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Effect of fertilizer and water deficiency stress on nitrogen in the root mass yield of lucerne for seeds

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SUMMARY – A pot trial was carried out to determine the effect of fertilizer and water deficiency stress on nitrogen in the root mass yield of lucerne for seeds. Ammonium nitrate and well matured cattle manure, as a source of mineral and organic nitrogen, were used. The plants were grown under optimum moistening conditions (75-80% of field capacity) and water deficiency stress (37-40% of field capacity). Under optimum moisture conditions the use of mineral fertilizer at a dose of 210 and 70 mg N/kg soil increased nitrogen in the root mass yield by 9 and 21%, and the manure applied at the same doses by 36 and 43%. Under water deficiency stress conditions the use of mineral fertilizer decreased nitrogen in the root mass yield by 8 and 12%, and the manure application increased it by 24 and 28%. As a whole, water deficiency stress decreased nitrogen in the root mass yield by 26 and 35% under mineral fertilizer, and by 20-21% under manure application. Plants treated with manure are less susceptible to the stress conditions of water deficiency.

Keywords: Mineral fertilizer, manure, water deficiency stress, nitrogen in root mass yield, lucerne.

RESUME – *"Effet de la fertilisation et du stress hydrique sur l'azote dans le rendement en masse racinaire chez la luzerne pour semence". Un essai en pots a été fait pour déterminer l'effet de la fertilisation et du stress de déficit hydrique sur l'azote dans le rendement en masse de racines chez la luzerne pour semences. On a utilisé du nitrate d'ammonium et du fumier d'étable bien pourri comme source d'azote minéral et organique. Les plantes étaient cultivées dans des conditions d'humidité optimale (75-80% de la capacité au champ) et de stress de déficit hydrique (37-40% de la capacité au champ). En conditions d'humidité optimale, l'utilisation de l'engrais minéral selon une dose de 210 et de 70 mg N kg^{-1} sol a augmenté l'azote dans le rendement en masse de racines de 9 et de 21% et le fumier d'étable apporté dans les mêmes doses, de 36 et de 43%. Dans les conditions de stress de déficit hydrique, la fertilisation minérale a diminué l'azote dans le rendement en masse de racines de 8 et de 12% et l'application du fumier d'étable l'a augmenté de 24 et de 28%. En général, le stress de déficit hydrique a diminué l'azote dans le rendement en masse de racines de 26 et de 35% pour la fertilisation minérale et de 20-21% pour l'application du fumier d'étable. Comme résultat du traitement des plantes avec du fumier d'étable, elles sont devenues moins susceptibles aux conditions de stress de déficit hydrique.*

Mots-clés : *Engrais minéral, fumier d'étable, stress de déficit hydrique, azote dans le rendement en masse de racines, luzerne.*

Introduction

Lucerne has the capability to utilize significantly more nitrogen than other legumes through its deep rooting characteristics (Jarvis, 2005). It is a high yielding crop, but drought determines to a great extent the quality and quantity of lucerne produced in arid and semi arid regions. Therefore search for ways to overcome negative effects of water deficiency stress is imperative and in aspect of nitrogen nutrition is of particular importance (Olesen and Bindi, 2002). The application of organic nitrogen to lucerne showed greater capacity to overcome depressive effect of water deficiency stress with regard to forage productivity, dry root mass and nitrogen in yield (Vasileva and Kostov, 2002). The aim of this study was to determine the effect of fertilizing and water deficiency stress on nitrogen in root mass yield of lucerne for seeds.

Materials and methods

The experiment was carried out with leached chernozem soil from the region of Pleven (Bulgaria) under the conditions of a pot trial with 10 treatments and 4 replications. Pots of 10 l capacity were used and 4 plants were grown in each pot. The following design was used: 1: Soil (control$_1$) + N_0PK+

75-80 % of field capacity (FC); 2: Soil + mineral N_1 + PK (MN_1 PK) + 75-80 % FC; 3: Soil + organic N_1 + PK (ON_1 PK) + 75-80 % FC; 4: Soil + mineral N_2 + PK (MN_2 PK) + 75-80 % FC; 5: Soil + organic N_2 + PK (ON_2 PK) + 75-80 % FC; 6: Soil ($control_2$) + N_0PK + 37-40 % FC; 7: Soil + mineral N_1 + PK (MN_1 PK) + 37-40 % FC; 8: Soil + organic N_1 + PK (ON_1 PK) + 37-40 % FC; 9: Soil + mineral N_2 + PK (MN_2 PK) + 37-40 % FC; 10: Soil + organic N_2 + PK (ON_2 PK) + 37-40 % FC. Optimum moisture content (75-80% of FC) was maintained for all treatments during the vegetation. From treatment 6 to 10 a 10-days water deficiency stress at the 5-6 leaf stage was imposed by stopping the watering till the moisture dropped to 37-40% FC. The following levels of N fertilization were applied: N_0 – unfertilized; N_1 – 70 mg N kg^{-1} soil; N_2 – 210 mg N kg^{-1} soil, P – 110 mg P kg^{-1} soil, K – 110 mg K kg^{-1} soil. Nitrogen was applied as ammonium nitrate (mineral nitrogen - MN) or matured cattle manure (organic nitrogen - ON). Nitrogen in manure was calculated on the base of total nitrogen. The soil mineral nitrogen and the ability of nitrogen mineralization were also taken into account. All treatments were treated against a background of P and K, the phosphorus being applied as triple super phosphate and potassium as KCl. The level of soil moisture was controlled by means of daily pot weighing. The mineral fertilizers were introduced into soil as the fertilizers were solubilized in water. The manure was ground and well mixed with soil. Lucerne (cv. Victoria) was grown for seeds. Under laboratory conditions, after washing of root system with distilled water dry root mass was recorded (dried at 60°C). Nitrogen in root mass yield was calculated as a product of dry mass of roots and total nitrogen content (determined by standard method). The experimental data was statistically analyzed using ANOVA.

