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INFLUENCE OF NITROGEN RATE IN SUNFLOWER ON THE EFFECT OF NITROGEN FERTILIZATION IN SUBSEQUENT WINTER WHEAT

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SUMMARY

Experiments were carried out on a slightly leached chernozem during 1991-1994. Four nitrogen rates in sunflower and five nitrogen rates in coming winter wheat were investigated. The aim of the study was to find out relationships between nitrogen fertilization in predecessor and in coming winter wheat, as well as their effect on the yield formation of the cereal culture. It was established that the nitrogen fertilization in sunflower had a significant influence on the grain yield of the coming winter wheat. The total nitrogen rates (previous + direct) correlated positively with the wheat grain yield. The highest coefficient of correlation was calculated when the theoretical total nitrogen rate contained 1/3 of the previous and the direct rates.

Key words: Previous N norm, direct N norm, relationships, regression equations

INTRODUCTION

Usually the sunflower and the winter wheat are in an interaction in the Bulgarian crop rotations.

Some authors found that high levels of N were accumulated in deep soil layers as a result of systematic fertilization of wheat with high nitrogen doses (Petrova, 1984; non-published data of Gospodinov and Ivanov). A part of that nitrogen is accessible to the sunflower because of its deeply located root system. Due to that cause, during 1970-1990, the nitrogen doses in sunflower decreased from 120 kg/ha N - in the beginning of the period (Kazakova, 1967; Petrova, 1972) to 60 kg/ha N (Iliev and Dimitrov, 1983; Iliev, 1988). The investigations of Tonev et al., (1993) carried out at the end of the period showed that nitrogen fertilization had no positive effect on yield. The sunflower area in Bulgaria increased nearly twice in last five years (Nankov, 1994) and now it is one of the main predecessors for winter wheat in the country. The latest investigations showed that

the wheat productivity after sunflower was on the same level as after corn (Shtereva and Tonev, 1992).

Strumpfe, 1977, as well as Dikstrit et al., 1985, considered that the previous nitrogen fertilization exerted an influence on the wheat grain yield. Our investigations on three grain legume (spring pea, common bean and soybean) and three cereal (winter wheat, corn and corn for silage) predecessors permitted us to reach conclusions about the influence of previous nitrogen fertilization on the effect of nitrogen rates in winter wheat (Tonev and Gospodinov, 1995; Tonev, 1996).

The aim of the present study was to determinate relationships between nitrogen fertilization in sunflower and nitrogen fertilization in subsequent winter wheat as well as their effect on the yield formation of the cereal culture.

MATERIAL AND METHODS

The trials were carried out during 1991-1994 in the experimental fields of the Institute of Wheat and Sunflower near Gen. Toshevo. The sunflower hybrid Albena was grown after winter wheat fertilized with $N_{120}P_{100}$. Sunflowers were sown on 25 April 91, 28 April 92 and 27 April 93. Four nitrogen rates (0, 40, 80 and 120 kg/ha N) were tested in combination with $P_{120}K_0$ - Factor A. Phosphorus was applied before ploughing at the end of the summer of the previous year, and nitrogen before sowing. The agrotechnical elements which were not an object of the present investigation were provided through the conventional technology (11). Sunflower seed yield was calculated on the basis of standard seed moisture (11 %).

The free area after harvest was cleaned from plant residues and it was fertilized with P_{120}. The soil was prepared for wheat sowing by disking. The wheat was sown made in the optimum time for the region (October 5-15) with a Pliska cultivar. Five plots with winter wheat were formed from a sunflower plot. In this way the following nitrogen doses in winter wheat were tested: 0, 40, 80, 120 and 160 kg/ha N (Factor B). Nitrogen was applied in one turn, in February, before the intensive spring vegetation of wheat. The remaining agrotechnical elements were covered with the conventional technology (11).

