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RATE OF NPK ASSIMILATIVE UPTAKE OF SUNFLOWER VARIETY VNIIMK 8931

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Biological characteristics of sunflower make it different from other crops. Its vegetation period is shorter than that of maize, sugar beet, and wheat; its level of dry matter, however, is rather high. It means that sunflower forms a large amount of organic matter in a short period of time. In Yugoslavia, research has been conducted mainly in the field of fertilization (Stevanović (6), the investigations concerning plant nutrition being almost completely neglected. This is why we decided to conduct a research on this subject. The purpose was to find out the quantities of NPK nutrients taken up per hectare, the rate of uptake at different stages of development, the uptake intensity, and the end of the forming of organic matter.

METHOD

The research was conducted in 1964, 1971, and 1973 at the experimental field „Rimski Šančevi" of the Institute of Agricultural Research in Novi Sad. The type of soil was chernozem. The sunflower variety VNIIMK 8931 was examined. The preceeding crop was wheat. The distance between rows was 70 cm, within rows 35 cm. The planting was performed from April 1 to April 10. The chemical composition of soil at the depth from 0 to 35 cm was :

	% of humus	% of N	mg/100 g of soil	
			P_2O_5	K_2O
1st year	3.23	18.5	14.4	40.4
2nd year	3.11	16.9	18.2	35.1
3rd year	3.36	18.9	17.5	38.6

Fertilization. In the first research year 75 kg/ha of N + 80 kg/ha of P_2O_5 + + 60 kg/ha of K_2O were applied ; in the other two years 65 kg/ha of N + 70 kg/ha of P_2O_5 + 60 kg/ha of K_2O were applied. The mode of application — one half of the entire quantities of phosphorus and potassium were plowed in and other half was harrowed in just before planting. One quarter of the entire quantity of nitrogen was plowed in August, the second quarter was applied before planting, and the remaining half was top-dressed at the stage of 7—8 pairs of leaves. The basic cultivation to the depth of 35 cm was performed in August. In the first two research years ten plants were used for analyses ; in 1973, 100 plants were analysed at each stage of development with the exception of the stage of cotyledon, when 500 plants were used. The analysed roots were 30 cm long. Nitrogen was determined by macro Kjeldahl, phosphorus by spectrophotometry (Gericke and Kurmis, 1952), potassium by flame spectrophotometry.

Climatic conditions. 1973 was the most favourable for sunflower growing. The conditions of the first two research years were less favourable and rather similar :

Month	1964		1971		1973	
	Prec. in mm	Mean monthly temp. in °C	Prec. in mm	Mean monthly temp. in °C	Prec. in mm	Mean monthly temp. in °C
April	50	12.1	26	11.9	89	10.0
May	47	15.4	40	18.6	31	17.5
June	62	22.1	43	19.2	87	19.4
July	116	20.6	20	21.5	38	21.2
August	59	19.3	40	22.5	34	21.0
Whole year	674		383		487	

RESULTS

At the cotyledon stage, the quantity of absolutely dry matter per hectare was almost identical with the weight of seed material planted — on the three-year average it was 3.6 kg/ha, while the weight of absolutely dry seed material was 2.9 kg/ha. The smallest amounts of dry matter were formed at the initial stages of development. Under the above soil and climatic conditions and amounts of fertilizers applied, the variety VNIIMK 8931 formed only 9.7 kg/ha of dry matter at the stage On the three-year average, 20.3% of absolutely dry matter was formed 364.3 kg/ha, which is only 3.1% of the entire quantity of dry matter. On the three-year average, 20,3% of absolutely dry matter was formed from emergence to bud formation, and 27.6% from the end of flowering to physiological ripeness. The forming was the most intensive from bud formation to the end of flowering — 57.1% of dry matter was formed (at the stage of physiological ripeness the amount of dry matter is

indexed 100%). On the three-year average, the absolute quantities of dry matter were:

bud formation	2345.3 kg/ha
beginning of flowering	6455.3 kg/ha
end of flowering	8910.5 kg/ha
phys. ripeness	11510.6 kg/ha

The intensity of assimilative uptake during vegetation was not the same in all plant organs. Leaves had the most intensive uptake, roots the least intensive. On the three-year average, the nitrogen content in 10 development stages was in leaves 3.36%, in seeds 2.19%, in heads 1.85%, in stalks 1.21%, and in roots 1.03% in absolutely dry matter. The case was different with phosphorus — seeds had 0.52%, heads 0.40%, leaves 0.35%, stalks 0.23%, and roots 0.21% of phosphorus in absolutely dry matter. The potassium uptake differed from that of nitrogen and phosphorus — leaves had the most intensive uptake — 2.53‰, stalks 2.45%, heads 2.16%, roots 1.69%, while seeds had the least intensive uptake, 1.28%. The results obtained by Fenelonova (2) were identical with our findings regarding the intensity of nitrogen and phosphorus uptakes.

