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Evaluation Impact of Amount and Distribution of Nitrogen Fertilizer on Barley Crop Production and Qualitative Characteristics

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RESEARCH ARTICLE

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ABSTRACT

BACKGROUND: Nitrogen is one of the most significant influencing elements that help the atmosphere function better both quantitatively and qualitatively. Balanced and efficient use of applied nitrogen is of paramount importance in the overall nutrient management system than any other plant nutrient in order to reduce its negative impact on the environment.

OBJECTIVES: A study was conducted in Weis city, located in the southwest of Iran, to examine the effect of pure nitrogen from urea (46% nitrogen) on grain yield and qualitative traits of experimental barley.

METHODS: A split plot randomized full-block design was used to conduct the experiment over four replications. The main plot contained 50, 90, and 130 kg of nitrogen concentrations per hectare. In the sub-plot, nitrogen was distributed as follows: 50% during the planting stage and 50% during the shooting stage, 25% during the pregnancy stage, and 75% during the planting stage and shoot stage.

RESULT: The results demonstrated a substantial interaction between nitrogen distribution technique and amount on seed yield, biological yield, harvest index, spike length, plant height, seed protein percentage, and seed protein yield. As a result of raising nitrogen fertilizer application to 130 kg per hectare, barley plants produced more seed (517 grams per square meter) and seed protein (71.65 grams per square meter), according to the study's results.

CONCLUSION: Based on the overall findings of this study, it can be concluded that barley plants should be grown with a nitrogen fertilizer consumption of 130 kg per hectare using a method that divides the planting stage by 25% and the stage of stem growth by 75% in order to produce the highest possible quantitative and qualitative yield.

KEYWORDS: *Cereal, Nourishment, Protein content, Seed yield, Split application.*

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1. BACKGROUND

Barley is one of the most significant and traditional crops. After rice, corn, and wheat, this plant is fourth in significance and is used to feed chickens, animals, and humans (Dhillon and Uppal, 2019). The plant must consume balanced elements required for root development to receive its ideal nourishment. The materials produced during the photosynthesis process will be of good quality and quantity, and the efficiency of fertilizer consumption will be reasonable, provided that the number of elements in the root development area is optimal for the transfer of materials to the plant (Walsh *et al*., 2012). The highest production per unit area is attained using chemical fertilizers. By addressing nutritional deficiencies in the soil and employing good management techniques, farmers continuously work to increase crop yield to genetic potential (Beatty *et al*., 2010). A particular focus is placed on managing the use of food components, particularly nitrogen, for economic production, preserving sustainable agriculture, and ensuring food security. In this regard, it is crucial for the cultivation of this product to use agricultural inputs properly, logically, and optimally, notably nitrogen. As well as to minimize waste its use during production, consider its superior quality, enhance community health, and avoid environmental contamination (Belete *et al*., 2018). One of the most essential nutrients that plants need is nitrogen, which is vital for the physiological functions of plants. Due to the fact that it is essential to ensuring optimal crop yield, its shortage more severely restricts quantitative and qualitative yield than other nutrient deficiencies (Jahan *et al*., 2007). Nitrogen fertilizer application rates and timing after planting are crucial factors for plants to thrive and produce more per unit area. The use of fractional nitrogen fertilizers can be a valuable strategy for increasing nitrogen fertilizer efficiency (Fan *et al*., 2004). According to a 2009 study on spring barley plants by Ofosu-Anim and Leitch, nitrogen boosts spring barley plant height, leaf chlorophyll content, and yield. The study discovered that distributing nitrogen fertilizer during the stem and spike stage and providing the nitrogen the plant needed during these periods of growth prevented the seeds from shriveling to a significant degree (Hirooshi *et al*., 2007). Walsh *et al*. (2018) studied nitrogen fertilizer management in wheat planting systems (Zero, 45, 90 and 135 kg of nitrogen per hectare). They claimed that different nitrogen treatments applied at various periods considerably impacted wheat protein content and grain production. There was no statistically significant difference between the treatments using 90 and 135 kg of nitrogen per acre. In drought stressed conditions, an adequate nitrogen supply encourages root growth and boosts water absorption from the soil's deeper layers. Additionally, it has been shown that adding nitrogen at various phases of wheat growth improves grain yield, the quantity of grains in each spike, grain weight, harvest index, protein percentage, and nitrogen use efficiency (Subedi *et al*., 2007). The endurance of the plant's photosynthetic surface is strengthened by providing nitrogen at various growth phases. The weight of the seeds has increased due to the transfer of additional photosynthetic components to the seeds (Tehulie and Eskezia, 2021).

