English Version

Yield and production components of barley plant (*Hordeum vulgare*) in function of nitrogen fertilization

Mikael Neumann[1], Marcos Rogério de Oliveira[2], Cecília Aparecida Spada[3], Danúbia Nogueira Figueira[3], Mailson Poczynek[3]

Abstract

The experiment was conducted to evaluate the effect of increasing nitrogen levels on forage yield and components of barley plant (*Hordeum vulgare*). The treatments were: T_1 – 0 kg ha^{-1} of N; T_2 – 80 kg ha^{-1} of N; T_3 – 100 kg ha^{-1} of N; T_4 – 120 kg ha^{-1} of N; T_5 – 150 kg ha^{-1} of N; T_6 – 180 kg ha^{-1} of N and T_7 – 220 kg ha^{-1} of N. No significant interaction (P>0.05) was observed between fertilization levels and evaluation period for variables for tiller m^{-2} number and dry matter content of barley plant. The regression equations for tiller m^{-2} number observed of 23 days (854.0752 + 2.1593N) and 45 (1020.7458 + 1.4729N) days after culture implantation showed linear behavior rising in 2.16 and 1.47, respectively for each kg of nitrogen applied. The regression equations for dry matter production observed of 23 days after culture implantation (720.0365 + 3.4388N) also to adjusted linear behavior rising in 3.44 kg ha for each kg of nitrogen applied. No difference (P>0.05) was observed for dry matter production observed 45 days after culture implantation in function of nitrogen fertilization. The culture implantation cost (R$ ha^{-1}) showed linear behavior (181.9183 + 0.9842N), rising in R$ 0.98 for each kg of nitrogen applied.

Key words: dry matter contents; dry matter production; fertilization; *Hordeum vulgare*

Introduction

The culture of the barley plant (*Hordeum vulgare*) destined to the brewing industry requires a differenced fertility for the grain production aiming at the animal feeding. The demand of nitrogen per plant occurs since the elongation until the flowering, directly influencing in the vital processes of the photosynthesis, respiration, multiplication and cellular differentiation. It is also an essential constituent of the amino acids (MALAVOLTA et al., 1997) and molecules of protein, enzymes, coenzymes, nucleic acids and cythocromes. Besides its important function as integrant of the molecule of chlorophil, nitrogen is one of the nutrients which present the most relevant effects in the increase of production of grains in winter cereals (BULL e CANTARELLA, 1993).

The formation of grains in the barley crop is directly related to the translocation of sugar (CRAWFORD et al., 1982) and nitrogen (KARLEN et al., 1988) from vegetative organs, mainly from leaves to grains. Besides that, it is evident the relation between the green leaf area and the grain production, since the well supplied leaves in nitrogen has higher capacity to assimilate CO_2 and synthesize carbohydrates during the photosynthesis, resulting in larger accumulation of biomass. Under conditions of deficiency of nitrogen the cellular division is retarded in the points of growth, which results in reduction of the leaf area and in the plant size (ARNON, 1975). The increase of productivity provided by nitrogen may be attributed, also, to its effects over the growth of the root system (BALKO and RUSSEL, 1980) and the number of grains per plant (BALKO and RUSSEL, 1980; EBELHAR et al., 1987). According to Amado et al. (2002), nitrogen is the nutrient required in larger amount by the poaceae and, in years in which the climate conditions are favorable to the culture of barley, the amount of nitrogen demanded to optimize the productivity of grains may reach values superior than 150 kg ha^{-1}, which would hardly be supply only

1 Agronomic Engineer, Dr. Researcher of the NUPRAN, Professor of the Department of Veterinary Medicine of the Universidade Estadual do Centro-Oeste (State University of MidWest – Unicentro), Rua Simeão Camargo Varela de Sá, nº 03, CEP: 85.040-080, Guarapuava-PR. email: mikaelneumann@hotmail.com – Author for correspondence.

2 Veterinary doctor, máster in Agronomy – Vegetal Production from Unicentro. email: oliveira.ma Coldplay - Green Eyes rcos.r@gmail.com

3 Student of the graduation in Veterinary Medicine, Trainee of the Núcleo de Produção Animal da Unicentro email: spadacecilia@hotmail.com; danmedvet07@gmail.com;

by soil, and thus there is a necessity to use other supplementary sources of the nutrient.