Our results also show that the intensity of assimilative uptake varied through the vegetation. The most intensive uptake of nitrogen, phosphorus, and potassium occured at the beginning of vegetation and then decreased in time. This is true for roots, stalks, and leaves. The intensity of nitrogen uptake ranged from 2.45% at the first stages to 0.36% at the end of vegetation in the roots, from 2.45% to 0.39% in stalks, and from 4.64% to 1.31% in leaves. The intensity of phosphorus uptake of leaves renged from 0.47% to 0.21%, of stalks from 0.43% to 0.10%, and of roots from 0.43% to 0.11%.

Table 1

The uptake of NPK nutritive matter by sunflower root system according to the stages of development (3-year average results-variety VNIIMK 8931)

Stage of development	Fresh mass weight of one plant (g)	% dry matter	Absolutely dry matter (kg/ha)	% in absolutely dry matter			kg/ha		
				N	P_2O_5	K_2O	N	P_2O_5	K_2O
Cotyledon	0.61	5.0	1.2	2.18	0.24	3.17	0.02	0.01	0.04
2 pairs of leaves	1.14	6.7	3.1	2.45	0.43	6.87	0.07	0.05	0.22
6 pairs of leaves	7.40	12.5	50.4	1.38	0.31	2.72	0.59	0.15	1.11
10 pairs of leaves	26.83	16.0	170.0	0.98	0.24	1.95	1.65	0.40	3.26
Bud formation	46.03	17.7	319.1	0.82	0.22	1.47	2.57	0.69	5.31
Flowering (beginning)	95.06	18.7	710.6	0.72	0.16	1.25	5.16	1.17	8.88
Flowering (end)	105.16	20.5	872.4	0.56	0.15	1.34	5.19	1.34	12.30
Grain forming (sterile flowers dry up)	91.10	21.0	767.1	0.44	0.13	1.12	3.48	0.97	8.74
Grain forming (sterile flowers fall off)	89.40	24.3	894.8	0.36	0.11	1.19	3.30	1.06	11.27
Physiological ripening	80.26	28.5	922.2	0.38	0.13	1.02	3.52	1.28	9.62

The intensity of potassium uptake of leaves ranged from 4.1% to 1.6%, of stalks from 4.18% to 1.64%, of roots from 3.17% to 1.02% (table 1). These are the three-year average results. They indicate a similarity in nitrogen and phosphorus uptakes of roots and stalks, while the potassium uptake is quite different.

There was a mutual regularity which stood for roots, stalks and leaves — the NPK uptake was the most intensive at the beginning of vegetation and the least intensive at the end of vegetation. However, this regularity did not stand for heads and seeds. In seeds, the nitrogen content increased from 1.86% to 2.60%, the phosphorus content from 0.49% to 0.52%, while the potassium content decreased from 1.71% to 0.92%. The nitrogen and phosphorus uptakes of heads were again different — the nitrogen and phosphorus contents decreased from 3.10% and 0.63% to 0.88% and 0.17%, respectively. The potassium content increased from 1.66% to 2.89%. Fenelonova (2) had arrived at the same conclusions.

Table 2

The uptake of NPK nutritive matter by sunflower stalks according to the stages of development (3-year average results — variety VNIIMK 8931)

Stage of development	Fresh mass weight of one plant (g)	% dry matter	Absolutely dry matter (kg/ha)	%			kg/ha		
				N	P_2O_5	K_2O	N	P_2O_5	K_2O
				in absolutely dry matter					
Cotyledon	0.61	5.0	1.2	2.18	0.24	3.17	0.02	0 01	0.04
2 pairs of leaves	1.14	6.7	3.1	2.45	0.43	6.87	0.07	0.05	0.22
6 pairs of leaves	46.92	7.0	130.5	1.91	0.32	4.18	2.65	0.43	5.56
10 pairs of leaves	136.28	9.1	502.0	1.34	0.28	3.14	6.84	1.39	15.74
Bud formation	348.13	8.4	1178.0	1.26	0.26	2.56	20.04	3.18	30.83
Flowering (beginning)	744.43	11.0	3404.1	0.82	0.20	2.08	27.27	6.56	69.57
Flowering (end)	860.14	12.4	4250.8	0.77	0.19	1.92	34.29	7.97	82.79
Grain forming (sterile flowers dry up)	719.93	14.1	4122.4	0.50	0.17	1.77	20.16	7.07	71.99
Grain forming (sterile flowers fall off)	600.6	17.3	3993.4	0.39	0.14	1.66	19.84	5.52	68.17
Physiological ripeness	430.33	24.0	4204.97	0.47	0.10	1.64	19.90	4.26	67.93

