30}P_{60}K_{90} + N_{30} + N_{60}$	161.8	144.7	155.9	94.4	78.4	81.9	241.0	200.9	171.4
	$N_{30}P_{90}K_{120} + N_{60} + N_{60}$	205.2	215.0	158.1	112.5	106.3	85.5	292.2	253.0	189.7
	$N_{30}P_{60}K_{90} + N_{60} + N_{30}$	150.7	170.1	145.7	83.7	90.0	80.8	223.7	214.0	175.4
	$N_{30}P_{45}K_{60} + N_{30} + N_{30}$	121.5	114.2	115.7	70.4	66.9	67.2	168.4	149.0	159.9
Black giant	without fertilizers (control)	106.6	87.2	129.2	75.6	61.7	76.0	165.8	141.4	158.8
	$N_{30}P_{60}K_{90} + N_{30} + N_{60}$	168.6	157.5	189.5	101.9	84.1	101.6	217.7	191.8	220.2
	$N_{30}P_{90}K_{120} + N_{60} + N_{60}$	205.9	188.1	173.3	121.9	98.3	105.8	283.1	237.8	247.8
	$N_{30}P_{60}K_{90} + N_{60} + N_{30}$	156.2	130.2	133.0	94.1	69.4	75.7	220.3	182.8	167.5
	$N_{30}P_{45}K_{60} + N_{30} + N_{30}$	132.0	111.1	139.5	82.8	68.4	81.0	209.6	161.3	178.8

Indices of NPK accumulation from soil are the highest with the fertilization program $N_{30}P_{90}K_{120} + N_{60} + N_{60}$. Under the research results in this phase of development the difference between sowing terms, which had been tracing during the autumn period, slightly decreased.

Cultivator Champion of Ukraine accumulated nitrogen at most during introduction of $N_{30}P_{60}K_{90} + N_{60} + N_{30}$ and sowing on August 20 and made 230.8 kg/ha, which exceeded the control one by 164.2 kg/ha. For this variant this index was higher than during introduction of $N_{30}P_{90}K_{120} + N_{60} + N_{60}$. During sowing on September 01 with these fertilization programs the highest indices were also registered, which made 178.0 та 178.6 kg/ha. Maximum accumulation of nitrogen by cultivator Dembo 215.0 kg/ha in the phase of budding was registered during sowing on September 01 and with the fertilization program $N_{30}P_{90}K_{120} + N_{60} + N_{60}$, having exceeded the control one by 163.8 kg/ha. Cultivator Black giant accumulated a lot of nitrogen from soil on control variants (87.2-129.2 kg/ha), which was higher than of other cultivators. The maximum index at the rate of 205.9 kg/ha was registered during August 20 and with the fertilization program $N_{30}P_{90}K_{120} + N_{60} + N_{60}$.

Phosphorus accumulation by winter rape plants from soil was within the range 35.5 – 124.3 kg/ha. Maximum index was registered for cultivator Champion of Ukraine during sowing on

August 20 and with the fertilization program $N_{30}P_{90}K_{120} + N_{60} + N_{60}$. Minimum background of mineral nutrition accumulated 69.1-92.0 kg/ha of phosphorus. Cultivator Dembo also accumulated larger quantity of this element against the maximum background of mineral nutrition and made 85.5-112.5 kg/ha depending on the sowing term.

In the phase of the winter rape plants are in sore need of potassium, which is proven by its high accumulation in comparison with other elements. Among all cultivators and sowing terms the maximum indices are shown by the fertilization program $N_{30}P_{90}K_{120} + N_{60} + N_{60}$, which vary within the limits from 189.7 till 332.2 kg/ha, exceeding the control one by up to 3 times. It shall be noted that plants of cultivator Black giant accumulated a lot of potassium on control variants – 141.4 - 165.8 kg/ha in comparison with other cultivators.

During this phase an intensive accumulation of basic nutrition elements from soil was taking place. Rise of mineral nutrition dose promoted larger accumulation of NPK from soil by the winter rape plants.

Before the phase of anthesis the content of accumulated elements in the plant was increasing on the average 1.5 times in comparison with the phase of budding. During this phase the winter rape plants accumulated NPK at most with high level of mineral nutrition, which significantly exceeded their accumulation by plants on control variants (Table 3).