2. OBJECTIVES

This research aimed to determine the best level and the most appropriate split application of nitrogen fertilizer in order to achieve the maximum yield in barley in Veys.

3. MATERIALS AND METHODS

3.1. Experimental Site and Design

This experiment was conducted in a field in Veys city, southwest Iran, between 2013 and 2014. Veys city is situated at a latitude of 31 degrees and 36 minutes, a longitude of 48 degrees and 53 minutes, and a height of 50 meters above sea level. Four simple randomized complete block design replications were used to implement this design as a split plot. Treatments were carried out in the main plot and subplot. The main plot contained 50, 90, and 130 kg nitrogen concentrations per hectare. In the sub-plot, nitrogen was distributed as follows: planting stage 50% and stemming stage 50%, planting stage 25%, 50% of stem growth, 25% of pregnancy stage, 25% of planting stage, and 75% of the stem growth stage. Before the experiment, the field soil samples were gathered, and their physical and chemical properties were assessed (Table 1).

Table 1. Chemical characteristics and some other important properties of the soil of tested field

Depth of soil (cm)	Soil Texture	Potassium (ppm)	Nitrogen (%)	Organic carbon (%)	EC ($ds.m^{-1}$)	pH
0-30	Sandy loam	188	0.04	0.90	3.91	6.80

Harrowing, 30 cm-deep plowings, 15 cm-deep disking, and troweling were some of the land preparation techniques used. Thirty-six plots were used in the experiment. Each replication contained nine plots with seven planting lines positioned 25 cm apart and 6 meters long. There were also 1.5 meters between the two sub-plots, and the area between the two main plots was 1.5 meters separated using a Forrower (ditcher). The number used was 13 Joe, which is the average nationwide.

3.2. Crop Management

Prior to cultivation, all treatments used phosphorus fertilizer based on 100 kg of pure phosphorus from a triple superphosphate source and 150 kg of potassium sulfate per hectare. A small amount of nitrogen fertilizer was provided as basic fertilizer throughout three distributions, both at the time of planting and after computation. After computation, the leftover fertilizer was spread in the test plots in the form of roots and at the stem growth stage.

The prepared seeds were hand spread and on a regular basis. Then, the cultivation lines were covered with soil 3 to 4 cm thick. The experimental field was watered right away after sowing. In practice, manual weeding was used to combat both narrow-leaved and broad-leaved weeds.

3.3. Measured Traits

After removing the margins from each plot of lines (3, 4, 5, and 6), an area of 1 square meter was taken, and the following attributes were examined during the seed's physiological growth stage. A square meter-sized portion of each plot was removed to calculate the biological performance (from the four middle lines). After bringing the samples to the lab and keeping them there for 48 hours in a vented oven at a temperature of 75 degrees Celsius, a portion weighing about 500 grams was separated. Their weight was calculated after drying. The harvest index was determined by dividing the proportion of biological yield by the seed yield (Koocheki and Sarmadnia, 2008). After removing 0.5 m from the beginning and ending of the four center lines, a surface area equal to 1 square meter was harvested to calculate the grain yield during the ripening stage. The grain was separated from the straw after threshing, and the grain yield was determined in grams per square meter after weighing (Khalilzadeh *et al*., 2017). The height of roughly 20 shrubs was randomly measured from the soil's surface to their stem tips at the time of harvest, and their average was used to determine the plant's height. Twenty plants from each plot were randomly chosen during the physiological treatment stage, and the average spike length was determined using these 20 plants. The total nitrogen percentage of the seeds was estimated in the lab using the Kjeldahl machine before the raw protein percentage of the seeds was determined. Then, the nitrogen percentage of the seeds was multiplied by a factor of 5.7 to determine the amount of protein in the seeds. Protein content in the seed was multiplied by seed yield to achieve seed protein yield (Keeney and Nelson, 1982).