The results in table 2 show that stalks had the largest quantities of N, P, and K at the end of flowering — 34.2 kg/ha, 7.9 kg/ha, and 82.7 kg/ha, respectively. The amounts decreased at later stages of development. At the stage of physiological ripeness, the amounts of N, P_2O_5, and K_2O were — 17.5 kg/ha, 2.9 kg/ha, and 22.4 kg/ha, respectively. It means that 41.9% of nitrogen and 46.6 of phosphorus were mobilized from stalks for the seed forming. After the stage of physiological ripeness, stalks retained 58% of nitrogen and 53.4 of phosphorus of the quantities present at the end of flowering.

The leaves also had the largest quantities of N, P, and K at the end of flowering. However, the quantities are different from those found in stalks. The quantity of nitrogen in leaves was two times larger,

while the quantity of potassium was two times smaller. The quantities of phosphorus were on the same level. At the end of flowering, the leaves contained 66.5 kg/ha of nitrogen, at the stage of physiological ripeness only 17.5 kg/ha (table 3). These results indicate that 73.8% of nitrogen was reutilized for seed forming. According to Eritin (interpreted by Deakov (1), two thirds of the nitrogen content in leaves are mobilized for seed forming. In other word. leaves can be considered as a "plant storage" for nitrogen.

Table 3

The uptake of NPK nutritive matter by sunflower leaves according to the stages of development (3-year average results — variety VNIIMK 9931)

Stage of development	Fresh mass weight of one plant (g)	% dry matter	Absolutely dry matter (kg/ha)	% in absolutely dry matter			kg/ha		
				N	P_2O_5	K_2O	N	P_2O_5	K_2O
Cotyledon	0.89	6.6	2.3	4.25	0.44	3.04	0.10	0.05	0.07
2 pairs of leaves	1.60	10.5	6.6	4.21	0.37	4.14	0.30	0.15	0.29
6 pairs of leaves	33.95	13.9	189.9	4.64	0.47	3.21	8.63	0.95	6.28
10 pairs pf leaves	93.51	15.1	563.9	4.09	0.40	2.48	22.73	2.31	14.81
Bud formation	134.63	14.9	818.5	4.00	0.38	2.43	31.37	3.13	19.46
Flowering (beginning)	221.35	17.0	1543.7	3.56	0.34	2.32	54.36	5.26	35.61
Flowering (end)	282.76	18.7	2175.3	3.07	0.31	2.21	66.59	6.84	48.81
Grain forming (sterile flowers dry up)	232.30	20.7	1966.0	2.58	0.30	2.04	50.23	5.92	39.94
Grain forming (sterile flowers fall off)	176.10	23.0	1619.4	1.89	0.26	1.84	30.42	4.28	9.62
Physiological ripeness	83.61	38.4	1320.1	1.31	0.21	1.60	17.51	2.92	22.43

The NPK uptake of heads is somewhat different from those of leaves and stalks. The largest quantities of N and P are taken up a few days after the grain forming, while the largest quantity of K is taken up at the stage of physiological ripeness (table 4).

Table 4

The uptake of NPK nutritive matter by sunflower heads according to the stages of development (3-year average results — variety VNIIMK 8931)

Stage of development	Fresh mass weight of one plant (g)	% dry matter	Absolutely dry matter (kg/ha)	% in absolutely dry matter			kg/ha		
				N	P_2O_5	K_2O	N	P_2O_5	K_2O
Bud formation	5.03	14.4	29.4	3.10	0.68	1.66	0.91	0.20	0.24
Flowering (beginning)	93.16	13.8	503.3	2.55	0.55	1.95	12.86	2.76	9.92
Flowering (end)	202.28	14.1	1133.5	1.85	0.45	2.00	19.56	4.96	22.11
Grain forming (sterile flowers dry up)	346.58	12.0	1698.2	1.26	0.33	2.04	20.86	5.48	34.56
Grain forming (sterile flowers fall off)	327.20	11.6	1646.7	1.49	0.24	2.45	21.10	3.84	36.59
Physiological ripeness	269.78	12.6	1394.2	0.88	0.17	2.89	11.70	2.33	38.25

In seeds, the largest quantities of nitrogen, phosphorus, and potassium were found at the stage of physiological ripeness (table 5).

