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TILLAGE AND NITROGEN RATE EFFECTS ON SOYBEAN YIELD IN THE SPECIFIC CONDITIONS FROM DANUBE MEADOW

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Abstract. *Soybean is a plant with multiple uses both for food and feed purposes, as well as raw material for different industrial purposes. This is due to its chemical composition, respectively to the richness in lipids and proteins, soybean being important also from an agronomic point of view, for the nitrogen natural fixation and improving soil fertility. The aim of the performed research was to investigate the behaviour of the soybean crop at different tillage and nitrogen rates. In this respect, field experiments were performed under rainfed conditions located in South Romania, respectively in the Danube meadow, in the years 2023 and 2024. The experimental factors were: Factor A: Soil tillage (a1 - Ploughing - depth of 25 cm + 2 disc harrows – Control; a2 - Scarifying - depth of 35 cm + 2 disc harrows; a3 - Gruber Tiger - depth of 25 cm; a4 - Gruber Tiger - depth of 15 cm; a5 - Disc harrow - depth of 15 cm – 2 passed); Factor B; Nitrogen rate (b1 - N0 - unfertilized – Control; b2 - 60 kg/ha; b3 - 80 kg/ha; b4 - 120 kg/ha). The conventional tillage system had a positive response for 2023, given the high amount of precipitation in spring, but in the dry year 2024, the minimum tillage system played an important role in conserving water in the soil in spring, which leaded to better seed yields. Generally, in any tillage variant and climatic conditions, the increasing of the nitrogen rate was associated with a positive effect on the yield elements, seed yield and yeild quality.*

Keywords*: grains yields, nitrogen rate, productivity elements, soil tillage, soybean.*

INTRODUCTION

Soybean is a plant with multiple uses. In Romania, in 2023, soybean was cultivated on 141,671 ha, with an average production of 2140 kg/ha, resulting in a total production of over 303 thousand tons (INS, 2024). Soybean has a great importance for human nutrition, animal feed and industry. Its grains contain over 30% protein substances with high nutritional value and 17-20% edible oil used as such in food or for the preparation of margarine, the manufacture of plastics and other many uses (MORARU AND RUSU, 2012; POP ET ALL., 2013). The remaining meal after oil extraction is used in animal feed due to its high protein content. Thanks to nitrogen fixing bacteria (*Bradyrhizobium japonicum*) on the roots, soybean can produce 50-150 kg nitrogen/ha, which ensures an increase in soil fertility (MAITY ET ALL., 2023).

Among the requirements necessary for soybean varieties for the minimum tillage system, there are specified the following: disease resistance, rapid germination capacity in lower temperature conditions, increased vigor in young plants (DE FELICE ET ALL., 2006). Special requirements are related to tolerance (resistance) to white mold (*Sclerotinia sclerotiorum*) and septoria (*Septoria glycines*) (CHEȚAN ET ALL., 2016, VARGA ET ALL., 2024).

On the other hand, nitrogen is the most widely used fertilizer nutrient in agriculture on a global scale (GOVINDASAMY ET ALL., 2020). Despite being one of the most abundant elements on earth, nitrogen deficiency is probably the most common nutritional problem affecting plants worldwide. Furthermore, excessive and inefficient use of nitrogen fertilizer results in increased crop production costs and pollution problems (LANGHOLTZ ET ALL., 2021). At the same time, soybean fertilization involves the idea of not adding nitrogen fertilizer because soybeans receive nitrogen from two sources: natural nitrogen fixation and soil nitrogen (residual N and mineralization of organic matter) (CIAMPITTI AT ALL., 2021). Regardless of the soil tillage system practiced, for effective weed control, an important role is played by crop rotation (AL-KAISI ET ALL., 2020; YU ET ALL., 2022). The quality of the work performed within the chosen soil tillage system is essential, as well as a preventive and curative weed control strategy and knowing the particularities of infestation of specific weeds (CHETAN ET ALL., 2016).

MATERIAL AND METHODS

The aim of the performed research was to investigate the behaviour of the soybean crop at different tillage and nitrogen rates conditions.

The research was performed in field experiments under rainfed conditions within SC Agrochirnogi SA (one of the farms belonging to the company SC. Unic Prod Com SRL) located in South Romania, respectively in the Danube meadow, near Oltenița city from Călărași County.

The soil is mostly alluvial type, characterized by: medium and/or heavy texture, with an upper horizon of 20 – 35 cm thick, a dark brown – yellowish colour, having a granular and unstable structure.

The temperature values recorded in both 2023 and 2024 are notable for exceeding high values in summer time by over 2-3 degrees compared to the average for the area (27ºC). In 2023, the average annual temperature was 12.5ºC, the annual maximum was 42.2ºC (on August 2024), and the annual minimum was –2.90ºC (on February 17, 2023) (Figure 1).

