Turkish Journal of Range and Forage Science, 2021, 2(1): 26 – 30
doi: 10.51801/turkjrfs.879575

Review

Turkish Journal of Range and Forage Science

https://dergipark.org.tr/tr/pub/turkjrfs

Nitrogen Requirement of Italian Ryegrass (*Lolium multiflorum*): A Review

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A R T I C L E I N F O

Received *13/02/2021*
Accepted *12/03/2021*

Keywords:

Italian ryegrass
Lolium multiflorum
Nitrogen
Yield
Quality

A B S T R A C T

Nitrogen is an essential nutrient for ryegrass but excess of it may lead to accumulation of nitrate in plants which may be lethal for ruminants. Irrigation, seed rate, variety, quality, cutting time and frequency, location altitude and fertilizer types were selected as variable in this review, which were selected to see the response of Italian ryegrass to different nitrogen doses. A series of comments were also mentioned in the conclusion part of this article to improve future studies in this area.

1. Introduction

Italian ryegrass (*Lolium multiflorum* Lam.) is a rough forage crop which is widely cultivated in cool and temperate regions for its high productivity and digestibility. Nitrogen (N) is an essential nutrient for ryegrass growth but excessive N fertilizers may lead to over accumulation of nitrate-N in plants, which may be lethal for ruminants (Tan et al., 2021). Italian ryegrass has high production capacity and feed quality under N fertilization (Rechițean et al., 2018). This crop is often fertilized with high levels of N to increase dry matter (DM) yields. High amount of N application increases the N content in herbage (De Villiers and Van Ryssen, 2001).

A study was conducted to determine whether N content of Italian ryegrass affects the performance of South African Merino lambs. 100, 200, 400, 600 or 800 kg N ha^{-1} were applied to the pastures. N fertilization increased the total N and nitrate-N and decreased non-structural carbohydrate concentrations in the plants. Rumen ammonia-N concentration increased with increasing N concentration in twelve and four-month-old lambs. A quadratic relationship was observed between N content and DM intake of twelve-month-old lambs, while a negative linear relationship was observed for four-month-old lambs. A quadratic relationship was observed between the N content of ryegrass and average daily gain for lambs of both age groups. The equations Show potentially negative effects of high concentrations of N and nitrate-N on intake and growth rate of lambs (De Villiers and Van Ryssen, 2001).

Italian ryegrass parcels were received three irrigation applications at field capacity 1) once

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every two weeks, 2) once a week, 3) twice a week in the study of Abraha et al., (2015). Also three N levels were applied for topdressing after each harvest 1) at a rate of 0 kg N h^{-1} cycle−1, 2) at a rate of 30 kg N h^{-1} cycle−1, 3) at a rate of 60 kg N h^{-1} cycle−1. Yields were increased with the amount of water and N fertilizer applied. DM content, in vitro organic matter digestibility (IVOMD), crude protein (CP) and metabolisable energy (ME) increase with the irrigation application once every two weeks. With high N application, higher irrigation levels significantly increased DM yield, while water stress improved to some extent pasture quality by increasing DM content, IVOMD, CP and ME values.

3 different seed ratios (10, 15 and 20 kg ha^{-1}) and 4 different nitrogen levels (0, 30, 60 and 90 kg N ha^{-1}) in *Lolium multiflorum* had been tested in a study conducted by Bora et al. (2020) in India. Seed rates and N levels significantly affected the quality values of Italian grass. 20 kg ha^{-1} seed rate was superior for quality at all (three) cuts. Highest CP yield was obtained with 20 kg ha^{-1} seed rate. CP content, crude fat content, crude fiber content of the ryegrass were also significantly higher at seed rate of 20 kg ha^{-1}. 90 kg N ha^{-1} application resulted with higher quality parameters. Highest CP yield was obtained by 90 kg N ha^{-1} application. The crude protein content, crude fat content, crude fiber content of the ryegrass were significantly higher at 90 kg N ha^{-1} application.

Eckard et al. (1995) established annual ryegrass (variety Midmar) pastures on three locations for a period of four years (1987-1990). N fertilizer was topdressed at 0, 200, 300 or 400 kg N ha^{-1} y−1 and at intervals of 4 or 6 weeks. DM yield indicates a little benefit from applying more than 40 kg N ha−1 per application in autumn, and exceeding 50 kg N ha^{-1} per application the doses during spring. Pastures fertilized every 4 weeks at the above rates produced equal or higher yields than pastures fertilized at 6-week intervals.

