THE INFLUENCE OF FERTILIZERS ON SUNFLOWER YIELD AND QUALITY

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In the complex of agrotechnical practices in growing sunflower, fertilization is of greatest importance. Bulgarian agriculture disposes of larger quantities of fertilizers in the recent years and their rational use is an important economical problem.

Differentiated fertilization of sunflower has been applied as regards the different soil types in the country by means of experiments carried out in the main soil and climatic regions : carbonate chernozem — Trastenik village (the district of Pleven) and Alvanovo village (the district of Targovishte) ; podzolic chernozem - Rakovski village (the district of Razgrad) ; leached chernozem — Gramada village (the district of Vidin) and Gorni Dubnic (the district of Pleven) ; grey cinnamonic forest soil — the town of Isperih (the district of Razgrad) and Nikolaevo village (the district of Pleven) ; smolnitsa — Badeshte village (the district of Stara Zagora) ; leached cinnamonic forest soil — Patriarch Evtimovo village (the district of Plovdiv) and Krepost village (the district of Haskovo) and podzolic cinnamonic forest soil — Sbor village (the district of Bazardgik).

The experiments have been carried out according to a complex multifactorial diagram of the type 4 x 4 x 3 with rates of fertilization as follows : N — 60,120, 180 and 240 ; P_2O_5 — 60, 80, 160 and 240 and K_2O — 120, 240 kg/ha.

The results of the experiments of many years show that large sunflower yields are obtained on carbonate chernozem under optimum and evenly distributed precipitations and when irrigated (table 1).

In the district of Pleven the yields from the non-fertilized variant reach up to 22.4 q./ha. When fertilizing only with nitrogen and with increasing the fertilization restes there is an increase of the yield from 22 to 23%. When fertilizing only with phosphorus P_2O_5 — 160 kg/ha, the yield increases by 23%. When increasing the quantity of phosphorus

Table 1

Results concerning sunflower fertilization (1968—1973)

Variants	carbonate chernozem		leached chernozem smolnitsa		leached cinnamonic forest soil		podzolic cinnamonic forest soil			
	Trastenik		Alvanovo		Badeshte		P. Evtimovo		Sbor	
	q/ha	%	q/ha	%	q/ha	%	q/ha	%	q/ha	%
000	22.4	100	31.6	100	17.1	100	18.5	100	15.8	100
$N_{120}P_{80}$	32.9	147	43.0	136	21.2	124	26.0	140	30.6	194
$N_{120}P_{160}$	31.0	138	39.6	125	20.7	121	28.3	153	31.7	201
$N_{180}P_{80}$	31.2	139	36.0	114	21.6	126	28.3	153	32.5	206
$N_{180}P_{160}$	31.3	140	36.0	114	22.0	129	29.0	157	33.6	213
$N_{180}P_{240}$	31.8	142	35.6	113	21.2	124	29.2	158	37.5	237
$N_{240}P_{240}$	26.5	118	33.3	105	20.9	122	28.7	155	35.8	227
$N_{120}P_{80}K_{120}$	30.1	134	41.3	131	21.8	127	27.0	146	38.6	244
$N_{120}P_{160}K_{120}$	33.3	149	39.0	123	19.4	113	24.7	133	37.2	235
$N_{180}P_{160}K_{120}$	32.9	147	36.0	114	22.9	134	27.3	148	35.5	225
$N_{240}P_{240}K_{240}$	31.9	142	37.0	117	22.4	131	28.0	151	47.0	297

up to 240 kg/1000 m² , there is a decrease of the yield. The efficiency of the complex nitrogen-phosphorus and nitrogen-phosphorus-potassium fertilization increases by 47%.

Largest sunflower seed yield — 32.9% is obtained when the rates of nitrogen and phosphorus fertilization are the lowest — $N_{120}P_{80}$ kg/ha, where the efficiency per unit of the nutrient substance is 5 kg of seed. Increasing the rates of phosphorus, nitrogen and potassium fertilization does not lead to the increase of the yield.