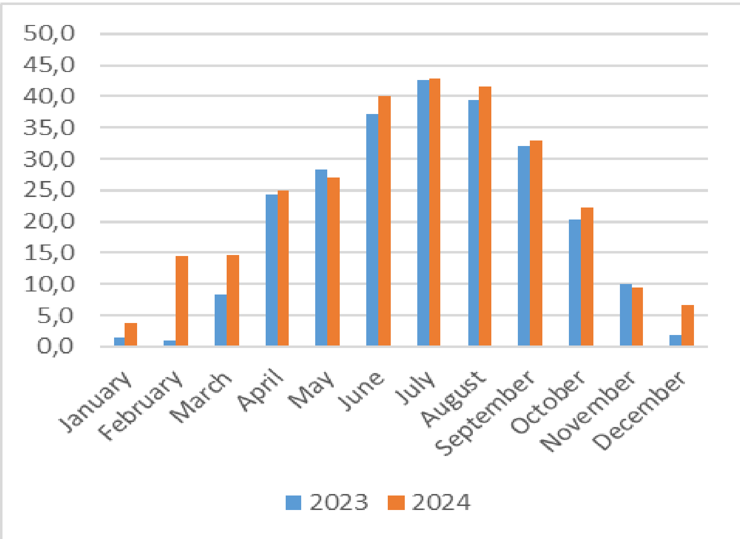

Figure 1. Temperatures in experimental field (2023-2024)

In terms of rainfall, it can be noted the large amount of these that fell in April, which led to the delay of about two-three weeks of the optimal sowing moment, which took place on May 3, 2023 (Figure 2). By comparison, the year 2024 was noted for a lack of precipitation, especially in the months of May and June, which led to a weaker emergence of plants compared to 2023.

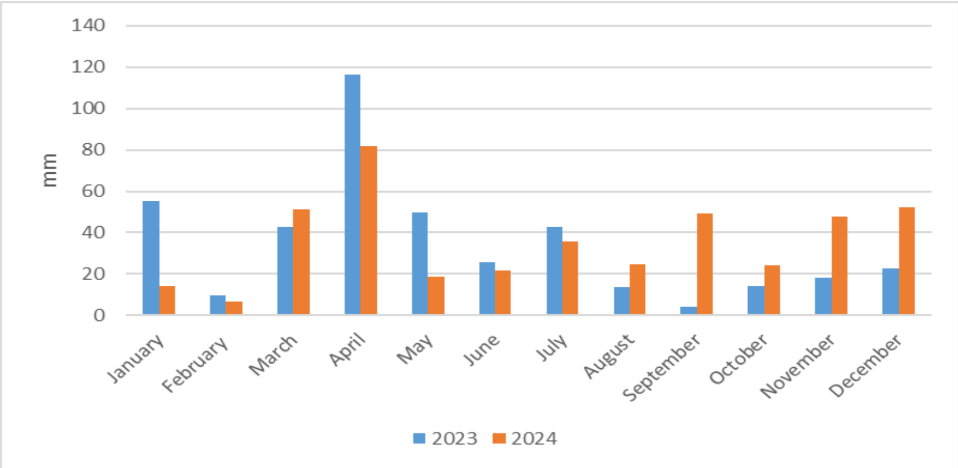

Figure 2. Rainfall in experimental field (2023-2024)

The field experiment was based on the method of subdivided plots into 3 replications, having two experimental factors (bifactorial experiment), respectively:

- Factor A: Soil tillage, with 5 variants:
  - a1 - Ploughing - depth of 25 cm + 2 disc harrows (Control);
  - a2 - Scarifying - depth of 35 cm + 2 disc harrows;
  - a3 - Gruber Tiger - depth of 25 cm;
  - a4 - Gruber Tiger - depth of 15 cm;
  - a5 - Disc harrow - depth of 15 cm (2 passed).
- Factor B; Nitrogen rate, with 4 variants:
  - b1 - N0 - unfertilized (Control);
  - b2 - 60 kg/ha;
  - b3 - 80 kg/ha;
  - b4 - 120 kg/ha.

Each experimental variant had 120 m^2, resulting from 20 m length and 6 m width. In all experimental variants, except for Control variant, there was applied before seedbed preparation the complex fertilizer of type 16:16:16 in a rate of 250 kg/ha, assuring 40 kg/ha as active substance of N, P_2O_5 and K_2O. In May (1-5 of May), the nitrogen rate according to the experimental variant was assured by applying the liquid fertilizer UAN (Ureea Ammonium Nitrat Solution) containing 32% nitrogen.

For each variant, the following determinations were performed at harvest: number of pods/plant; number of grains/plant; average number of grains/pod; grain mass/plant (g); Thousand Grains Weight (TGW) (g). Grains Yields (kg/ha), moisture content (U) (%) and Hectoliter Mass (MH) (kg/hl) were determined, as well as the content in lipids (%) and proteins (%).

The previous plant was maize, and the soybean variety was PR92B63, a mid-early variety, with excellent productive potential. The soil tillage according to the classic system (ploughing and scarifying) took place in the fall, and the minimum tillage (Gruber Tiger 15 cm, Gruber Tiger 25 cm, Disc harrow (2 passed) were executed in the spring.