The Institute of Wheat and Sunflower near Gen. Toshevo lies in the northeastern part of the country, and according to the soil and climatic conditions its experimental field represents the I_9 agroecological region (Yolevsky et al., 1980). The slightly leached chernozem here has a comparatively well-developed humus horizon (60-80 cm) and according to the humus content it belongs to medium humic soils (Yolevsky et al., 1959). Its nutritative regimen shows medium level of total N, low level of P_2O_5 and medium to high level of K_2O. The recent investigations on four types of crop rotation fertilized with optimum and high NPK doses showed that the humus content decreased by 0.8 % and the contents of macroelements were increased particularly in the soil layer of 80-100 cm (Nankova et al., 1994).

Table 1: Seed yield of sunflower (1991-1993), kg/ha.

Fertilization	1991	1992	1993	Average	Differences according to N_0, ± kg/ha
N_0P_{120}	2702	2190	2089	2327	-
$N_{40}P_{120}$	2710	2282	2213	2402	+75
$N_{80}P_{120}$	2520	2287	2455	2421	+94
$N_{120}P_{120}$	2530	2300	2070	2300	-27
L.S.D. at 0.05	248	151	648		205
0.01	357	217	932		276
0.001	525	319	1371		365

Table 2: Grain yield of winter wheat (1992-1994), kg/ha.

Nitrogen rate, kg/ha		Grain yield, kg/ha			
In sunflower	In wheat	1992	1993	1994	Average
0	0	4503	4010	4898	4470
	40	4998	4640	4983	4874
	80	5493	5177	5108	5259
	120	5850	5330	5220	5467
	160	6042	5420	5385	5616
40	0	4630	4554	4900	4695
	40	4850	5468	5165	5161
	80	5320	5840	5200	5453
	120	5818	6265	5383	5822
	160	5985	5958	5380	5774
80	0	4510	5040	5080	4877
	40	4943	5298	5238	5160
	80	5553	5600	5323	5492
	120	5933	6012	5420	5788
	160	5790	5910	5367	5689
120	0	4455	5060	5068	4861
	40	5433	5350	5217	5333
	80	5852	5375	5377	5535
	120	6140	5883	5380	5801
	160	5758	5790	5320	5623

RESULTS

The highest average yield of sunflower was produced in 1991 - 2616 kg/ha, and the lowest in 1993 - 2251 kg/ha. On average for the period, the seed yield increased from N_0P_{120} to $N_{80}P_{120}$ but the differences according to the control variant were not significant (Table 1). These results confirmed the conclusions reached in our previous investigation (Tonev et al., 1993) and supported the actual concept about sunflower reaction to direct nitrogen fertilization.

On average for the studied variants, the grain yield of the subsequent winter wheat varied from 5221 kg/ha (1994) to 5399 kg/ha (1993). These values were higher from 1.0 to 2.2 % in relation to the average for the period (Table 2).

On average for the variants of direct nitrogen fertilization in wheat, the influence of nitrogen dose in predecessor had a significant effect on wheat yield (Table 3). The relative effect was most expressed in 1993 when it reached 14.3 %. On average for the period, the maximum nitrogen rate in sunflower (N_{120}) had the highest influence - 5.7 %, but the differences between 40 and 120 kg/ha N were under the limit of significance (0.95 % according to the control variant). This result allowed us to come to the conclusion that although the yield increased in proportion to the previous nitrogen rates of $N_{0\text{-}120}$ the nitrogen rates in sunflower higher than N_{40} were not justified.

Table 3: Results from dispersion analysis of wheat yield data (1992-1994).

Source of variation	df	F	Control yield and ±D, kg/ha
I. Factor A - N rate in sunflower	3	7.0***	
(LSD at 0.05, 0.01 and 0.001 = 142, 188 and 239 kg/ha)			
1. 0 kg/ha - control			5137
2. 40 kg/ha - ± differences (D)			+244***
3. 80 kg/ha - ± D			+264***
4. 120 kg/ha - ± D			+293***
II. Factor B - N rate in winter wheat	4	52.76***	
(LSD at 0.05, 0.01 and 0.001 = 159, 209 and 268 kg/ha)			
1. 0 kg/ha - control			2725
2. 40 kg/ha - ± differences (D)			+407***
3. 80 kg/ha - ± D			+710***
4. 120 kg/ha - ± D			+993***
5. 160 kg/ha - ± D			+950***
A x B	12		
Error	354	0.56 NS	

