Effect of Nitrogen Fertilizer and Rate of Seeds on Some Growth Criteria and Dry Matter Production of Barley (Hordeum Vulgare L.)

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Abstract

A field experiment was carried out at the Second Agricultural Research and Experiments Station of the College of Agriculture / University of Al-Muthanna in Al Bandar region, during the winter season (2019-2020), in order to know the effect of nitrogen fertilization and seed rate on the production of dry matter for barley crop, and the experiment was applied according to the arrangement of the split plates. According to the design of randomized complete blocks with three replications, the number of experimental units was 120 units. The experiment included the secondary factor of five seed quantities (40, 60, 80, 100 and 120 kg ha\(^{-1}\)) and the main factor included 4 levels of nitrogen fertilizer (0, 50, 100 and 150 kg ha\(^{-1}\)). The results showed that the rate of seed were significantly superior in most of the growth characteristics and dry matter of the barley crop, where the rate of seeds 80 kg ha\(^{-1}\) outperformed in the characteristics of plant height, dry weight of the stem, dry weight of leaves, dry weight of ears and dry weight of the plant, where their averages were (96.64 cm, 10.34 g, 7.20 g, 4.78 g and 22.3 g) respectively, while the level of 120 kg ha\(^{-1}\) seed rate outperformed in increasing the area of the flag leaf, which amounted to 23.67 cm\(^{2}\), and the lowest seed level 40 kg ha\(^{-1}\) gave an increase in the length of the spike, which reached 7.06 cm. As for nitrogen fertilizer levels, the levels were significantly higher in all studied traits, where the amount of fertilizer 100 kg ha\(^{-1}\) outperformed in all studied traits, plant height (100.20 cm) and area leaf flag (24.38 cm\(^{2}\)), the number of tillers (8.38 tillers Plant\(^{-1}\)), the length of the spike (6.92 cm), the dry weight of the stem (10.84 g), the leaves (7.29 g), the spikes (5.38 g), and the dry weight of the whole plant (23.51 g). As for the interaction between the rate of seed and nitrogen fertilization, the combination (80 kg ha\(^{-1}\) seed * 100 kg ha\(^{-1}\) nitrogen) outperformed and gave the highest averages for most of the studied traits. And the weight of the full bat where their averages were (13.20, 10.51, 7.37 and 31.07 g) respectively.

Keywords: Barley, Seed rate, Nitrogen fertilizer levels, Dry matter.

1. Introduction

Barley (Hordeum vulgare L.) is one of the cereal crops, and it is the fourth among the strategic grain crops after wheat, rice and maize in terms of cultivated area and production, it is also characterized by its resistance to difficult growing conditions in dry and semi-arid areas such as cold, drought, alkaline, salinity and bush, due to its rapid growth and faster maturity than wheat, the crop is grown on a large scale in the central and southern regions of Iraq because of its high ability to withstand the prevailing salinity and drought conditions [1]. The cultivated area in Iraq for the year 2019 to the barley crop reached 930.25 thousand hectares, the production amounted to 1519 thousand tons, and the yield per hectare was 0.102025 ton ha\(^{-1}\), the Mosul governorate occupied the first place in terms of production with a quantity of 1265 thousand tons, representing (83.1%) of the total production in Iraq [2]. Determining the quantity of seeds and the way plants are distributed per unit area has a significant impact on the components of the yield (the number of spikes per unit area, the number of grains per spike, and the weight of 1000 grains). Accordingly, it is necessary to determine the ideal seed quantities because of their important role in increasing the grain yield and increasing the production of dry matter [3], and the nitrogen fertilization in terms of quantity and dates of its addition during the growth stages is one of the important keys to the management of the crop [4] to raise productivity and improve quality, the barley plant's need for fertilizer varies according to the growing season, soil quality and plant growth stages, depending on the physiological condition and environmental factors. In order to know the level of fertilizer, The optimum seed quantity to produce the maximum dry matter for the barley crop.
2. Material and Methods

The experiment was carried out at the second agricultural research station of the College of Agriculture, Al-Muthanna University, during growing season 2019-2020 in a mixture of soil, the specifications of which are shown in Table (1), with the aim of knowing the appropriate amount of nitrogen fertilizer and the best rate of seed to produce the largest amount of dry matter and to ensure its efficient distribution between plants for two varieties of barley.