One day before sowing, the seedbed preparation was carried out with a combinator. The sowing was carried out with a 6 m Horch Pronto seeder assuring the following parameters: sowing density of 60 germinating grains/m^2, sowing depth of 4-5 cm, row spacing of 15 cm.

The weed control was assured after plant emergence by applying the herbicide products Basagran SL (Bentazone 480 g/l) and Corun (Bentazone 480 g/l + Imazamox 22.4 g/l). Basagran herbicide was applied against annual and perennial dicotyledonous weeds, at a rate of 2 l/ha, when the weeds have emerged and are in the 2-4 leaf phase. Corun herbicide has a broad spectrum of control of dicotyledonous and monocotyledonous weeds, applied in the early stages of weed vegetation, from the cotyledon stage to the 4 true leaf stage, at a rate of 1.9 l/ha + 1 l/ha of Dash HC as adjuvant.

Against pathogens, the commercial product Pictor Active (Boscalid 150 g/l + Pyraclostrobin 250 g/l) was applied in rate of 0.5 l/ha, to control: white mold (*Sclerotinia sclerotiorum*), downy mildew (*Peronospora manshurica*), pod blight of soybean (*Diaporthe sojae*), and leaf spot of soybean (*Septoria glycines*). The fungicide was applied in the BBCH stages 51–75, respectively from the appearance of the first visible flower buds, until the moment when 50% of the pods reached normal size.

Against pests, such as the red spider (*Tetranycus urticae*) and the pod moth (*Etiella zinckenella*), the product Nissorun (Hexythiazox 10%) was applied at a rate of 0.2 l/ha. When the pods appeared, the insecticide product Coragen (Chlorantraniliprole 200 g/l) was applied in a rate of 125 ml/ha, against *Helicoverpa armigera*.

Harvesting was carried out with the New Holland CR9090 combine on September 20 in 2023, and two weeks early in 2024.

The results are presented from the point of view of the singular and combined effect on both influence of tillage and nitrogen rate to yielding components, seed yield, proteins and lipids contents.

RESULTS AND DISCUSSIONS

Results on the influence of tillage. The tillage influence on soybean yielding elements revealed values of over 115 g of TGW in the case of ploughing and disc harrow variants in 2023 and over 110 g in the case of Gruber Tiger (25 cm) variant in 2024 (Table 1). The number of grains/plants varied between 56.53 and 65.43 in 2023 and between 24.63 and 34.38 in 2024.

If the average value in 2023 for TGW was 112.40 g and in 2024 it was of 109.05 g, with a decrease for average TGW in 2024 of 4.81%, the average value for the number of grains per plant was of 58.8 in 2023 and of 29.18 in 2024, with a decrease in 2024 of 16.29%, respectively with a decrease at half in 2024 (Table 1).

TGW registered the smallest variation among the experimental variants (2.03% in 2023 and 4.81% in 2024), while the number of grains per plant registered a variation much more consistent (5.11% in 2023 and 16.29% in 2024) (Table 1).

Regarding the grain yields, for the year 2023, the best yield was recorded with ploughing tillage method, with about 3000 kg/ha. Similarly, in the case of the Gruber Tiger (25 cm) variant, the yield was about 2617 kg/ha. In 2024, the grain yield was reduced due to registered drought. However, the yield obtained in the case of minimum tillage variants (Disk harrow at 15 cm, Gruber Tiger at 15 cm and Gruber Tiger at 25 cm) was noted, where yield varied between 1380 and 1742 kg/ha. The lowest grain yield was recorded in the case of Ploughing and Scarifying variants, with around 1000 kg/ha (Figure 3).

Table 1

The influence of soil tillage on soybean productivity elements in 2023-2024

Yielding elements	Ploughing (25 cm) + 2 disc harrows (Control)	Scarifying (35 cm) + 2 disc harrows	Gruber Tiger (25 cm)	Gruber Tiger (15 cm)	Disc harrow (15 cm) (2 passes)	*Average*	CV (%)
2023							
No of branches/plant	1.58	1.34	1.41	1.41	1.50	*1.45*	*5.75*
No of flow with pods/stem	8.94	9.36	9.18	9.23	8.60	*9.06*	*2.96*
No. of pods/stem	15.63	13.95	18.66	14.34	13.55	*15.23*	*12.17*
No. of fertile pods/plant	29.71	25.72	32.93	26.09	24.22	*27.73*	*11.40*
No. of sterile pods/plant	1.55	2.13	1.65	2.48	2.78	*2.12*	*22.26*
No. of grains/plant	65.43	56.53	61.12	57.23	53.72	*58.80*	*6.92*
No. of grains/pods	2.19	2.22	1.99	2.28	2.31	*2.20*	*5.11*
Grain mass/plant (g)	8.01	6.51	6.96	6.39	6.01	*6.78*	*10.15*
TGW (g)	115.95	114.22	110.84	110.06	110.92	*112.40*	*2.03*
2024							
No of branches/plant	1.23	1.14	1.66	1.31	2.04	*1.48*	*22.53*
No of flow with pods/stem	17.28	8.95	7.68	6.32	6.85	*9.41*	*42.81*
No. of pods/stem	13.21	12.18	18.66	16.43	16.30	*15.36*	*15.31*
No. of fertile pods/plant	11.75	9.98	16.52	14.22	14.01	*13.30*	*16.87*
No. of sterile pods/plant	1.47	2.19	2.15	2.20	2.78	*2.16*	*19.25*
No. of grains/plant	22.40	24.63	31.77	32.73	34.38	*29.18*	*16.29*
No. of grains/pods	2.17	2.59	1.93	2.51	2.49	*2.34*	*10.67*
Grain mass/plant (g)	6.36	5.51	5.79	5.39	5.01	*5.61*	*8.02*
TGW (g)	117.57	105.41	102.03	109.81	110.42	*109.05*	*4.81*