The carbonate chernozem in the district of Targovishte (north-east Bulgaria) is distinguished by its heavier mechanical composition as well as by its high natural fertility. The yield from the non-fertilized variant is 31.6 q/ha. At fertilization with 120, 180 and 240 kg of nitrogen/ha the yield varies indefinitely from 14 to 18%. When fertilizing only with phosphorus at rates higher than 180 kg/ha the yield of sunflower seed decreases. Fertilization with potassium does not increase the yield. The highest yield — 43.0 q/ha is obtained at $N_{120}P_{80}$. Increasing the rates of nitrogen and phosphorus fertilization as well as potassium fertilization leads to decreasing of the yields.

The highest yield — 38.0—40.0 q/ha on the podzolic chernozem in the north-east part of the country — Rakovski village (the district of Razgrad) is obtained at higher fertilization rates (120 kg of nitrogen/ha) on a high phosphorus degree of ground fertilization (table 2).

The balance of the introduced and extracted nutrients shows that these fertilization rates are sufficient for obtaining large and high quality yields.

The results obtained on the leached chernozem in the district of Pleven are analogical to those on the podzolic chernozem in the distinct of Razgrad. When increasing the nitrogen fertilization rates from 60 to 180 kg/ha at degree of ground fertilization P_2O_5 — 60 kg, the yield

Table 2

Results concerning sunflower fertilization (1968—1972)

Variants	Rakovski podzolic chernozem		Gorni Dubnik leached chernozem		Nikolaevo grey forest soil	
	yield q/ha	%	yield q/ha	%	yield q/ha	%
000	28.0	100	22.5	100	15.8	100
$N_{120}P_{80}$	34.0	121	29.3	130	25.8	163
$N_{180}P_{80}$	36.0	129	31.1	138	27.2	172
$N_{120}P_{160}$	34.0	121	30.7	136	25.2	159
$N_{180}P_{160}$	36.0	129	31.4	140	28.9	183
$N_{240}P_{160}$	28.3	101	31.1	138	30.2	191
$N_{120}P_{240}$	30.0	107	29.8	132	28.5	180
$N_{180}P_{240}$	36.6	131	32.0	142	29.8	189
$N_{240}P_{240}$	38.3	137	32.5	144	31.2	197
$N_{120}P_{80}K_{120}$	33.3	119	27.4	122	26.5	168
$N_{120}P_{160}K_{120}$	30.0	107	30.3	135	28.9	183
$N_{180}P_{160}K_{120}$	32.7	117	32.0	142	29.0	183
$N_{240}P_{240}K_{120}$	38.6	138	32.6	145	31.8	201

increases at the same nitrogen fertilization. When increasing phosphorus fertilization rates from 120 to 180 kg the yield varies within the same limits and tends to decrease. Nitrogen-phosphorus fertilization at potassium soil medium fertility of the leached chernozem does not increase the yield.

The grey forest soils possess lower natural fertility which is expressed by the yield at the non-fertilized variant on the dark-grey forest soil of Isperih (the district of Razgrad). The medium yield of the non-fertilized variant is 17.1 q/ha and on the grey soils of the foothill areas of the Balkan it is 15.8 q/ha. As it could be expected due to the low natural fertility fertilization especially in the foothill areas of the Balkan is very efficient. With increasing the fertilization rates the sunflower yield in that region increases constantly. On smolnitsa and leached cinnamonic forest soils in south Bulgaria the effect is almost the same. On the smolnitsa of Badeshte village (the district of Stara Zagora) the medium yield is 17.1 q/ha and on the leached cinnamonic forest soils in the districts of Plovdiv and Haskovo it is respectively 18.5 and 18.9 q/ha. On smolnitsa even at the highest rates of fertilization the effect of fertilization is weakly expressed due to the droughty character of that region. We have obtained satisfactory results on leached cinnamonic forest soils too. At precipitations evenly distributed during the vegetation period and above the normal level, fertilization increases the yield by more than two times.

The regularity already established for the cereal crops grown on these soils is well expressed when growing sunflower too. Highest efficiency is obtained out of nitrogen fertilization; lower — out of phosphorus fertilization and potassium fertilization bears no effect.

Precipitations and especially the drought in the period July-August, disturbing the normal progress of the transition period of blosso-

ming and fruit-formation turn out to be limiting factors on the effect of fertilization due to which the yield remains small.