Maximum nitrogen accumulation by the winter rape plants during the phase of anthesis made 359.1 kg/ha for cultivator of Champion of Ukraine during sowing on September 01 and with the fertilization program $N_{30}P_{90}K_{120} + N_{60} + N_{60}$, which exceeded the control one by 300.7 kg/ha. Index was also high for this cultivator with the fertilization program $N_{30}P_{60}K_{90} + N_{60} + N_{30}$ and made 188.4-306.7 kg/ha, depending on the sowing term. Cultivator Dembo also showed high nitrogen accumulation with these fertilization programs in all sowing terms. Maximum index reached 325.1 kg/ha. During the phase of anthesis cultivator Black giant accumulated the least amount of nitrogen, at that the index reached of up to 284.6 kg/ha.

Table 3

Accumulation of basic nutrition elements in dry vegetative mass of winter rape plants in the phase of anthesis, kg/ha

Cultivator	Fertilization program	N			P ₂ O ₅			K ₂ O		
		Sowing terms								
		08.20	09.01	09.10	08.20	09.01	09.10	08.20	09.01	09.10
Champion of Ukraine	without fertilizers (control)	84.1	58.4	87.4	67.0	50.5	59.3	151.1	113.9	160.0
	$N_{30}P_{60}K_{90} + N_{30} + N_{60}$	172.3	186.2	184.3	105.5	116.6	117.7	283.9	312.6	351.9
	$N_{30}P_{90}K_{120} + N_{60} + N_{60}$	245.4	359.1	310.9	151.9	155.6	154.6	421.8	414.1	405.4
	$N_{30}P_{60}K_{90} + N_{60} + N_{30}$	306.7	230.6	188.4	177.0	123.9	105.6	411.6	366.6	249.3
	$N_{30}P_{45}K_{60} + N_{30} + N_{30}$	210.4	151.5	257.5	124.2	97.5	141.4	332.9	271.4	370.0
Dembo	without fertilizers (control)	97.3	67.7	106.5	71.6	52.2	58.7	188.3	127.6	142.2
	$N_{30}P_{60}K_{90} + N_{30} + N_{60}$	206.9	171.5	304.4	131.3	106.1	172.9	345.8	255.0	406.6
	$N_{30}P_{90}K_{120} + N_{60} + N_{60}$	256.6	221.6	325.1	164.0	119.4	155.3	466.5	343.8	392.9
	$N_{30}P_{60}K_{90} + N_{60} + N_{30}$	164.1	170.7	211.0	110.3	115.8	134.4	297.7	310.8	325.8
	$N_{30}P_{45}K_{60} + N_{30} + N_{30}$	187.8	122.2	229.7	112.9	87.9	122.8	308.1	211.1	302.4
Black giant	without fertilizers (control)	122.2	88.7	141.4	104.0	66.6	103.1	266.7	142.8	233.2
	$N_{30}P_{60}K_{90} + N_{30} + N_{60}$	222.9	186.8	284.6	139.6	112.5	167.5	348.2	286.6	428.4
	$N_{30}P_{90}K_{120} + N_{60} + N_{60}$	272.6	203.0	214.2	145.9	121.2	121.2	389.4	305.4	334.2
	$N_{30}P_{60}K_{90} + N_{60} + N_{30}$	201.2	226.3	242.3	115.1	139.1	145.5	309.0	328.7	359.1
	$N_{30}P_{45}K_{60} + N_{30} + N_{30}$	198.6	160.3	253.2	144.8	110.4	121.8	377.9	261.2	324.7

Phosphorus accumulation in full bloom phase was increasing in variants with high fertilizers doses. With the fertilization program $N_{30}P_{90}K_{120} + N_{60} + N_{60}$ this index for cultivator Champion of Ukraine was 151.9-155.6 kg/ha depending on the sowing term, when on the control one it was 3 times less and was within the range from 50.5 up to 67.0 kg/ha. For cultivator Dembo

this fertilization program ensured phosphorus accumulation within the range of 119.4-164.0 kg/ha. But the maximum index was in variant $N_{30}P_{60}K_{90} + N_{30} + N_{60}$ during sowing on September 10, which made 172.9 kg/ha. Cultivator Black giant accumulated phosphorus of 66.6-167.5 kg/ha, at that on control variants the index was rather high – up to 122.2 kg/ha.

In the phase of budding, as well as of anthesis the plants have been accumulating potassium at most, which witnesses of high need for this element for growth and development of the white rape.