Results and discussion

Mineral and manure fertilizing effect on dry root mass of lucerne (Table 1). At optimum moisture, the use of 70 and 210 mg N kg^{-1} soil mineral fertilizer increased the dry root mass by 6%, as compared to the control. The use of manure at the dose of 70 and 210 mg N kg^{-1} soil increased the dry root mass by 34 and 24%, respectively. Under both conditions of growing, the mineral and manure fertilizing had a strong effect on nitrogen in root mass yield. For the treatments under optimum moisture, the mineral fertilizing at the dose of 210 and 70 mg N kg^{-1} soil increased nitrogen in the root mass yield by 9 and 21%, respectively. The use of manure resulted in a bigger increase of nitrogen in the root mass yield (36% for the dose of 210 mg N kg^{-1} soil, and 43% for the dose of 70 mg N kg^{-1} soil).

Table 1. Nitrogen in root mass yield of lucerne grown for seeds after mineral and manure fertilizing and water deficiency stress

Treatments	Dry root mass			Nitrogen in root mass yield		
	g pot^{-1}	+, increase -, decrease to C1,C2	cv	mg N kg^{-1} DM	+, increase -, decrease to C1,C2	decrease to 75-80% FC
Optimal moisturing (75-80% FC)						
1. N_0+ PK (C1)	11.5 ^{b}	-	19.1	256.9		-
2. Mineral N, 70 mg kg^{-1} soil + PK	12.2 ^{b}	+6	4.1	309.8	+21	-
3. Organic N, 70 mg kg^{-1} soil+ PK	15.5 ^{a}	+34	30.3	367.4	+43	-
4. Mineral N, 210 mg kg^{-1} soil+PK	12.2 ^{b}	+6	9.0	280.3	+9	-
5. Organic N, 210 mg kg^{-1} soil+PK	14.3 ^{ab}	+24	27.9	349.9	+36	-
LSD 5%	1.9					
Water deficiency stress (37-40% FC)						
6. N_0+ PK (C2)	9.1^{ab}	-	36.5	226.6	-	-12
7. Mineral N, 70 mg kg^{-1} soil + PK	6.9 ^{b}	-23	18.7	199.9	-12	-35
8. Organic N, 70 mg kg^{-1} soil+ PK	10.1^{a}	+12	40.5	290.5	+28	-21
9. Mineral N, 210 mg kg^{-1} soil+PK	7.4 ^{b}	-19	8.1	208.4	-8	-26
10. Organic N, 210 mg kg^{-1} soil+PK	9.4^{a}	+3	43.8	280.3	+24	-20
LSD 5%	2.1					

[a, b]Different letters in the same column denote significant difference ($P< 0.05$) between means.
cv: coefficient of variation.

The forms of nitrogen fertilization (mineral, organic) influenced the average values of dry root mass, as well as the coefficient of variation, characterizing the arithmetic mean. The mineral nitrogen fertilizer made the plants equal, resulting in close values of dry root mass and low coefficient of variation. For manure, the values of arithmetic means of dry root mass were higher, but the coefficient of correlation was higher, too. Probably, that was due to the non homogenous composition of manure.

Under conditions of water deficiency stress, the mineral fertilizing decreased the dry root mass by 23% for the dose of 70 mg N kg^{-1} soil, and by 19% for the dose of 210 mg N kg^{-1} soil. The manure application at the dose of 70 mg N kg^{-1} soil increased it by 12%.

Water deficiency stress decreased the dry root mass for two experimental doses of manure by 35%. The decrease for mineral fertilizing was from 39 to 43%.

Under the conditions of water deficiency stress, when using 70 mg N kg^{-1} soil applied as manure, the increase of nitrogen in the root mass yield was 45%, as compared to the same dose of mineral fertilizer, and for the dose of 210 mg N kg^{-1} soil it was 34%. That data coincided with the results of Sidiras *et al*. (1999) for vetch. Under water deficiency stress, the mineral fertilizing decreased nitrogen in the root mass yield by 8 and 12%, but the manure application increased it by 24 and 28%, respectively.

As a whole, the water deficiency stress decreased nitrogen in the root mass yield by 26 and 35% under mineral fertilizing, and slightly, by 20-21%, under manure application. The experimental data allowed us to conclude that plant treatment with manure made the plants less susceptible to the stress conditions of water deficiency.

Conclusions

The mineral fertilizing at the dose of 70 and 210 mg N kg^{-1} soil increased the dry root mass of lucerne for seeds by 6%. The manure, applied at the same doses, increased the dry root mass by 34 and 24%, respectively. At optimum moisture, the use of mineral fertilizer at the dose of 210 and 70 mg N kg^{-1} soil increased nitrogen in root mass yield by 9 and 21%, and the manure applied at the same doses by 36 and 43%.

The water deficiency stress imposed at the 5-6 leaf stage, decreased the dry root mass for two experimental doses of manure by 35%. The decrease for mineral fertilizing was from 39 to 43%. Under conditions of water deficiency stress the mineral fertilizing decreased nitrogen in root mass yield by 8 and 12%, and the manure application increased it by 24 and 28%. As a whole, the water deficiency stress decreased nitrogen in root mass yield by 26 and 35% under mineral fertilizing, and by 20-21% under manure application. The plant treatment with manure made them less susceptible to the stress conditions of water deficiency.

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