The deficiency of nitrogen influences in several physiologic and morphologic aspects of the poaceae, as well as number of tillers, development of individual leaves and its photosynthetic capacity. According to Carambula (1977), in a general way, the factor which influences the most the forage productivity is nitrogen, since it is the nutrient the most limiting to the plant growth.

This work had as objective to evaluate the effect of different levels of nitrogen fertilization in cover concerning the quantitative agronomic characteristics of the plant and barley to the brewing industry.

Material and methods

It was used areas with good characteristics of aptitude and use for the cultivation of barley, in the Fazenda Jacu, located in the municipality of Candói, state of Paraná, close to the BR 373, property of the Mr Rui Carlos Mendes de Araújo.

The soil of the experiment area is classified as Latossolo Bruno Alumínico típico[1] (EMBRAPA, 2006). The experimental area has been used in the last years with poaceae of annual cycle (oat, ryegrass and wheat) in the winter season for pasture or grain production and maize and soybean crops in the summer season, receiving at each cultivation season, fertilization of phosphorus and potassium, according to the Recomendações de Adubação e Calagem para os Estados do Rio Grande do Sul e Santa Catarina (Recommendation of Fertilization and Liming for the States of Rio Grande do Sul and Santa Catarina - 2004).

The climate of the region of Candói – PR is Cfb (Humid subtropical mesothermic), without dry season, with fresh summers and moderated winter according to the classification by Köppen, in altitude of approximately 900 m, annual average rainfall of 1.944 mm, minimum annual average temperature of 12.7 °C, maximum annual average temperature of 23.5 °C and air relative humidity of 77.9%. Cartographically it is located at 25º 23' 26" of South latitude and 51º 27' 15" of West longitude.

The soil of the experimental area, in February 2005, presented the following chemical characteristics (layer 0 to 20 cm): pH $CaCl_2$ 0.01 M: 5.3; P: 3.4 mg dm^{3-}; K^+: 0.32 $cmol_c$ dm^{-3}; MO: 5.23 dag kg^{-1} %; Al^{3+}: 0.0 $cmol_c$ dm^{-3}; $H^+ + Al^{3+}$: 3.24 $cmol_c$ dm^{-3}; Ca^{2+}: 6.1 $cmol_c$ dm^{-3}; Mg^{2+}: 2.9 $cmol_c$ dm^{-3} and base saturation: 74.2%.

It was evaluated the qualitative agronomic characteristics of the barley plant under the effect of different levels of nitrogen top-dressing: T_1 – 0 kg ha^{-1} de N; T_2 – 80 kg ha^{-1} de N; T_3 – 100 kg ha^{-1} de N; T_4 – 120 kg ha^{-1} de N; T_5 – 150 kg ha^{-1} de N; T_6 – 180 kg ha^{-1} de N; e T_7 – 220 kg ha^{-1} de N.

The barley crops were installed in June 25, in no-tillage system, succeeding the maize crop, due to dissection with herbicide based on *Glyphosate* (Commercial product Roundup: 1.0 L ha^{-1}). In the seeding of the cultivar BRS-195, of short cycle, it was used spacing between lines of 17 cm, depth of seeding of 3 cm and density of 67 plants per linear meter (125 kg ha^{-1}) referenced to the breeding company. The barley planting was performed in plots with total area of 150 m^2 (10 m x 15 m). The base fertilization was constituted by 410 kg ha^{-1} of the NPK fertilizer in the formula 05-17-17 (N-P_2O_5-K_2O), according to the Recomendações de Adubação e Calagem para os Estados do Rio Grande do Sul e Santa Catarina (Recommendation of Fertilization and Liming for the States of Rio Grande do Sul and Santa Catarina - 2004), and in top-dressing, 23 days after planting (July 18) it was applied different dosed of N in the form of urea (45% of nitrogen). With exception of the N of the seeding, all the applied N had as source the urea.