3.4. Statistical Analysis

SAS statistical software was used to analyze the data variance, and Duncan's test was applied to compare the averages at the five percent confidence level.

4. RESULT AND DISCUSSION

4.1. Plant height

The interaction effect of various nitrogen fertilizer amounts and fertilizer distribution techniques on the height of the barley plant was significant at the 5% confidence level, according to the analysis of the variance table (Table 2). The findings indicated that a nitrogen fertilizer amount of 130 kg per hectare and a fertilizer distribution strategy (25% at the time of sowing and 75% at the stem growth stage) resulted in the highest plant height (Table 3). The application of nitrogen fertilizer and fertilizer distribution during the plant's vegetative growth and before blooming can be credited with the favorable materialization process that led to the increase in the height of the barley plant. Nitrogen consumption boosts vegetative growth in the plant and decreases the abscisic acid/gibberellin ratio (Bardehji *et al*., 2020). In this regard, Ceretta *et al*. (2005) concluded that increased nitrogen fertilizer distribution and consumption results in an increase in plant height. On the other hand, nitrogen fertilizer has a favorable and significant impact on plant height characteristics, according to Mousanaei *et al*. (2017). They claimed that the lengthening between the nodes was the primary cause of the rise in plant height, which was supported by the results of this study.

Table 2. Summary of the ANOVA results of mean squares of the studied traits in barley

S.O.V	df	Plant height	Spike length	Biological yield	Seed yield	Harvest index	Seed protein percentage	Seed protein yield
Replication	2	35.89^{ns}	3.22^{ns}	450.67^{ns}	94.82^{ns}	19.54^{ns}	4.67^{ns}	14.54^{ns}
Nitrogen fertilizer (NF)	2	50.89^{ns}	5.89^{ns}	1076.56^{**}	463.25^{**}	24.94^{*}	9.89^{**}	41.94^{**}
Error a	4	28.61	4.82	348.53	110.82	12.4	5.4	15.53
Split application (SA)	2	98.77^{**}	3.89^{ns}	762.87^{*}	439.67^{**}	27.77^{*}	8.89^{**}	42.77^{**}
NF × SA	4	74.77^{*}	5.18^{*}	1134.44^{**}	421.18^{**}	46.77^{**}	6.77^{*}	46.44^{**}
Error b	12	36.14	2.62	471.77	93.62	11.16	3.16	17.16
CV (%)	-	12.44	8.82	10.93	11.93	10.28	9.93	10.28

^{ns}, **, and *: mean squares of the treatments are respectively non-significant and significant at 1% and 5% probability level.

4.2. Spike length

The interaction effect of various nitrogen fertilizer amounts and fertilizer distribution techniques on the height of the barley plant was significant at the 5% confidence level, according to the analysis of the variance table (Table 2). The findings demonstrated that the treatment of 130 $kg.ha^{-1}$ of nitrogen fertilizer and the fertilizer distribution method (25% at the time of planting and 75% at the shooting stage) resulted in the most extensive length of the spike (Table 3). The spike length in this study has grown due to the increase in nitrogen during growth and seed production, which is the most vulnerable stage in absorbing the nitrogen and creating photosynthetic components. Additionally, using less fertilizer during planting time compared to the other growth phases can be advantageous because too much nitrogen fertilizer is out of the plant's reach at the beginning of growth. The findings of this study were consistent with those of other researchers, who have also highlighted the beneficial role of nitrogen in extending spike length, including Hayat *et al*. (2015) and Mosanaei *et al*. (2017).

4.3. Biological yield

The results indicated that biological performance was significantly impacted by nitrogen fertilizer treatments, fertilizer distribution techniques, and their interactions at the 1% confidence level (Table 2). The highest biological yield was achieved using 130 kg/ha of nitrogen fertilizer and a fertilizer distribution strategy, including 25% at planting and 75% at the stem growth stage (Table 3). The application of nitrogen fertilizer has caused various vegetative portions to flourish, which has resulted in this type of improvement in biological performance. The utilization of nitrogen fertilizer has resulted in a significant increase in plant height, followed by an improvement in the plant's green surface and, ultimately, an expansion of the aerial organs that has improved the plant's biological performance (Alam *et al*., 2007). However, it appears that the higher biological yield in the fertilizer distribution treatment was 25% at the time of planting and 75% at the stage of stem growth because nitrogen had a favorable effect on the distribution of photosynthesis materials in the leaf and stem parts and the growth of accumulated materials in the seed, which is consistent with the results obtained by Fan *et al*. (2004). Additionally, the amount of nitrogen absorbed is restricted at different growth phases, and extra nitrogen is eliminated from the plant's access. Because the plant has a limited capacity to absorb nitrogen, especially after planting, using less nitrogen fertilizer at that time and devouring the remainder during rapid vegetative growth would maximize the growth of the aerial organs. Furthermore, compared to the other two treatments, the plant with the larger leaves, extended greening times, and longer stems achieved higher biological performance (Emam and SeghatAlslami, 2009).