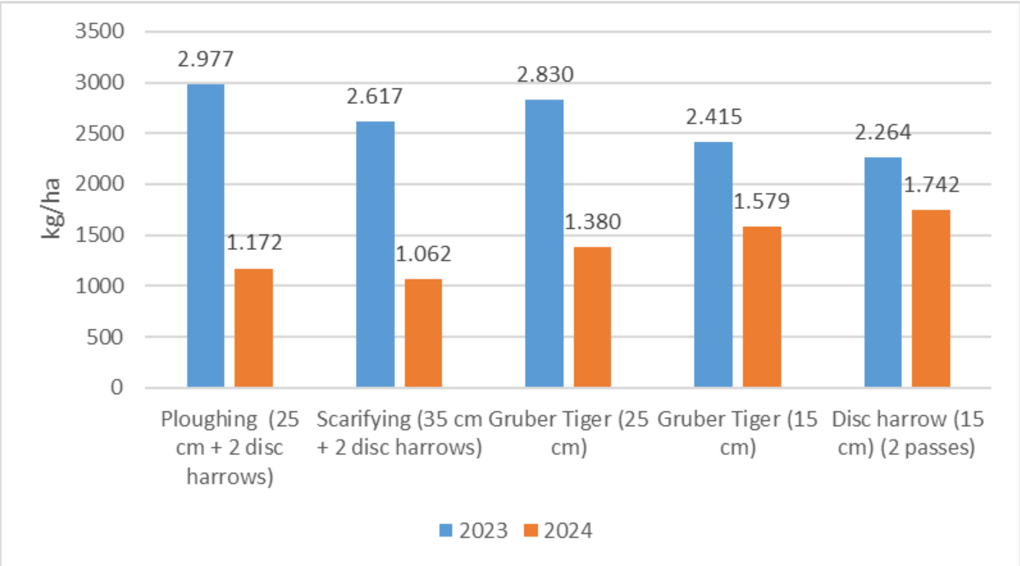

Figure 3. The influence of soil tillage on soybean production in 2023-2024

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Regarding the influence of tillage on seed moisture content and Hectoliter Mass, there was no significant influence between the tested variants. The seed moisture content varied between 9.69 and 10.27% and the Hectoliter Mass varied between 67.4 and 72.75 kg/hl. It has to be pointed out the smaller values registered in 2024, as well as the very small variation, with the values of the coefficient of variation smaller then 1% (Table 2).

Regarding the influence of tillage on the chemical composition of seeds in period 2023-2024, lipids content varies between 18.03 and 19.78% and protein content between 35.32 and 36.98%. Opposite to the values of seed moisture content and Hectoliter Mass, in the case of the chemical composition of seeds it has to be pointed out the higher values registered in 2024, again with very small variation (Table 3).

Table 2

Influence of tillage on seed moisture content and Hectoliter Mass in 2023-2024

Experimental variants	2023		2024	
	Moisture (%)	HM (kg/hl)	Moisture (%)	HM (kg/hl)
Ploughing (25 cm + 2 disc harrows)	10.05	72.75	10.05	67.55
Scarifying (35 cm + 2 disc harrows)	10.27	71.25	9.77	67.45
Gruber Tiger (25 cm)	10.08	72.00	9.71	67.4
Gruber Tiger (15 cm)	10.21	71.00	10.21	68.45
Disc harrow (15 cm) (2 passes)	10.04	71.75	9.69	67.71
Average	*10.13*	*71.75*	*9.88*	*67.71*
Coefficient of variation – CV (%)	0.92	0.85	2.10	0.57

Table 3

Influence of soil tillage on lipids and proteins content of soybean grains in 2023-2024