The management of the barley crop, after the plant emergence, involved practices of weed control trough the chemical method using the herbicide based on metsulfuron-methyl in August 20 (Commercial product Ally: 4 g ha^{-1}), of control of fungus with the fungicide based on cyproconazole (triazole) + propiconazole (triazole) in August 08 (Commercial product Artea: 0.3 L ha^{-1}) and the base Azoxystrobin (strobilurin) + cyproconazole (triazole) in September 21 (Commercial product Priorextra: 0.3 L ha^{-1}), and of control of aphids with the insecticide based on cypermethrin (pyrethroid) + thiamethoxam

1 Brazilian Soil Classification

(neonicotinoid) in August 20 (Commercial product Engeo: 50 mL ha^{-1}) by means of a technical report of the plantation.

The agronomic evaluations were conducted in each experimental area, in three moments during the barley cycle (35 days after the plant emergence, 60 days after the plant emergence and in the harvest), trough the collection of randomized samples of barley plants (0.25 m^2 sample^{-1}). In the obtained samples, the parameters evaluated 35 days after the barley emergence were number of plants m^{-2}, number o tillers m^{-2}, content of the biomass and production of the biomass of the shoot. The productive potential of the plantations was determined by the total mechanized harvest of the barley plant of each experimental unit (November 15).

The evaluations performed in the harvest of Harley grains found: grain production (kg ha^{-1}), laboratory determination of the levels of humidity (%), impurities (%), germination (%), hectolitre weight (HW), crude protein (% on a DB) of the grains and classification trough separation by sieves of the Type A brewing = sieve > 2,8 mm; Type B brewing = sieve between 2.5 and 2.8 mm; Type C out of pattern – ration = sieve between 2.2 and 2.5 mm and Type D = sieve < 2.2 mm.

In order to determine the content of dry matter (DM) of the biomass of the shoot and root of the plants, samples were weighted and pre-dried in forced air oven at 55 °C, with new weight after 72 hours of drying according to AOAC (1984).

The economical analysis was constituted by the determination of the cost of establishment and crop management (R$ ha^{-1}) and average cost of grain production (R$ t^{-1}). In the total cost of grain production (R$ ha^{-1}), it was considered barley seeds (40.00 R$ sc^{-1}), chemical fertilizer NPK (605.00 R$ t^{-1}), herbicide for dissection (11.69 R$ l^{-1}), selective herbicide to post-emergent culture (1890.00 R$ L^{-1}), insecticide (135.20 R$ L^{-1}), fungicide (152.50 R$ L^{-1}) and urea (800.00 R$ t^{-1}). It was obtained the estimative of the total cost of the process in the different levels of nitrogen fertilization by the relation between agronomic response of the barley, cost of the used input and productivity per unit of area.

The experiment design was the randomized blocks, composed by seven treatments and three replications. The data collected for each parameter were submitted to the analysis of variance and the polynomial analysis of regression, considering the variable level of nitrogen fertilization, trough the proceeding "proc reg" of the program SAS (1993).

Results and Discussion

In Table 1 it is presented the average values of rainfall, normal temperature and temperature occurred in the period of conduction and management of the barley culture (July to November/2005). As it can be seen in Table 1, there was great variation in the climate conditions between the occurred values and the normal values, which affected negatively the development of the barley crop and enabled high expression of the interaction between genotype and environment, since in the months of July and August 2005, vegetative stage of the barley, lower incidence of rainfall was observed in relation to the normal average, while in the reproductive phase, between the months of September and October 2005, the incidence of rainfall was superior to the normal average.

The parameters number of plants m^{-2}, number of tillers m^{-2} and content of the DB of the shoot of barley plants, according to evaluation period, under

Table 1. Average value of rainfall and normal temperature and temperature which occurred in the period of conduction and management of the barley culture, Candói, PR, 2005.

Month/year*	Rainfall (mm)		Temperature (°C)	
	Normal	Occurred	Normal	Occurred
July/05	130.3	114.3	12.8	10.2
August/05	93.9	32.0	14.2	21.7
September/05	175.1	311.0	15.3	15.3
October/05	202.6	554.5	17.6	21.0

** Experiment data, Candói, PR.*

different levels of nitrogen fertilization are presented in Table 2. There was no significant interaction (P>0.05) between level of nitrogen fertilization and period of evaluation to the number of tillers m^{-2} and content of DM of the barley plants. The equations of regression for the number of tillers m^{-2} observed 35 days after planting (Y = 854.0752 + 2.1593N) and 60 days after planting (Y = 1020.7458 + 1.4729N) had linear behavior, showing that for each kg of N applied in top-dressing in the barley crop it increases the number of tillers in 2.16 and 1.47, respectively.