Three sources of N fertilizer (urea, limestone ammonium nitrate (LAN) and ammonium sulphate) showed no consistent significant trends in terms of the dry matter yield and nitrogen or nitrate-N content of *Lolium multiflorum*. Ammonium sulphate acidified the soil clearly, while LAN was the least acidifier (Eckard, 1990).

N fertilizer application levels of 0, 150, 300 and 450kg N ha^{-1} were applied in combination with different defoliation intervals (every 2, 4, 6 and 8 weeks and twice a season) to by Theron and Snyman (2004), to observe the digestibility and fiber component of *L. multiflorum* cv. Midmar. Organic Matter Digestibility (OMD), NDF and ADF significantly changed by levels of N, defoliation intervals and the interactions of these two factors. N dozes were less effected OMD, NDF and ADF than defoliation interval due to influence of defoliation interval on plant growth stage and maturity than N level. OMD decreased with increasing N levels and lengthening of the defoliation interval. Defoliation interval being 4 weeks or less due to the increase in N levels resulted in a decrease in ADF and NDF content.

In a study of Hides (1978), four Italian ryegrass varieties with different origin and winter hardiness were grown at lowland and an upland location to subject to two N levels and five autumn cutting treatments. Winter kill was increased by increasing levels of N fertilizer and by late or frequent autumn defoliations.

Sunaga et al. (2006) were developed a simple technique to estimate the nitrate (NO_3) N concentration of Italian ryegrass crop under field conditions. Using a hand-held chlorophyll meter (SPAD-502) at the heading stage is a rapid method for estimating the NO_3-N concentration in the crop to feed cattle safely and to escape high levels of nitrate and poisoning of ruminants. SPAD readings increased with increasing NO_3-N concentrations. However, the relationship was not a linear curve. A critical value for the SPAD reading was 47 for a NO_3-N concentration of 2.0 g kg^{-1} DM, a critical value for the acute nitrate poisoning of ruminants.

In a study of Casals et al. (2007), the effects of different levels of N on seed yield and yield components of Italian ryegrass were assessed in three locations (two in France and one in Belgium), during three growing seasons (1998 to 2000). N rates was from 40 to 130 kg N ha^{-1}, with a reference zero N treatment. A good relationship between N level uptake at ear emergence and seed yield was observed with a maximum yield obtained at about 110 kg ha^{-1} N uptake. Soil born nitrogen, measured by N uptake at ear emergence on non-fertilized treatments, varied from 25 to 75 kg ha^{-1} between trials. Results show that the estimation of soil born nitrogen is necessary for the calculation of N supply.

In Brazil, at four years (2013, 2014, 2015 and 2016), four harvest times and seven N doses (0, 50, 100, 150, 200, 250 and 300 kg ha^{-1}) application on natural re-sown ryegrass, use of N as topdressing showed little effect on the persistence of ryegrass plants in the four years of study. The efficiency of N utilization was inversely proportional to the increment of the nitrogen doses used (Silveira et al., 2020).

A two year field experiment with diploid (cv. Tur) and tetraploid (cv. Kroto) Italian ryegrass were carried out differentiation of N fertilization and cutting frequency by Koter and Krawczyk (1981). Highest green matter yields were obtained from the five-fold cutting treatment with 30-35 days cut intervals at the earing stage. The highest yields of DM were obtained from 4 and 5 cuts during the season with 35-40 days cut intervals at full earing or at the beginning of anthesis. N application at 80 kg ha cut^{-1} (400 kg ha year^{-1}) optimized the yields of DM in the high frequency cutting treatments (intervals of 25-30 days). The tetraploid variety of ryegrass produced higher yields of green matter compared to diploid variety.

A study was conducted to investigate the optimum N fertilizer amount for the green forage production of Italian ryegrass in Korea in 1987 and 1988. Three levels of N fertilizer were applied (4, 8 and 12 kg N ha^{-1}). Green yield and nitrate content of green forage were observed at three cuttings (April 30, May 20 and June 10). Yield of green forage at all cutting times were highest at highest dose of N and lowest at lowest dose of N application. Nitrate content in the green forage at all cutting times was high with increasing amount of nitrogen fertilizer and with decreasing ratio of K/(Ca+Mg) in green forage (Lee et al., 1990).