Experimental variants	2023		2024	
	Lipids (%)	Proteins (%)	Lipids (%)	Proteins (%)
Ploughing (25 cm + 2 disc harrows)	18.46	35.91	18.03	36.13
Scarifying (35 cm + 2 disc harrows)	19.09	35.32	18.52	35.87
Gruber Tiger (25 cm)	18.21	36.18	19.00	36.98
Gruber Tiger (15 cm)	18.06	36.40	19.28	36.77
Disc harrow (15 cm) (2 passes)	18.21	35.32	19.78	37.07
Average	*18.41*	*35.83*	*18.92*	*36.56*
Coefficient of variation – CV (%)	1.98	1.23	3.20	1.31

Results on the influence of nitrogen rate. The yielding elements were influenced by the nitrogen rate. Generally, all the values of the yield elements increased with increasing of nitrogen rate from 0 to 1202 kg/ha, except the number of sterile pods per plant, which decreased (Table 4). Thus, in the case of the nitrogen rate of 120 kg/ha, the best values of the yielding elements were obtained. For example, the TGW was 124 g, and the number of grains per plant was over 94 in 2023. High temperatures and drought had a very large influence on yielding elements in 2024. Thus, TGW was about 120 g in the case of variant with 120 kg/ha of nitrogen, and around the number of grains per plant was of 40, which means less than half value registered in 2023.

Pisulewska et al. (1999) prove that higher nitrogen fertilization significantly increases the number of pods per plant. In the studies by Caliskan et al. (2008), Mehmet (2008) and Chafi et al. (2012), it has been demonstrated that both the number of pods per plant and the TGW (*Thousand Grain Weight*) increase under the influence of nitrogen fertilization.

Table 4

Influence of nitrogen rate on yielding elements of soybean (2023-2024)

Yielding elements	N0 (Control)	N60	N90	N120	*Average*	CV (%)
2023						
No of branches/plant	1.09	1.50	1.54	1.66	1.45	14.72
No of flow with pods/stem	6.39	9.08	10.14	10.63	9.06	18.09
No. of pods/stem	9.12	12.78	15.90	23.11	15.23	33.78
No. of fertile pods/plant	15.71	23.31	27.50	44.41	27.73	37.91
No. of sterile pods/plant	2.51	2.25	1.89	1.81	2.12	13.30
No. of grains/plant	32.94	47.25	60.16	94.86	58.80	39.00
No. of grains/pods	2.20	2.08	2.22	2.30	2.20	3.66
Grain mass/plant (g)	3.32	5.13	6.84	11.82	6.78	46.74
TGW (g)	101.81	109.01	114.73	124.04	112.40	7.24
2024						
No of branches/plant	1.06	1.35	1.64	1.85	1.48	20.31
No of flow with pods/stem	7.18	8.35	10.27	11.85	9.41	19.02
No. of pods/stem	14.28	15.31	14.01	17.82	15.36	9.81
No. of fertile pods/plant	12.53	13.50	12.40	14.76	13.30	7.12
No. of sterile pods/plant	2.32	2.28	1.92	2.11	2.16	7.40
No. of grains/plant	21.49	28.16	31.69	35.39	29.18	17.57
No. of grains/pods	1.97	2.18	2.68	2.53	2.34	11,91
Grain mass/plant (g)	3.26	4.86	6.84	11.68	6.66	47.49
TGW (g)	100.78	106.16	111.67	117.57	109.05	5.73

Nitrogen (N) is an important nutrient for soybean growth and development. Soybean seed yield was strongly influenced by the effect of nitrogen application at a rate of 120 kg/ha, both in 2023 and 2024. Thus, yield exceeded the control by over 3700 kg/ha in 2023 and by 1700 kg/ha in 2024. This highlights the major role that nitrogen has for the soybean crop, knowing that it needs large quantities of nitrogen, which it covers in part from the symbiosis with nitrogen-fixing bacteria, or from the application of fertilizers. Nitrogen fertilization and seed inoculation are the main factors affecting the yield and chemical composition of soybean seeds (SERAFN-ANDRZEJEWSKA, 2024). The agronomic characteristics such as plant height, dry weight and crop yield are improving by the application but also by the amount of nitrogen. In general, the application of nitrogen in all crops leads to an increase in yield.

According to a study that has been carried out, there is a need to supply inorganic nitrogen to soybeans for higher yields due to the fact that it cannot meet the high nitrogen needs through nitrogen fixation (KUMAWAT ET AL., 2000). A study conducted by Saxena and Chandal (1992), showed that the maximum plant height was presented in 40 N kg/ha. Naik and Rao (2004), conducted an experiment in which they recorded the same result in terms of height increase. In our results the highest value in plant height was in N100 and in N120.

It was observed that the plant height increased from control to N120. This is due to the fact that nitrogen promotes plant growth in general, with the result that as the levels of applied nitrogen increase, so does the plant height, the same being observed by Pradhan et al. (1995).

Regarding seed moisture content and Hectoliter Mass, these were not significant influences of the nitrogen rate (Table 5).