For the parameter content of DB of the shoot of barley plants in the first evaluation period (August 05), there was no significant difference between the different levels of nitrogen fertilization (Table 2). In the second period of evaluation (September 01), it was verified that for each kg of nitrogen applied in top-dressing in the barley culture (Y= 13.3961 – 0.0206N) the content of DM of the shoot decreased in 0.02%.

The production of DB of the shoot and grains can be found in Table 2. There was no significant interaction (P>0.05) between level of nitrogen fertilization and period of evaluation for the production of DM of the plants in the first period of evaluation (Y = 720.0365 + 3.4388N) when submitted to analysis of regression adjusted linearly, indicating that for each kg of N applied in top-dressing in the barley culture it increased in 3.44 kg ha^{-1} while the production of clean and dry grains (Y = 2356.7810 + 0.1789N – 0,0063N^2). In relation to the data of the accumulated production of DB in the second period of evaluation (September 01, 60 days after planting), it was not observed significant differences in the production of DB between the different levels of nitrogen fertilization.

The maintenance of the differences concerning the production of DB was not achieved due to the low rate of absorption of N by the plants in the vegetative stages of development, appropriated level of water availability during the development of the culture, by the fact that in all the treatments it was applied 20.5 kg ha^{-1} of N in the seeding, amount enough to eliminate possible conditions of deficiency of N, especially when in succession to the summer poaceae and due to the non subdivision of the doses of N applied to the culture in top-dressing, attributing in this situation of management, probably, larger occurrence of losses of N by leaching and/or volatilization facing the potential of absorption of

Table 2. Number of plants m^{-2}, number of tillers m^{-2}, content of dry biomass in the aerial portion of the plants and production of dry biomass of the plant shoot and the barley grains, under different levels of nitrogen fertilization.

Level of N (kg ha^{-1})	Nº of plants m^{-2} (August 05 2005)[a]	Nº tillers m^{-2}		Content of Dry Matter, %		Production of Dry Matter, kg ha^{-1}			
		(August 05 2005)[b]	(September 01 2005)[c]	Shoot (August 05 2005)	Shoot (September 01 2005)[d]	Shoot (August 05 2005)[e]	Shoot (September 01 2005)	Crude grains (August 05 2005)	Clean and dry grains (November 05 2005)[f]
0	223	835	1027	15.93	13.16	683.7	2204.5	2902.2	2356.0
80	279	959	1107	19.19	10.75	869.4	2270.4	2911.1	2446.9
100	325	1120	1176	16.35	11.18	1122.2	2454.5	2906.7	2137.7
120	294	1147	1253	19.08	10.93	1332.8	2257.6	2764.4	2297.6
150	291	1225	1184	19.57	11.25	1274.4	2216.8	2797.8	2250.2
180	397	1283	1311	15.46	9.55	1254.7	2115.3	2697.8	2266.3
220	360	1248	1341	17.85	8.53	1429.8	2206.3	2542.2	2051.3
Average	**309.9**	**1116.6**	**1199.8**	**17.47**	**10.89**	1138.1	2246.5	2788.9	2258.0
C.V. %	15.24	16.42	10.58	17.26	16.25	29.08	12.66	4.62	6.38
P > F	0.0141	0.0919	01636	0.6009	0.1102	0.1477	0.8178	0.0603	0.0825

a – Number of plants m^{-2} = 226.5909 + 0.6853N (CV: 15.48%; R^2: 0.4968; P>F=0.0004), in which N = level of nitrogen fertilization changing from 0 to 220 kg ha^{-1} of N.

b – Number of tillers m-2 (Aug/05) = 854.0752 + 2.1593N (CV: 15.68%; R2: 0.4241; P>F=0.0014).

c – Number of tillers m-2 (Sep/01) = 1020.7458 + 1.4729N (CV: 9.20%; R2: 0.4625; P>F=0.0007).

d – Content of MB of the plant (Sep/01) = 13.3961 – 0.0206N (CV: 15.27%; R2: 0.4276; P>F=0.0013).

e – Production of the MB of the plant (Aug/05) = 720.0365 + 3.4388N (CV: 29.01%; R2: 0.3443; P>F=0.0052).

f – Production of clean and dry grains (Nov/05) = 2356.7810 + 0.1789N – 0.0063N2 (CV: 6.87%; R2: 0.2652; P>F=0.0625).

the barley plants.