Türk et al. (2019) conducted a study with three annual ryegrass varieties (Alberto, Devis, and Baqueano) and applied seven different N doses (0, 50, 100, 150, 200, 250 and 300 kg ha^{-1}) to see the yield and quality under Isparta ecological conditions of Turkey during 2017-2018 and 2018-2019 growing. N applications increased plant height, stem thickness, hay yield, CP ratio, CP yield while decreased ADF and NDF ratios. Plant height and ADF ratio were highest at Devis variety; stem thickness, hay yield, CP ratio and CP yield values were highest at Alberto variety. 250 kg ha^{-1} N dose produced highest forage yield and quality under Isparta ecological conditions.

Variation of N content of *L. multiflorum* cv. Midmar by applied N (0kg N ha^{-1}, 150kg N ha^{-1}, 300kg N ha^{-1} and 450kg N ha^{-1}) and defoliation intervals (every 2, 4, 6 and 8 weeks and twice a season) was determined in a field trial of Theron et al. (2002). Four N levels were combined with five defoliation intervals. Total N, non-protein N and true protein were significantly influenced by N level, defoliation interval and their interactions. Total N content varied from 0.68% to 3.38%, the true protein from 0.57% to 2.74% and the non-protein N from 0.11% to 0.65%. Assimilated N in the herbage ranged between 9.8 kg N ha^{-1} to 423.0 kg N ha^{-1}. Linear relationships between total N, true protein and non-protein N, respectively, were detected.

Trevino et al. (1980) conducted a ryegrass N fertilization study in Central Spain with N levels of 1) 0 kg N ha^{-1}, 2) 40 kg N ha^{-1}, 3) 80 kg N ha^{-1}, 4) 120 kg N ha^{-1} applied after each cut. Total N, protein N, non-protein N and alcohol extractable N contents at each of the three cuts were increased with increasing N rate but nitrate content was not affected. Total N contents increased from 1.87, 1.31 and 1.38 g g 100^{-1} DM to 2.78, 2.55 and 3.02 g and CP contents from 1.50, 0.98 and 1.06 g N 100^{-1} DM to 2.17, 1.98 and 2.40 g at each of the 3 cuts, respectively.

Karatassiou et al. (2010) studied the effects of water stress on N partitioning and leaf area of Italian ryegrass in pots. Plants were subjected to three water applications: 1) well-watered, 2) water stressed, 3) re-watered after establishment. Measurements were applied during the growing season. Water regime was significantly affected leaf area and N contents. After seventeen days of water stress, N loss increased in leaves, stems and roots of well-watered plants, while it significantly decreased in stems of water stressed and re-watered plants. Negative correlation between leaf area and nitrogen content was found, suggesting that Italian ryegrass may develop mechanisms to adapt to drought.

Influence of N fertilization to the mineral composition of Italian ryegrass was evaluated at three successive cuts from February to May in Northeast Portugal in 1994-1995 with four varieties factorial combined with five levels of nitrogen: 1) 0 kg ha^{-1}, 2) 40 kg ha^{-1}, 3) 60 kg ha^{-1}, 4) 80 kg ha^{-1}and 5) 100 kg ha^{-1}applied at seeding and topdressed after the first two cuts in a study of Fernandes and Moreira (2000). Effect of cuts and plant maturity were more effective on N, Ca, Mg, P and K concentrations compared to N fertilization while there were no significant differences between varieties. Higher levels of N fertilization resulted with higher N and K concentrations at three cuts.

2. Conclusions

Italian rygrass is a nitrogen responsive high yielding quality crop with its high adaptation. Irrigation improves its yield. T o escape from feeding animal injuries, it is important to apply in well a balanced quantity.

Amount of available water in root zone and root zone wetting frequency is an important determiner for the nitrogen uptake speed and efficiency, utilization, leaching, transformation into different forms of nitrogen. In relation with this, evaporation during the season is another important determiner nor just for *L. multiforum* but for all nitrogen fertilizer studies. Due to interactions between micronutrient and nitrogen contents of soils, it is important to determine and apply deficient amount of micronutrients to soils during studies. Also, to do this, it is important to put a yield target before the planning of the studies. This yield target may be the 25-50% higher yield levels of the averages of the study location to make farmers benefit from the study. As readers and engineers, we may also benefit more from these studies if these parameters can be mentioned in abstracts of the research studies.

It was interesting to see the SPAD instruments as a valuable farmer tool to determine the fertilization correct time and amount both to increase yield and escape from animal nitrate injury.

There is a deficit of information fort he determination of approprirate type of nitrogen fertilizer type for this species in drought and well watered conditions. Also seed production trials are very less. Researchers need to plan their future studies in the light of these friendly critics to be valued by more researchers and different regions of the world.

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