Regarding the content of lipids, the values increased with the increasing of the nitrogen rate, starting with 17.46% in 2023 and 17.95% in 2024 for the control variant and reaching 19.47% in 2023 and 19.99% in 2024 in the case of variant fertilised with 120 kg/ha of nitrogen (Table 6). The same situation was registered with the protein content, this increasing

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from 34.71% in 2023 and 35.71% in 2024 for the control variant to 36.96% in 2023 and 37.36% in 2024 for the variant fertilised with 120 kg/ha of nitrogen (Table 6).

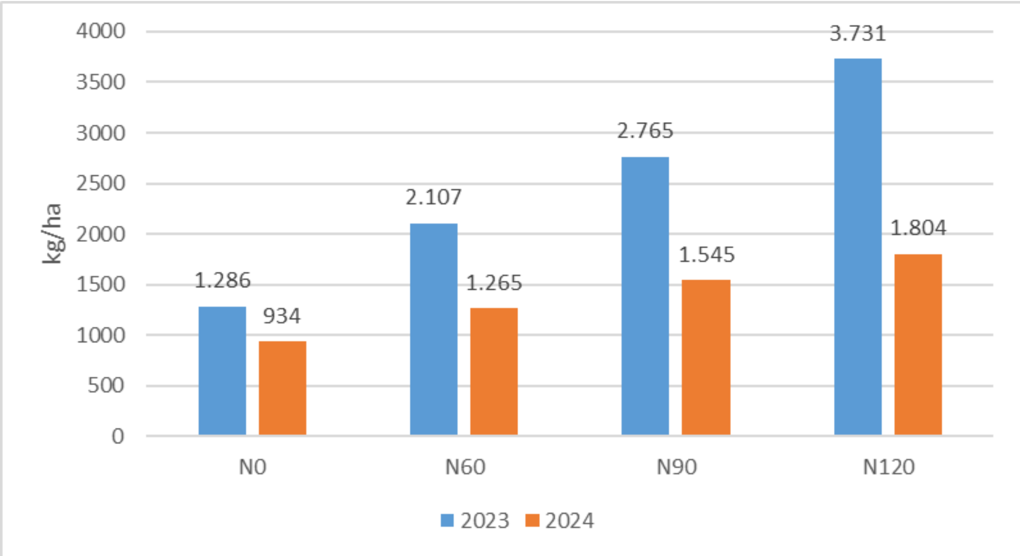

Figure 4. Nitrogen rate influence to soybean grains yields (kg/ha) in 2023-2024

Table 5

Influence of nitrogen rate on seed moisture content and Hectoliter Mass in 2023-2024

Experimental variants	2023		2024	
	Moisture (%)	HM (kg/hl)	Moisture (%)	HM (kg/hl)
N0 (Control)	10.17	72.20	9.99	67.56
N60	10.10	71.20	9.90	67.62
N90	10.08	72.00	9.87	68.36
N120	10.19	72.60	9.99	67.94
Average	*10.14*	*72.00*	*9.94*	*67.87*
Coefficient of variation – CV (%)	0.45	0.71	0.54	0.47

Table 6

The influence of nitrogen rate on lipids and proteins content of soybean grains in 2023-2024

Experimental variants	2023		2024	
	Lipids (%)	Proteins (%)	Lipids (%)	Proteins (%)
N0 control	17.46	34.71	17.95	35.71
N60	18.12	35,35	18.53	36.36
N90	18.57	36,01	19.22	36.83
N120	19.47	36.96	19.99	37.36
Average	*18.41*	*35.76*	*18.92*	*36.57*
Coefficient of variation – CV (%)	3.97	2.33	4.03	1.66

Results on the influence of the combined effect of tillage and nitrogen rate. The correlation between the application of 120 kg/ha nitrogen rate and ploughing has a positively influence to all productivity elements of soybean plants for 2023 year.

Thus, TGW was the highest in this combination, respectively about 135 g. in the other cases, regardless of the soil cultivation method, fertilization with N90 and N120 was highlighted (Table 7).

In 2024, minimum tillage methods were noted, both for TGW values but also for the other productivity elements presented in the table 8.

Table 7

The influence of soil tillage and nitrogen dose on soybean productivity elements in 2023