It is suggested that the response of the application of N in the culture of barley did not show technical efficiency and economic mainly due to the lower development in the initial phase of the culture, by the low availability of water associated to a higher temperature than the normal in the period of growth and elongation of the tillers, in August and later by the water stress which occurred in the months of September and October, due to the return of the rainfalls, which generated a fast growth and consequent plant lodging (Table 1).

The evaluation of the effect of the nitrogen top-dressing in the barley culture is an important practice in the context of plant fertilization, which contributes in the minimizing of the costs of production, however it must be added that the efficiency of the fertilization depends, among other factors, on the climate conditions, on the type of the soil, as well as on the capacity of extraction of nutrients by plants during the cultivation.

It is suggested, according to Mazilish et al. (1980) that the increasing doses of nitrogen applied in the summer culture (maize) determine increase of the leaf area of the plants and higher accumulation of DB of roots, which consequently promoted significant increases in the integrity of the leaf tissues in function of the higher synthesis of photoassimilates and/or the higher capacity of absorption of soil nutrients by the roots.

In Table 3 it is presented the average values of humidity, impurity, germination, crude protein and hectolitre weigh to barley grains, according to levels of nitrogen fertilization. It was not observed significant differences in the content of impurities, germination and hectolitre weight of barley grains between the different levels of nitrogen fertilization.

The data of the content of barley grain humidity ($Y = 15.8040 - 0.0349N + 0.0001N^2$) when submitted to analysis of regression adjusted quadratically (Table 3), indicating that the point of minimum unit was in 174.5 kg ha^{-1} of N applied in top-dressing in the culture of barley.

In Table 3 it is presented the average values of the classification, trough sieves, of the barley grains, according to levels of nitrogen fertilization. The data of the classification, trough raffles of barley grains, when submitted to the analysis trough regression, adjusted quadratically for the classification type A ($Y = 9.3605 - 0.0325N + 0.0001N^2$) and type

Table 3. Percentage of humidity, impurity, germination, content of crude protein, hectolitre weight and gravimetric classification of the barley grains, under different levels of nitrogen fertilization.

Content of N	Humidity [a]	Impurity	Germination	Crude Protein [b]	Hectolitre weight	Type A: brewery Sieve > 2.8 mm [c]	Type B: brewery 2.5 to 2.8 mm [d]	Type C: ration 2.2 to 2.5 mm [e]	Type D: forage < 2.2 mm [f]
(kg ha^{-1})	....	....	%	....	....	....	.... %	....	....
0	15.93	3.43	93.0	14.33	51.47	9.20	39.40	40.00	11.43
80	13.40	2.93	94.7	14.50	51.53	7.33	33.43	42.63	15.87
100	13.73	6.60	96.3	14.73	50.10	7.63	33.70	41.93	17.60
120	13.33	4.03	95.0	14.60	49.13	7.70	33.33	42.17	16.80
150	14.07	5.00	94.3	15.00	50.13	6.50	30.70	44.13	19.33
180	13.77	2.57	95.7	15.30	50.70	5.73	30.63	44.03	19.60
220	14.30	5.87	95.0	15.33	48.83	8.07	27.70	37.17	27.50
Average	14.08	4.35	94.9	14.83	50.27	7.45	32.70	41.72	18.30
C.V. %	3.74	41.62	1.63	2.08	4.08	15.23	6.54	4.63	16.68
P > F	0.0009	0.1257	0.2952	0.0098	0.5962	0.0566	0.0008	0.0101	0.0015

a – Humidity = 15.8040 – 0.0349N + 0.0001N² (CV: 4.16%; R2: 0.6678; P>F=0,0001), in which N = level of nitrogen fertilization varying from 0 to 220 kg ha-1 of N;

b – Crude protein = 14.2059 + 0.0051N (CV: 2.36%; R2: 0.5116; P>F=0.0003).

c – Type A = 9.3605 – 0.0325N + 0.0001N² (CV: 17.25%; R2: 0.3127; P>F=0.0342),.

d – Type B = 38.7441 – 0.0498N (CV: 5.87%; R2: 0.7661; P>F=0.0001).

e – Type C = 39.4347 + 0.0726N – 0.0003N2 (CV: 16.82%; R2: 0.6754; P>F=0.0001).

f – Type D = 10.5821 + 0.0636N (CV: 16.82%; R2:0.6754; P>F=0.0001).