4.4. Seed yield

According to the variance analysis table's data, the simple and reciprocal impacts of various nitrogen fertilizer dosages and fertilizer distribution strategies on barley grain yield were significant at the 1% confidence level (Table 2). In this study, applying 130 $kg.ha^{-1}$ of nitrogen fertilizer and dividing the fertilizer into two phases (25 percent at planting and 75 percent at the shooting stage) resulted in the highest seed yield (Table 3). Nitrogen fertilizer application has a discernible impact on grain yield because it is effective in biochemical interactions, lengthening the growing season and accumulating dry matter in aerial organs and grain yield components (Klikocka *et al*., 2016). Conforming to the research of Hatfield and Prueger, the improvement of grain yield in this study was mainly caused by an increase in yield components with high nitrogen quantities and the generation of a higher photosynthetic level. In comparison to the application of fertilizer in the earlier phases, the stemming stage witnessed a considerable rise in grain production. It happened due to the consumption of more nitrogen fertilizer due to the plant's entry into the reproductive stage and the increased need for the plant. Because nitrogen plays a crucial role in the formation of amino acids and proteins, and since proteins are essential to the health of plants, an increase in nitrogen has led to an increase in plant seed production. The results mentioned earlier agree with those of (Belete *et al*., 2018; Ma *et al*., 2019).

4.5. Harvest index

The harvest index was significantly affected by various nitrogen fertilizer levels, fertilizer distribution techniques, and their interactions (Table 2). The application of 130 kg.ha^{-1} of nitrogen fertilizer and the method of fertilizer distribution (25 percent at the time of planting and 75 percent at the stem growth stage) resulted in the greatest harvest index (Table 3). The level of the harvest index increased as fertilizer levels raised. The improved nutrient absorption is responsible for the rise in the harvest index. The plant can use solar radiation more effectively and send more photosynthetic materials to the seeds, increasing the ratio of seeds to dry matter, which ultimately leads to an increase in harvest index ratios. This is due to the plant's improved ability to absorb nutrients and increase the leaf surface index. According to Klikocka *et al*. (2016), nitrogen fertilizer can enhance the allocation of photosynthetic materials in the economically important section of the plant (seed) and raise the harvest index by expanding the reservoir. The results showed that employing the lowest nitrogen fertilizer ratio at planting time and the remainder at the stem growth stage produced the highest harvest index. The findings demonstrated that the highest harvest index was generated using the lowest nitrogen fertilizer ratio during planting time and the remaining at the stem growth stage. As long as enough nitrogen is present, there will not be an issue with nutrients in the post-flowering period to fill the seeds, and the plant's photosynthesis will not interfere with it. These results were in line with those obtained by Bardehji *et al*. (2020).

4.6. Seed protein percentage

The grain protein characteristic was tested for interactions between levels of various nitrogen fertilizers and fertilizer distribution techniques. The variance analysis table findings showed that the difference was statistically significant at the 5% level (Table 2). The treatment with 130 kg.ha^{-1} of nitrogen fertilizer and fertilizer distribution method (25% at the time of sowing and 75% at the stem growth stage) produced the highest percentage of seed protein (Table 3). Variety, weather, and soil fertility are only a few of the variables that affect seed protein content; soil fertility is one of these variables that has a significant impact. Nitrogen is a crucial component of soil fertility and directly correlates with the amount of seed protein (Mohammadi *et al*., 2013). The results of the performed studies demonstrate that boosting nitrogen consumption and applying it as a spray during the last stages of growth enhances the proportion of seed protein (Fealegari *et al*., 2017).