Maximum index of potassium accumulation for cultivator Dembo was 466.5 kg/ha during sowing in August 20 and with the fertilization program $N_{30}P_{90}K_{120} + N_{60} + N_{60}$, which exceeding control by 278.2 kg/ha. On variants, where 90 kg a.s. of potassium was brought in, its accumulation by plants was within the limits of 255.0-406.6 kg/ha. The winter rape of cultivator Champion of Ukraine ensured the highest index of 421.8 kg/ha during sowing on August 20, on September 01 – 414.1 kg/ha and on September 10 – 405.4 kg/ha against the background of mineral nutrition $N_{30}P_{90}K_{120} + N_{60} + N_{60}$.

High accumulation of basic nutrition elements by the winter rape plants in phases of budding and anthesis positively impacted on the seeds yield, which was proved by high correlation factors. They made for nitrogen – 0.805 and 0.764, for phosphorus – 0.741 and 0.737, for potassium – 0.768 and 0.816 respectively in phases of budding and anthesis.

Under the results of our researches the highest yield index of winter rape seeds was shown by cultivator Dembo during sowing on August 20 and with $N_{30}P_{90}K_{120} + N_{60} + N_{60}$, which made 2.87 t/ha for three years of the research (Fig. 1). Maximum yield on this variant was obtained in 2010, which was 3.54 t/ha.

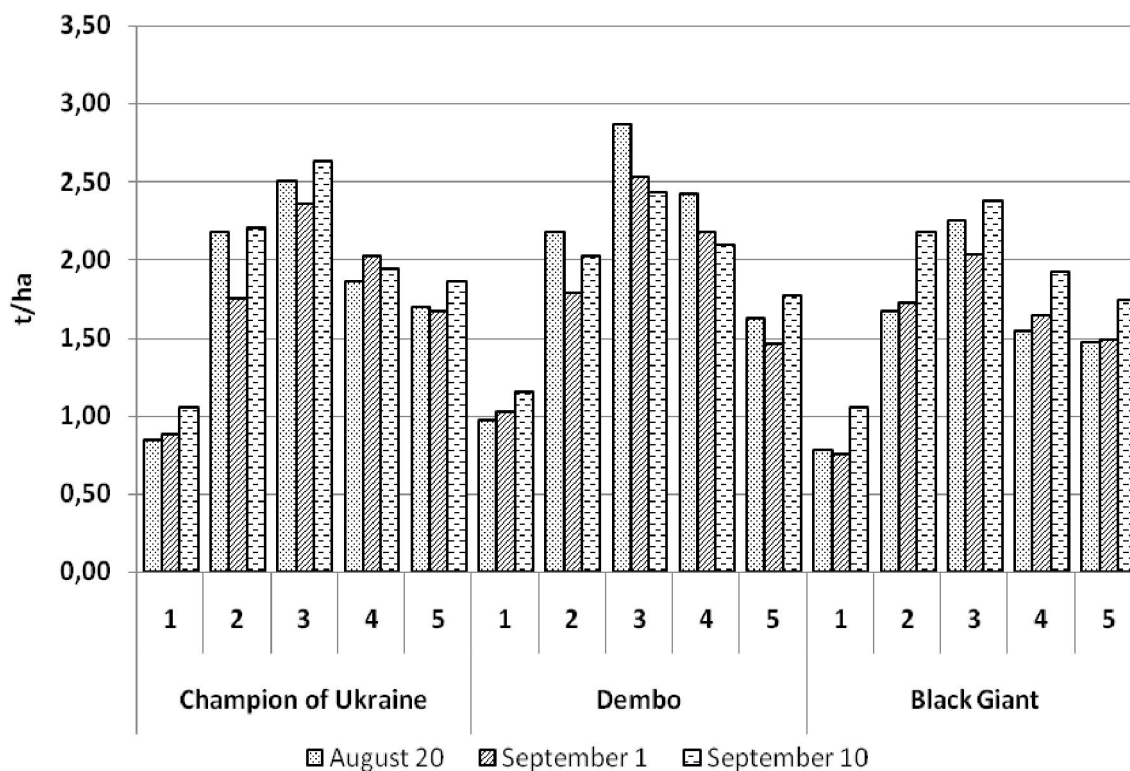


Fig. 1. Winter rape seeds yield in the average for 2010-2012.
**(1. without fertilizers (control); 2. $N_{30}P_{60}K_{90} + N_{30} + N_{60}$; 3. $N_{30}P_{90}K_{120} + N_{60} + N_{60}$;
 4. $N_{30}P_{60}K_{90} + N_{60} + N_{30}$; 5. $N_{30}P_{45}K_{60} + N_{30} + N_{30}$.)**