Tillage soil	Nitrogen rate (kg/ha)	No of branches/ plant	No of flow pods/ stem	No of pods/ stem	fertile pods/ plant	Sterile pods/ plant	Grains/plant	No. of grains/ pods	Grain mass/plant (g)	TGW (g)
V1- Plowing (25 cm + 2 disc harrows)	N0 (Control)	1.00	7.50	9.85	17.93	1.77	32.47	1.87	3.23	100.26
	N60	1.47	8.73	10.20	19.03	1.37	43.47	2.32	4.72	108.36
	N90	1.77	9.23	17.42	33.33	1.50	72.80	2.21	8.76	120.25
	N120	2.10	10.30	25.05	48.53	1.57	112.97	2.36	15.33	134.94
Average		**1.58**	**8.94**	**15.63**	**29.71**	**1.55**	**65.43**	**2.19**	**8.01**	**115.95**
V2- Scarifying (35 cm + 2 disc harrows)	N0 (Control)	1.00	7.37	9.80	16.87	2.63	35.80	2.18	3.63	101.98
	N60	1.67	9.33	13.43	24.73	2.13	50.40	2.09	5.63	114.06
	N90	1.40	9.87	12.82	23.50	2.00	51.53	2.24	6.05	117.49
	N120	1.30	10.87	19.75	37.77	1.73	88.37	2.38	10.73	123.35
Average		**1.34**	**9.36**	**13.95**	**25.72**	**2.13**	**56.53**	**2.22**	**6.51**	**114.22**
V3- Gruber Tiger (25 cm)	N0 (Control)	1.13	5.50	8.65	15.43	1.87	27.77	1.85	2.76	99.64
	N60	1.17	9.43	16.17	30.50	1.83	57.63	1.88	6.29	110.14
	N90	1.70	10.60	21.90	31.20	1.60	66.40	2.14	7.39	113.17
	N120	1.63	11.17	27.93	54.57	1.30	92.67	2.10	11.41	120.40
Average		**1.41**	**9.18**	**18.66**	**32.93**	**1.65**	**61.12**	**1.99**	**6.96**	**110.84**
V4- Gruber Tiger (15 cm)	N0 (Control)	1.00	6.37	8.92	14.57	3.27	35.27	2.47	3.50	101.36
	N60	1.63	9.43	12.77	22.87	2.67	45.43	2.04	4.90	108.03
	N90	1.53	10.60	14.43	26.37	2.03	55.83	2.18	6.08	110.54
	N120	1.47	10.53	21.25	40.57	1.93	92.40	2.44	11.09	120.31
Average		**1.41**	**9.23**	**14.34**	**26.09**	**2.48**	**57.23**	**2.28**	**6.39**	**110.06**
V5- Disc harrow (15 cm) (2 passes)	N0 (Control)	1.33	5.23	8.38	13.77	3.00	33.40	2.60	3.47	105.81
	N60	1.57	8.47	11.33	19.40	3.27	39.33	2.05	4.09	104.44
	N90	1.30	10.40	12.95	23.10	2.33	54.23	2.35	5.95	112.21
	N120	1.80	10.30	21.55	40.60	2.50	87.90	2.22	10.55	121.23
Average		**1.50**	**8.60**	**13.55**	**24.22**	**2.78**	**53.72**	**2.31**	**6.01**	**110.92**

Table 8

The influence of soil tillage and nitrogen dose on soybean productivity elements in 2024

Tillage soil	Nitrogen rate (kg/ha)	No of branches/ plant	No of flow pods/ stem	No of pods/ stem	fertile pods/ plant	Sterile pods/ plant	Grains/ plant	No. of grains/ pods	Grain mass/ plant (g)	TGW (g)
V1- Plowing (25 cm + 2 disc harrows)	N0 (Control)	1.00	6.83	16.85	15.42	1.43	22.01	1.43	1.95	101,41
	N60	1.17	5.73	16.87	15.50	1.37	21.13	1.36	2.39	117,00
	N90	1.30	7.90	8.42	6.92	1.50	22.80	3.31	7.76	120,25
	N120	1.43	8.63	10.72	9.15	1.57	23.63	2.58	13.33	131,60
Average		**1.23**	**7.27**	**13.21**	**11.75**	**1.47**	**22.40**	**2.17**	**6.36**	**117,57**
V2- Scarifying (35 cm + 2 disc harrows)	N0 (Control)	1.00	6.30	8.60	6.07	2.53	17.57	3.08	2.63	98,00
	N60	1.17	8.67	11.43	9.33	2.10	24.73	2.65	4.63	102,67
	N90	1.13	9.87	13.00	10.67	2.33	24.87	2.34	5.05	111,20
	N120	1.27	10.97	15.67	13.87	1.80	31.37	2.28	9.73	109,77
Average		**1.14**	**8.95**	**12.18**	**9.98**	**2.19**	**24.63**	**2.59**	**5.51**	**105,41**
V3- Gruber Tiger (25 cm)	N0 (Control)	1.13	4.50	18.65	16.18	2.47	23.85	1.52	1.76	98,97
	N60	1.17	6.10	17.83	15.85	1.98	29.86	1.88	5.29	101,06
	N90	2.03	8.93	18.23	16.85	1.38	36.04	2.14	6.39	103,84
	N120	2.30	11.17	19.93	17.18	2.75	37.33	2.17	9.70	104,25
Average		**1.66**	**7.68**	**18.66**	**16.52**	**2.15**	**31.77**	**1.93**	**5.79**	**102,03**
V4- Gruber Tiger (15 cm)	N0 (Control)	1.00	3.70	13.92	11.73	2.18	22.93	2.22	2.50	103,69
	N60	1.33	5.10	16.10	13.43	2.67	32.10	2.46	3.90	104,70
	N90	1.43	7.27	14.43	12.40	2.03	39.17	3.20	5.08	110,54
	N120	1.47	9.20	21.25	19.32	1.93	36.73	2.17	10.09	120,31
Average		**1.31**	**6.32**	**16.43**	**14.22**	**2.20**	**32.73**	**2.51**	**5.39**	**109,81**
V5- Disc harrow (15 cm) (2 passes)	N0 (Control)	1.17	4.57	13.38	13.23	3.00	21.07	1.61	2.47	101,81
	N60	1.90	6.13	14.33	13.37	3.27	33.00	2.54	3.09	105,44
	N90	2.30	7.40	15.95	15.15	2.33	35.57	2.39	4.95	112,54
	N120	2.80	9.30	21.55	14.28	2.50	47.90	3.43	9.55	121,90
Average		**2.04**	**6.85**	**16.30**	**14.01**	**2.78**	**34.38**	**2.49**	**5.01**	**110,42**