Table 5

The uptake of NPK nutritive matter by sunflower seeds according to the stages of development

(3-year average results — variety VNIIMK 8931)

Stage of development	Fresh mass weight of one plant (g)	% dry matter	Absolutely dry matter (kg/ha)	%			kg/ha		
				N	P_2O_5	K_2O	N	P_2O_5	K_2O
				in absolutely dry matter					
End of flowering	94.53	15.2	578.2	1.86	0.44	1.71	10.84	2.54	9.82
Grain forming (sterile flowers dry up)	146.47	27.2	1565.6	1.99	0.52	1.39	31.19	8.14	27.23
Grain forming (sterile flowers fall off)	135.18	51.0	2781.4	2.34	0.57	1.12	65.24	16.13	30.68
Physiological ripeness	119.79	75.3	3668.9	2.60	0.57	0.92	95.95	21.22	33.02

The ratios between the quantities of nitrogen, phosphorus, and potassium taken up changed according to the stages of development (in kg/ha) :

Stalk	N	P_2O_5	K_2O
bud formation	1	0.15	1.53
end of flowering	1	0.23	2.41
physiological ripeness	1	0.21	3.41
leaves			
bud formation	1	0.09	0.62
end of flowering	1	0.10	0.73
physiological ripeness	1	0.16	1.28
head			
bud formation	1	0.21	0.26
end of flowering	1	0.25	1.13
physiological ripeness	1	0.19	3.26
seed			
end of flowering	1	0.23	0.90
physiological ripeness	1	0.22	0.34
entire plant			
bud formation	1	0.12	1.02
end of flowering	1	0.21	1.32
physiological ripeness	1	0.21	1.16

On the basis of the above data it can be stated that the NPK ratios change with the aging of plants — the quantity of P and K increases in stalks, leaves, and heads, while in seeds the quantity of K decreases and the quantity of P remains on the same level.

CONCLUSION

The quantity of dry matter kept increasing through the stages of plant development. The most intensive increase occurred at the stages of bud formation and flowering — 57.1%. 20.3% of dry matter was formed to the stage of bud formation, and 22.6% after the end of flowering to the stage of physiological ripeness. It means that in the period of 36 days 57.1% of dry matter was formed (from bud formation to the end of flowering) and 42.9% in the remaining 83 days.

The nitrogen uptake was the most intensive in leaves, the least intensive in roots. On the average for the 10 development stages, the uptakes of leaves, seeds, heads, stalks, and roots were 3.36%, 2.19%, 1.85%, 1.21%, and 1.03%, respectively.

The intensity of phosphorus uptake in seeds, heads, leaves, stalks, and roots was 0.52%, 0.40%, 0.35%, 0.23%, and 0.21%, respectively.

The potassium uptake differed from the nitrogen and phosphorus uptakes. The intensity of potassium uptake in leaves, stalks, heads, roots, and seeds was 2.53%, 2.45%, 2.16%, 1.69%, and 1.28%, respectively.

The intensity of NPK uptake decreased in roots, stalks, and leaves with the aging of plants (from emergence to the stage of physiological ripeness) — from 2.45% to 0.36%, from 2.45% to 0.39%, and from 4.64% to 1.31%, respectively. This regularity did not stand for heads and seeds. In seeds, the nitrogen content increased from 1.86% to 2.60%, the phosphorus content from 0.49% to 0.52%, while the potassium content decreased from 1.71% to 0.92%. In heads, the nitrogen and phosphorus contents decreased from 3.10% to 0.88% and from 0.68% to 0.17%, respectively. The potassium content, however, increased from 1.66% to 2.89%, which was quite different from the reaction of other plant parts.

Stalks had the largest quantities of nitrogen at the end of flowering — 34.2 kg/ha. At the end of vegetation, the quantity decreased to 17.5 kg/ha. 41.9% nitrogen from stalks were mobilized and used for seed forming. Leaves, as well as the stalks, had the largest quantities of nitrogen during flowering — 66.5 kg/ha. At the stage of physiological ripeness, they had only 17.5 kg/ha of nitrogen. The leaves are, therefore, "a plant storage" for nitrogen : 73.8% of it was reutilized for seed forming. The largest quantities of nitrogen can be found in heads a few days after seed forming. The largest quantities of nitrogen, phosphorus, and potassium in seeds were found at the stage of physiological ripeness 95.9 kg/ha, 31.2 kg/ha, and 33 kg/ha, respectively.

Stalks and leaves had the largest quantities of phosphorus at the end of flowering — 7.9 kg/ha and 6.8 kg/ha, respectively. Heads had

the largest quantities of phosphorus a few days after the end of seed forming.

Stalks and leaves had the largest quantities of potassium at the stage of flowering, and heads and seeds at the stage of physiological ripeness, i.e., at the end of vegetation.

The ratios between quantities of nitrogen, phosphorus, and potassium taken up kept changing through the vegetation — the quantity of phosphorus and potassium increased in stalks, leaves, and heads with the aging of plants, while in seeds the quantity of potassium decreased and the quantity of phosphorus remained on the same level.

LITERATURE

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