When reducing dose of mineral nutrition down to $N_{30}P_{60}K_{90} + N_{60} + N_{30}$ this cultivator ensured the seeds yield within the limits of 2.10-2.42 t/ha, at that this index was higher at the earlier sowing term. On variant $N_{30}P_{60}K_{90} + N_{30} + N_{60}$ the yield decreased down to 1.78 – 2.17 t/ha on all

sowing terms. Subject to the minimum norm of mineral fertilizers ($N_{30}P_{45}K_{60} + N_{30} + N_{30}$) the seeds yield was within the range of 1.46-1.77 t/ha.

In case of absence of mineral fertilizers introduction the yield of cultivator Dembo was 0.97-1.15 t/ha. It was the highest seeds yield for natural soil yield in comparison with other cultivators under research. This cultivator formed higher yield during sowing on August 20 against high backgrounds of mineral nutrition.

On the contrary from the previous one the winter rape cultivator Champion of Ukraine forms higher yields at later sowing terms in conditions of Western Polissya. According to the results of our researches cultivator Champion of Ukraine formed maximum yield against the highest background of fertilizing ($N_{30}P_{90}K_{120} + N_{60} + N_{60}$), which was 2.63 t/ha. Under favorable climatic conditions this cultivator formed the seeds yield of 3.28 t/ha.

In case of reduction of fertilizers norm down to $N_{30}P_{60}K_{90} + N_{30} + N_{60}$ the yield index was approximately 2 t/ha. Against the minimum background of mineral nutrition of Champion of Ukraine the yield index was within the range of 1.67-1.86 t/ha, which was higher than of Dembo and Black giant. On the control variant the seeds yield was 0.84-1.06 t/ha.

The winter rape cultivator Black giant formed higher seeds yield in later sowing terms. On the average for three years of the research the maximum yield was 2.38 t/ha with $N_{30}P_{90}K_{120} + N_{60} + N_{60}$ and during sowing on September 10. Yield was the highest in 2010 – 2.81 t/ha. This cultivator ensured higher yield on variant $N_{30}P_{60}K_{90} + N_{30} + N_{60}$, which made 1.67-2.18 t/ha than in case of fertilizing $N_{30}P_{60}K_{90} + N_{60} + N_{30}$.

Conclusions.

1. Notwithstanding the fertilization program the winter rape plants accumulate less phosphorus in all phases of their development, especially in phases of budding and anthesis.
2. From basic elements of mineral nutrition the winter rapeseeds need potassium at most. The plants accumulate it from soil above 400 kg/ha with high fertilizers doses. Somewhat smaller amount of nitrogen – 250-350 kg/ha and the least of phosphorus – 120-170 kg/ha is accumulated.
3. The highest winter rape seeds yield in edaphic-climatic zone of Western Polissya was achieved by introduction of $N_{30}P_{90}K_{120} + N_{60} + N_{60}$ for Dembo – 2.87 t/ha during sowing on August 20 and for Champion of Ukraine – 2.63 t/ha during sowing on September 10.

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Анотація

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Вплив рівня удобрення та строків сівби на накопичення основних елементів живлення та урожайність сортів ріпаку озимого

Рослини ріпаку озимого для нормального росту та розвитку потребують значну кількість основних елементів живлення. Так, у фазі повного цвітіння за системи удобрення $N_{30}P_{90}K_{120} + N_{60(III)} + N_{60(VII)}$ вони накопичують близько 400 кг/га калію, 300 кг/га азоту та 150 кг/га фосфору.

Ключові слова: ріпак озимий, строки сівби, сорти, валовий вміст NPK, накопичення NPK, фази росту та розвитку, врожайність

Аннотация

Дударчук И.С., Петренко Т.С., Мисковец К.В.

Влияние уровня удобрения и сроков сева на накопление основных элементов питания и урожайность сортов рапса озимого

Растения рапса озимого для нормального роста и развития требуют значительное количество основных элементов питания. Так, в фазе полного цветения за системы удобрения $N_{30}P_{90}K_{120} + N_{60(III)} + N_{60(VII)}$ они накапливают около 400 кг/га калия, 300 кг/га азота и 150 кг/га фосфора.

Ключевые слова: рапс озимый, сроки сева, сорта, валовое содержание NPK, накопления NPK, фазы роста и развития, урожайность