*** - Significance at level 0.001; NS - not significant.

The increase of the direct nitrogen rate in the range 0-120 kg/ha influenced positively the grain yield. The relative effect in 1992, 1993 and on average for the

period reached 31.2, 25.9 and 21.0 %, respectively. The highest average yield was obtained in the variant $N_{160}P_{120}$ when the previous fertilization was N_0P_{120}, as well as in the variant $N_{120}P_{120}$, when the previous nitrogen fertilization varied from 40 to 120 kg/ha N. In this way the increase of the previous rate influenced negatively the effect of the direct nitrogen fertilization in wheat from 18.6 % to 29.8 %.

The dispersion analysis showed that despite the well-expressed relative effects of previous and direct nitrogen fertilization significant relationships between them were not found.

DISCUSSION

Some working hypotheses were tested with the aim to find out the main correlation between the factors A and B, and the grain yield of the wheat. They were as follows:

- Putative influence of the range of the application rates on the studied factors;
- Putative influence of the theoretical total nitrogen rates (A + B) in proportion to the previously applied nitrogen rate.

Table 4: Correlation coefficients between wheat grain yield and investigated factors applied in different ranges.

Application of sunflower N rates in ranges	Factor	Application of wheat N rates in ranges		
		0-80	80-160	0-160
0 - 40	A	0.283	0.344	0.239
	B	0.759**	0.403	0.789**
	A + B	0.796**	0.523*	0.823**
	1/3 A + B	0.801**	0.462*	0.811**
	1/2 A + B	0.809**	0.486*	0.818**
	3/4 A + B	0.810**	0.503*	0.823**
	n	18	18	30
0-80	A	0.318	0.289	0.232
	B	0.745**	0.393*	0.782**
	A + B	0.752**	0.483**	0.793**
	1/3 A + B	0.807**	0.464*	0.812**
	1/2 A + B	0.809**	0.481**	0.816**
	3/4 A + B	0.797**	0.489**	0.814**
	n	27	27	45
0 - 120	A	0.338*	0.217	0.217
	B	0.733**	0.333*	0.758**
	A + B	0.706**	0.372*	0.729**
	1/3 A + B	0.807**	0.393*	0.788**
	1/2 A + B	0.796**	0.397*	0.784**
	3/4 A + B	0.771**	0.393*	0.772**
	n	36	36	60

*, ** - Significance at levels 0.05 and 0.01, respectively.

The results in Table 4 showed that the grain yield of wheat changed mainly under the influence of direct nitrogen fertilization (r = +0.758**) - on average for the investigated levels of factor A (0-120 kg/ha N) and B (0-160 kg/ha N). The total rate A + B had a significant influence regardless of the decrease in the correlation coefficient to +0.729**. The highest coefficient of correlation (+0.788**) was calculated for a limited part (1/3) of factor A in the total rates.

The application of nitrogen doses in different ranges showed that the established relationships had a specific effect on wheat grain yield, as follows:

- The direct nitrogen fertilization in the range 0-80 kg/ha N had a more expressed influence than the range of application 80-160 kg/ha;
- The influence of previous fertilization decreased after a direct rate N_{80};
- The effect of previous fertilization within the total doses was highest in the ranges 0-40 kg/ha N of factor A and 0-80 kg/ha N of factor B.

These conclusions gave the idea to search for theoretical changes of wheat yield for each level of nitrogen fertilization in sunflower and under the influence of direct nitrogen fertilization. The data were used as follows: the nitrogen doses were presented in their absolute quantitative (0, 40, 80, 120, 160) whereas grain yields in their non-dimensional quantitative (as relative coefficients according to the average for each annual yield). Twelve regression equations were worked out and the choice of the right model was made on 3 criteria - S y.x, R y.x and standard error (SE). In this way we found that the grain yield of wheat changed under the influence of direct nitrogen fertilization following parabolic curves, and the differences between empirical and theoretical data reached 2.0 % (Table 5). According to the these equations the maximum theoretical yield of wheat grown after sunflower was determined for the variant fertilized with 80 kg/ha the previous N rate and 120 kg/ha the direct N rate.