The podzolic cinnamonic forest soils in Sbor village (the district of Bazardgik) possess the lowest natural fertility. The largest effect on this soil type is obtained at phosphorus fertilization. Due to the low natural fertility the introduction of NPK into these soil types leads to increasing the yield. In the variant $N_{240} P_{240} K_{240}$ the yield reaches up to 47.0 q/ha (that is the yield increased three times compared to the non-fertilized variant).

It is obvious that the optimum rates of fertilization of sunflower have a large variation range from 80—100 kg of nitrogen and phosphorus for the chernozems to 200 kg and more for the podzolic cinnamonic forest soils and they are dependent on the natural soil fertility. The yield at the non-fertilized variant for the chernozems is 22.4—31.6 q/ha and for the smolnitsa and grey cinnamonic forest soils — 15.0—20.0 q/ha.

Fertilization influences both the yield and chemical composition and oil content of the sunflower seed. The protein content in the seeds increases with increasing the quantity of nitrogen in the carbonate chernozem. Similar changes are to be observed on smolnitsa and grey cinnamonic forest soils. At the phosphorus and potassium fertilization the changes of protein are irregular. High protein content is observed at the variants with nitrogen-phosphorus fertilization (and potassium fertilization on grey forest soils). A change in the oil content of the seeds under the influence of fertilization could also be observed. The oil content from carbonate chernozem decreases by 3% and from smolnitsa — by 5.2% at the non-fertilized variant when increasing the fertilization rates from 120 to 240 kg/ha. Similar changes are to be observed with the remaining soil types. The variations of the oil content are minimum at phosphorus and potassium fertilization.

Table 3

Economic efficiency of sunflower fertilization on grey forest soil — Isperih, Razgrad (1968—1972)

Variants	yield q/ha	oil content %	oil kg/ha	cost of sunflower seed leva/ha	fertilization expenses	net seed production leva/1000 m²
000	17.1	47.5	812	393	0	393
$N_{60}P_{60}$	25.0	46.3	1157	575	40	535
$N_{120}P_{60}$	28.5	43.8	1248	655	59	596
$N_{180}P_{60}$	29.8	43.1	1284	685	79	606
$N_{60}P_{120}$	27.1	42.2	1143	623	57	566
$N_{120}P_{120}$	29.7	43.9	1303	683	77	606
$N_{180}P_{120}$	32.1	41.9	1345	738	90	648
$N_{120}P_{180}$	31.5	43.3	1363	724	94	630
$N_{190}P_{180}$	32.9	43.0	1414	757	114	643
$N_{60}P_{60}K_{120}$	26.1	42.7	1114	600	59	541
$N_{120}P_{60}K_{120}$	28.9	43.6	1260	665	79	586
$N_{180}P_{60}K_{120}$	29.4	43.3	1273	676	106	570
$N_{80}P_{120}K_{120}$	27.6	42.9	1184	634	76	558

The oil content on all soil types at high complex fertilization ra-
tes — $N_{240}P_{240}$ is 1.2—1.8% lower than the same variant with
$N_{120}P_{80}$ kg/ha (tables 3, 4, 5).

Table 4

Oil content and chemical composition of sunflower seeds

Variants kg/ha	Carbonate chernozem		Chernozem smolnitsa		ratio	grey forest soil		1972
	1969	1971	1970	1972	husk:kernel	N	P_2O_5	K_2O
000	48.2	51.0	46.3	50.8	22.0 : 78.0	2.90	1.16	0.90
N_{120}	47.0	50.8	46.5	49.6	24.2 : 75.8	3.00	0.87	0.79
N_{180}	45.2	49.0	44.0	47.4	24.0 : 76.0	3.11	0.92	0.90
N_{240}	44.1	48.4	41.3	47.8	24.4 : 75.6	3.18	0.90	0.95
P_{80}	48.0	50.9	48.3	51.0	23.1 : 76.9	2.81	0.98	0.89
P_{160}	49.2	48.9	47.1	50.6	22.2 : 77.8	2.86	0.93	0.92
P_{240}	47.6	49.8	48.8	49.4	23.4 : 76.6	2.78	0.90	0.94
K_{120}	48.0	49.3	47.2	49.5	22.1 : 77.9	2.80	0.91	0.93
K_{240}	47.3	50.1	47.0	49.2	23.0 : 77.0	2.84	0.96	0.96
$N_{120}P_{80}$	47.0	49.6	46.1	49.7	23.5 : 76.5	2.96	0.89	0.87
$N_{180}P_{160}$	46.7	48.4	45.8	48.3	25.0 : 75.0	3.05	0.94	0.90
$N_{240}P_{240}$	45.8	47.2	45.0	47.6	24.6 : 75.4	3.51	0.91	1.04
$N_{180}P_{160}K_{120}$	46.0	48.0	45.0	48.2	24.8 : 75.2	3.10	0.98	0.96
$N_{240}P_{240}K_{240}$	45.9	47.9	44.8	48.0				