C ($Y = 39.4347 + 0.0726N - 0.0003N^2$) (Table 3), indicating that the point of minimum and maximum classification for Type A and C were in 162.5 and 121 kg ha^{-1} of N applied trough top-dressing in the barley culture, respectively. For the classifications of the type B ($Y = 38.7441 - 0.0498N$) and D ($Y = 10.5821 + 0.0636N$), the adjustment of the equations were linear, showing that each kg ha^{-1} of N applied reduced the classification of the grains in the Type B in 0.0498% and increased in the Type D in 0.0636%.

In the Table 4 it is presented the costs of implantation and management of the cultivation (R$ ha^{-1}), cost of grain production (R$ ha^{-1}), gross revenue per unit of area (R$ ha^{-1}) and gross revenue in function of the production (R$ ha^{-1}) of the barley crop, under different levels of nitrogen fertilization.

The equations of regression for the parameter cost of implantation of crop (R$ ha^{-1}) ($Y = 464.4565 + 1.7847N$) and cost of grain production (R$ ha^{-1}) ($Y = 181.9183 + 0.9842N$), showed a linear behavior, indicating that in each kg ha^{-1} of N applied in the barley culture, the cost increased in 1.78 R$ ha^{-1} and 0.98 R$ t^{-1}, while the gross revenue per unit of area (R$ ha^{-1}) ($Y = 778.5850 - 0.8805N$ and gross revenue in function of the production (R$ t^{-1}) ($Y = 319.5306 - 0.2175N$) decreased in 0.88 R$ ha^{-1} and 0.22 R$ t^{-1}, respectively. It is considered that the productivity of the mass may be modified, according to Rambo et al. (2004), due to the variability of the meteorological conditions and of the soil, associated to the multiple processes which interfere in the complex dynamic of the N in the soil (leaching, volatilization, immobilization, mobilization, nitrification, denitrification, mineralization) and in its relation with the plant, may cause modification in the availability and necessity of this nutrient during the culture ontogeny.

This work evidenced that in the cultivar BRS 195, the productive and qualitative agronomic parameters were different under distinct means of nitrogen fertilization, showing that the viability of the nutrient nitrogen depends on a momentarily economical analysis of the culture quotation or in situations of reduction of prices and/or aggregation of value in the acquisition of nitrogen fertilizers. According to Rambo et al. (2004), the correct management of the nitrogen fertilization is fundamental in the principles of the precision agriculture aiming to increase the efficiency of use of N, to reduce the cost of cultivation production, to optimize the profit margin of the producer and to minimize the environmental contamination of the soil and the water.

Conclusions

Table 4. Cost of implantation and management of the cultivation (R$ ha^{-1}), cost of grain production of the barley culture (R$ ha^{-1}), gross revenue per unit of area (R$ ha^{-1}) and gross revenue in function of the production (R$ ha^{-1}) under different levels of nitrogen fertilization

Content of N (kg ha^{-1})	Investment R$ ha$^{-1(a)}$	Cost of production R$ t$^{-1 (b)}$	Gross revenue R$ ha$^{-1(c)}$	Gross revenue R$ t$^{-1 (d)}$
0	465.56	197.63	751.50	319.00
80	607.78	248.43	727.37	297.33
100	643.34	275.23	697.93	298.20
120	678.90	295.83	683.43	297.37
150	732.22	326.13	650.23	288.93
180	785.56	347.23	646.80	285.43
220	856.67	419.43	544.40	265.57
Average	681.43	301.43	671.67	293.12
C.V., %	0.0	5.48	4.78	3.63
P > F	0.0001	0.0001	0.0001	0.0023

a – Investment (R$ ha^{-1}) = 464.4565 + 1.7847N (CV: 0.06%; R2: 1.0; P>F=0.0001), in which N = content of nitrogen fertilization ranging from 0 to 220 kg ha^{-1} of N.

b – Cost of production (R$ t^{-1}) = 181.9183 + 0.9842N (CV: 6.73%; R2: 0.9199; P>F=0.0001),

c – Gross revenue (R$ ha^{-1}) = 778.5850 – 0.8805N (CV: 5.85%; R2: 0.7098; P>F=0.0001).

d – Gross revenue (R$ t^{-1}) = 319.5306 – 0.2175N (CV: 3.42%; R2: 0.6967; P>F=0.0001)..