Table 5: Regression models of grain yield change in wheat depending on nitrogen rate in sunflower.

Regression model	S y.x	R y.x	St. error
$y\ (0) = 0.835 + 0.00232\ x - 0.000006\ x^2$;	0.039	0.999	0.057
$y\ (40) = 0.877 + 0.0026\ x - 0.000008\ x^2$;	0.031	0.999	0.051
$y\ (80) = 0.903 + 0.00235\ x - 0.000007\ x^2$;	0.0166	0.9995	0.037
$y\ (120) = 0.899 + 0.003\ x - 0.000012\ x^2$;	0.016	0.9995	0.036

y (0), y (40), y (80) and y (120) - Grain yield of wheat after previous N rates 0, 40, 80 and 120 kg/ha, respectively; x - direct N rate in the range 0-160 kg/ha

CONCLUSIONS

Nitrogen fertilization in sunflower had a significant influence on grain yield of the subsequent winter wheat. The effect was more expressed in an the application range 0-80 kg/ha N.

The increase of the previous nitrogen rate from N_0 to N_{120} decreased the effect of the direct nitrogen fertilization in wheat.

The theoretical total nitrogen rates (previous + direct) correlated positively with the wheat grain yield. The highest coefficient of correlation was calculated when the total nitrogen rate contained 1/3 of the previous and the direct rates.

It was found that the yield change followed a parabolic curve under the influence of direct dose increase. Regression equations for each level of previous fertilization were worked out.

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INFLUENCIA DE LA DOSIS DE NITRÓGENO EN GIRASOL SOBRE EL EFECTO DE LA FERTILIZACION NITROGENADA EN EL TRIGO DE INVIERNO SIGUIENTE

RESUMEN

Los experimentos se llevaron a cabo en un chernozem ligero durante el periodo 1991-1994. Cuatro dosis de notrógeno en girasol y cinco dosis de nitrógeno en el trigo de invierno siguiente fueron investigadas. El objetivo del estudio fué encontrar la relación entre la fertilización nitrogenada en el trigo de invierno precedente y siguiente, asi como un efecto en la formación del rendimiento del cultivo de cereal. Se constató que la fertilización que la fertilización nitrogenada en girasol tuvo una influencia significativa en el rendimiento en grano del trigo de invierno siguiente. Esto fué mas claro en el rango de aplicación de 0-80 Kg/ha N. La suma (total) de dosis de nitrógeno (previa y directa) estuvo correlacionada positivamente con el rendimiento en semilla del trigo. El coeficiente de correlacción mas alto fué calculado cuando la suma de la dosis de nitrógeno contenía 1/3 de la dosis previa y toda la directa.

INFLUENCE DE LA DOSE D'AZOTE DU PRÉCÉDENT TOURNESOL SUR LA FERTILISATION AZOTÉE DU BLÉ D'HIVER

RÉSUMÉ

Les expérimentations ont été réalisées sur chernozium légérement filtrant durant 1991-1994. Quatre doses d'azote sur tournesol et 5 doses d'azote sur la culture de blé suivante ont été étudiées, le but de l'étude étant d'établir les relations entre la fertilisation azotée du précédent sur la culture de blé d'hiver suivante ainsi que leur effet sur la formation du rendement de la culture céréalière. On a trouvé que la fertlisation azotée du tournesol avait une influence significative sur le rendement en grains de la culture de blé d'hiver suivante, en particulier dans la gamme 0-80 kg d'azote/ha. La somme (totaux) des doses d'azote (précédent + direct) est corrélée positivement avec le rendement en grains du blé. Le coefficient de corrélation le plus élevé a été trouvé lorsque la somme des doses d'azote correspondait à 1/3 de l'apport du précédent et à la totalité de l'apport direct.