Table 5

**Economic efficiency of sunflower fertilization on carbonate chernozem — Alvanovo
(the district of Razgrad)**

Variants	Yield q/ha	Oil content %	Oil kg/ha	Cost of sunflower seed leva/ha	Expenses leva/ha	Net production leva/ha
000	31.6	49.6	1567	727	0	727
$N_{120}P_{160}$	39.6	48.2	1909	911	88	823
$N_{120}P_{80}$	43.0	48.3	2077	989	65	924
$N_{180}P_{80}$	36.0	47.0	1692	828	85	743
$N_{240}P_{240}$	33.3	46.5	1548	766	150	616
$N_{180}P_{160}K_{120}$	36.0	47.0	1692	828	127	701
$N_{240}P_{240}K_{240}$	37.0	46.5	1720	851	90	761

Besides the quantity and correlation of fertilizers the oil content in
seeds is also influenced by meteorological factors.

Under the same soil and geographical conditions of carrying out
the experiment the oil content varies strongly depending on the combi-
nation of meteorological factors. On carbonate chernozem at the non-fer-
tilized variant in 1969 the oil content had amounted to 48.2% and in
1971 — to 51.0%. — i.e. the difference is 2.8%. At the nitrogen fertili-
zation variant this difference is still greater. Similar differences are to
be observed at the phosphorus and potassium fertilization. It is obvious
that the meteorological factors (consisting mainly in the quantity and
distribution of precipitations during the vegetation period, the tempe-

rature of the soil and the air, sunshine, etc) influence greatly the oil content of the sunflower seed. These observations could balance to a certain degree with the timely and concrete agrotechnique, including fertilization (table 4).

The rightest criterion in determining the optimum fertilization rates is the economical efficiency of the practices, expressed by the net production in leva/ha. 2077 l/ha of sunflower oil with 924 leva/ha net production is obtained from fertilization on carbonate chernozem in the district of Targovishte at optimum fertilization. Similar results are obtained on the other soil types (table 5).

The results obtained show that the natural fertility of the different soil types in our country is different due to which the yields obtained from the non-fertilized variant are low (two times lower and more, depending on the soil type).

At optimum nutrient regime regulated by means of different fertilization rates the difference between the separate soil types becomes smaller and the yield of sunflower seed on all soil types reaches high limits — 35. q/ha. For achieving this effect on the different soil types it is necessary to apply various fertilization rates : on the chernozem — 80—120 kg N and P_2O_5 ; on grey and cinnamonic forest soils — 160—200 kg, the natural fertility thus ceasing to be a limiting factor for the yields.

We could draw the following conclusions based on the investigations carried out :

For obtaining 30.0—35.0 q/ha of sunflower seed the following fertilization rates should be applied : on carbonate chernozem — N 120—140 and P_2O_5 80 kg/ha ; on the leached chernozems in the north-west part of the country N 150—170 and P_2O_5 140—150 kg/ha ; for the middle areas (the district of Pleven) N120, P_2O_5 100 kg/ha ; on leached cinnamonic forest soils and smolnitsa N 140—180 kg, P_2O_5 — 150—180 kg/ha ; on podzolic cinnamonic forest soils — N 180—200, P_2O_5 160—180 and K_2O 120—140 kg/ha. At the above indicated fertilization rates the oil content is usually 48—50%.