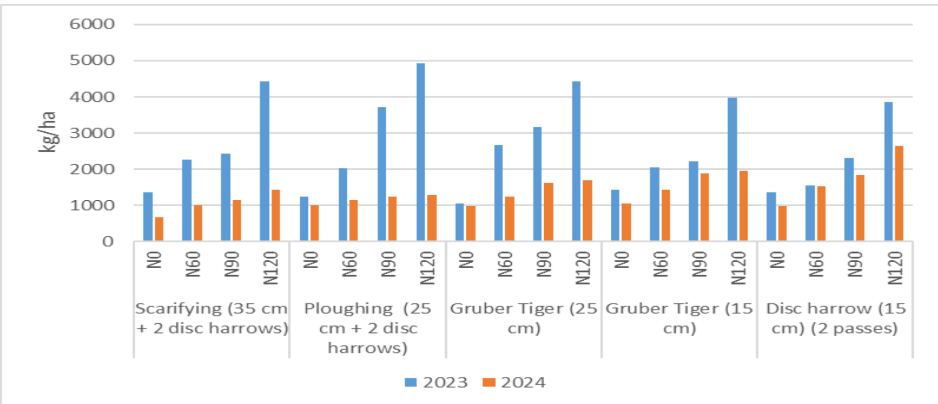

Figure 6. Soybean grains yields in 2023-2024

Table 9

The influence of tillage soil and nitrogen rate on lipids and proteins content of soybean grains (2023-2024)

Tillage soil	Nitrogen rate (kg/ha)	2023	2024	2023	2024
		Oil (%)	Proteins (%)	Oil (%)	Proteins (%)
V1- Plowing (25 cm + 2 disc harrows)	N0 (Control)	17.56	34.34	17.87	35.11
	N60	18.97	35.06	18.16	35.87
	N90	19.08	35.78	18.98	36.23
	N120	20.76	36.11	19.05	36.28
Average		**19.09**	**35.32**	**18.52**	**35.87**
V2- Scarifying (35 cm + 2 disc harrows)	N0 (Control)	18.01	34.89	17.34	35.02
	N60	18.05	35.99	17.78	36.03
	N90	18.78	36.01	18.02	36.57
	N120	19.01	36.23	18.98	36.88
Average		**18.46**	**35.91**	**18.03**	**36.13**
V3- Gruber Tiger (25 cm)	N0 (Control)	17.23	35.02	18.12	36.07
	N60	17.78	35.56	18.45	36.67
	N90	18.80	36.21	19.24	37.08
	N120	19.03	37.30	20.20	38.11
Average		**18.21**	**36.18**	**19.00**	**36.98**
V4- Gruber Tiger (15 cm)	N0 (Control)	17.07	35.16	18.20	36.21
	N60	17.94	35.77	19.04	36.67
	N90	18.08	36.79	19.78	36.98
	N120	19.15	37.87	20.10	37.21
Average		**18.06**	**36.40**	**19.28**	**36.77**
V5- Disc harrow (15 cm) (2 passes)	N0 (Control)	17.45	34.14	18.22	36.14
	N60	17.88	34.56	19.23	36.56
	N90	18.10	35.27	20.08	37.27
	N120	19.40	37.31	21.60	38.31
Average		**18.21**	**35.32**	**19.78**	**37.07**

CONCLUSIONS

The conventional tillage system had a positive response for 2023, given that the amount of precipitation in spring exceeded the average (350 mm) for the area by about 30 mm. In the dry year 2024, the minimum tillage system played an important role in conserving water in the soil in spring, which leaded to better plant growth and higher seed yields than in the case of conventional tillage.

Nitrogen fertilization is important to increase the soybean yield, in the performed research the variant with 120 kg/ha nitrogen proved to have the most important impact on seed yield. Generally, in any tillage variant and climatic conditions, the increasing of the nitrogen rate was associated with a positive effect on the yield elements.

The gradual increase of the nitrogen rate was associated regardless of the tillage method with a positive influence on the lipid and protein content of the soybean seeds. So, increase of the nitrogen rate increase both the seed yield and the yield quality.

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