The parameters number of tillers m^{-2}, number of plants m^{-2}, production of biomass of the shoot 35 days after planting, content of grain crude protein and grain classification on the type D were linearly increased until the level of 220 kg ha^{-1} of N in top-dressing in the barley culture.

The parameters content of plant biomass 60 days after planting and grain classification in the type B were linearly decreased until the level of 220 kg ha^{-1} of N in top-dressing in the barley culture.

Larger production of barley grains per unit of area were obtained in the level 14.19 kg ha^{-1} of N in top-dressing under climate conditions of water stress.

The cost of implantation and culure management (R$ ha^{-1}) and cost of production of grains in the barley culture (R$ ha^{-1}) were linearly increased, while the gross revenue per unit of area (R$ ha^{-1}) and gross revenue in function of the production (R$ ha^{-1}) were decreased linearly until the level of 220 kg/ha of N in top-dressing in the barley culture.

References

ARNON, I. **Mineral nutrition of maize**. International Potash Institute, Bern, 1975. 425p.

AMADO, T.J.C.; MIELNICZUK, J.; AITA, C. Recomendações de adubação nitrogenada para o milho no RS e SC adaptada ao uso de culturas de cobertura do solo, sob sistema plantio direto. **Revista Brasileira de Ciências do Solo**, Viçosa, v.26, p.241-248, 2002.

ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS - A.O.A.C. **Official methods of analysis.** 14.ed. Washington, D.C., 1984. 1141p.

BALKO, L.G.; RUSSEL, W.A. Response of maize inbred lines ton fertilizer. **Agronomy Journal.** Madison, v.72, n.5, p.32-723, 1980.

CARAMBULA, M. Verdeos de inverno. In: **PRODUCCIÓN y MANEJO DE PASTURAS SEMBRADAS**. Montevideo. Ed. Hemisferio Sur, p.217-242. 1977.

COMISSÃO DE QUÍMICA E FERTILIDADE DO SOLO – RS e SC. Manual de adubação e de calagem para os estados do Rio Grande do Sul e de Santa Catarina. 10ª ed. Porto Alegre, SBCS, 2004. 394 p.

CRAWFORD, T.W.; RENDING, V.V.; BROADBENT, F.E. Sources, fluxes, and sinks of nitrogen during early reproductive growth of maize (Zea mays L.). **Plant Physiology**. Lancaster, v.70, n.1, p.654-660, 1982.

EBELHAR, S.A.; KAMPRATH, E. J.; MOLL, R. H. Effects of nitrogen and potassium on growth and cátion composition of corn genotypes differing average ear number. **Agronomy Journal,** Madison, v.79, n.5, p.81-875, 1987.

EMBRAPA - Empresa Brasileira de Pesquisa Agropecuária. Sistema brasileiro de classificação de solos. 2ª ed. Brasília, EMBRAPA/CNPS, 2006. 305p.

KARLEN, D.L.; FRANNERY, R.L.; SADLER, E.J. Aerial accumulation and partitioning of nutrients by corn. **Agronomy Journal**, Madison, v.80, n.2, p.232-242, 1988.

MAIZLISH, N.A.; FRITTON, D.D.; KENDALL, W.A. Root morphology and early development of maize at varying levels of nitrogen. **Agronomy Journal**, Madison, v.72, n.1, p.25-31, 1980.

MALAVOLTA, E.; VITTI, G.C.; OLIVEIRA, S.A. **Avaliação do estado nutricional da planta - Princípios e aplicações.** 2ªed., Piracicaba, Associação Brasileira para o Estudo da Potassa e do Fosfato, p.58-67,1997.

RAMBO, L.; SILVA, P.R.F.; ARGENTA, G. et al. Parâmetros de planta para aprimorar o manejo da adubação nitrogenada de cobertura de milho. **Ciência Rural,** Santa Maria, v.34, n.5, p.1637-1645, 2004.

SAS INSTITUTE. **SAS Language reference.** Version 6, Cary, NC: 1042 p. 1993.