Table 3. Mean comparison results of the studied traits in barley under the interactive effects of different levels and split application of nitrogen fertilizer

Nitrogen fertilizer	Split application	plant height (cm)	spike length (cm)	Biological yield (g.m^{-2})	Seed yield (g.m^{-2})	Harvest index (%)	Seed protein percentage	Seed protein yield (g.m^{-2})
50 (kg.ha^{-1})	50% planting + 50% stemming	94.50c*	5.53c	919.05f	351.11f	38.02b	9.92d	34.82f
	25% planting + 50% stemming + 25% pregnancy	106.11b	5.73ab	1041.27e	351.88f	33.79f	10.17c	35.77f
	25% planting + 75% stemming	109.32ab	6.00b	1079.37e	352.05f	32.62ef	10.50c	36.97f
90 (kg.ha^{-1})	50% planting + 50% stemming	96.37c	5.67c	1022.22e	355.33f	34.76de	11.33b	40.27e
	25% planting + 50% stemming + 25% pregnancy	111.36ab	5.87b	1092.06e	407.70e	37.33bc	11.33b	46.21d
	25% planting + 75% stemming	111.94ab	6.17a	1180.95c	472.96c	40.05a	11.71b	55.38c
130 (kg.ha^{-1})	50% planting + 50% stemming	98.88c	6.00ab	1060.32d	431.30d	40.68a	13.50°	58.23c
	25% planting + 50% stemming + 25% pregnancy	110.54ab	6.20a	1263.49b	491.88b	38.93b	13.75a	67.63b
	25% planting + 75% stemming	113.05°	6.27a	1422.22°	517.96a	36.42c	13.83a	71.65°

*According to Duncan's test, the means with similar letters in each column are not significantly different at 5% probability level.

Given that the treatment of the fertilizer distribution method is 25% at planting and 75% at shooting, it can be claimed that supplying nitrogen at the end of the growing season has a more significant impact on the nitrogen and protein content of the seed than on the yield. A late application of nitrogen via grain protein distribution increases grain yield without using many nitrogen fertilizers. A limited amount of nitrogen is absorbed by the plant at the start of growth in the treatment of 50% of the planting stage, and the remaining nitrogen is kept out of the plant's reach through water washing in the form of nitrate and sublimation. If not enough, the amount of protein in the seeds would decline (Bly and Woodard, 2009). The results of this study were consistent with those of Overman and colleagues (2000), which demonstrated that nitrogen is divided among the plant's organs as the plant grows, increasing the concentration of this element in the plant's tissues. When the seed is filled, more nitrogen is transferred to the seeds, increasing the seed protein percentage.

4.7. Seed protein yield

At the 1% significance level, varied nitrogen fertilizer amounts, fertilizer distribution techniques, and their interactions impacted grain protein yield (Table 2). The treatment of 130 kg/ha of nitrogen fertilizer and fertilizer distribution method (25% at the time of sowing and 75% at the stem growth stage) resulted in the greatest yield of seed protein (Table 3). The application of nitrogen after vegetative growth is made to boost protein content. The amount of nitrogen applied and the wheat's nitrogen content plays a significant role in the enhanced protein production brought on by the late delivery of nitrogen (Fealegari *et al*., 2017). Spraying typically increases the seed protein content, especially when the grain yield is higher than anticipated (Bly and Woodard, 2009). Optimal use of nitrogen is associated with more grain production. When this component is delivered in the appropriate quantity, the product's quality will improve along with its quantity. It will have an impact on the seed's ability to store protein (Mohammadi *et al*., 2013). Kader *et al*. (2002) reported that using nitrogen fertilizer throughout the stalking and flowering periods of wheat increased grain production and protein yield, which support the results of this study.

5. CONCLUSION

As a result of raising nitrogen fertilizer application to 130 kg per hectare, barley plants produced more grain (517 grams per square meter) and grain protein (71.65 grams per square meter), according to the study's results. Consequently, based on the overall findings of this study, it can be concluded that barley plants should be grown with a nitrogen fertilizer consumption of 130 kg per hectare using a method that divides the planting stage by 25% and the stage of stem growth by 75% in order to produce the highest possible quantitative and qualitative yield.

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FOOTNOTES

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