The soil was fertilized with potassium sulfate (42% K) at a rate of 60 kg k ha\(^{-1}\) and in two batches, one before planting and the second batch a month after the first batch, and with a fertilizer Triple Super Phosphate (P\(_2\)O\(_5\) 46%) at a rate of 80 kg p ha\(^{-1}\), which was added all at once before planting and for all experimental units.

Table 1. Some physical and chemical properties of the experimental soil.

| Characteristics       | Units | Results |
|-----------------------|-------|---------|
| Sand                  | %     | 31      |
| Silt                  | %     | 26.5    |
| Clay                  | %     | 42.5    |
| Soil texture          |       | Clay sandy |
| ECe                   | ds.m\(^{-1}\) | 7.93  |
| Ph                    |       | 8.0     |
| OM                    | %     | 7.8     |
| N                     | %     | 0.39    |
| Available phosphorous | mg p kg\(^{-1}\) soil | 7.6 |
| Available potassium   | mg k kg\(^{-1}\) soil | 7.6 |

The experiment was carried out using the split plot design with three replications, and the number of experimental units was 120 units, the experiment included two factors, the first factor is nitrogen fertilizer at four levels (0, 50, 100 and 150 kg ha\(^{-1}\)), which are represented by (N\(_1\), N\(_2\), N\(_3\) and N\(_4\) ), the second factor is rate of seeds at five levels (40, 60, 80, 100 and 120 kg ha\(^{-1}\)), which are represented by (S\(_1\), S\(_2\), S\(_3\), S\(_4\) and S\(_5\) ) the main plots including levels of fertilizer and second plots including the rate of seeds. When signs of full maturity appear (yellow plants, yellow flag leaves and yellow spike), the plants were harvested on 13 April, 2020. At the stage of 75%, flowering the plant height (cm) and flag leave area (cm\(^2\)), at maturity the number of tillers, Spike length, weight of dry stem, weight of dry leaves, weight of dry spikes and the dry weight of plant were recorded.

3. Statistical analysis

After the data collection was completed, it was classified, arranged and statistically analyzed according to the statistical program Genstat Discovery 4, and a comparison of the averages of the coefficients was made at the 0.05 probability level.

4. Results and Discussion

4.1 Plant height

The results in Table (2) showed a significant effect of seed rate and level of nitrogen fertilization and the interaction between them on plant height of barley. The seed rate 80 kg ha\(^{-1}\) gave the highest average plant height, which was 96.64 cm, while the seed rate 100 and 60 kg ha\(^{-1}\) gave the lowest average plant height, which was 90.04 and 90.35 cm, respectively, this is due to the lack of competition between plants, thus increasing their elongation and obtaining adequate food. This result agreed with [5,6] who indicated that increasing seeding rates led to a decrease in plant height. As for the levels of fertilization, the level of 100 kg ha\(^{-1}\) exceeded in giving the highest average for this trait, which reached 100.20 cm, while the level of 50 kg ha\(^{-1}\) and the comparison treatment gave the lowest averages for this trait, which was 84.56 and 88.72 cm, respectively, this is attributed to the role that nitrogen fertilization plays in increasing the division and expansion of cells for the developing tops of the stem and leaves and that increasing the leaf area leads to increased shading and this in turn increases the action of auxin and gibberellin on increasing the elongation of the internodes, and then increasing the height, and this result agreed with [7,8]). As for the interaction between seed rate and fertilization levels, the two combinations (80 kg ha\(^{-1}\) seed × 100 kg ha\(^{-1}\) nitrogen) and (60 kg ha\(^{-1}\) seed × 150 kg h\(^{-1}\) nitrogen) gave the two highest averages for this trait, reaching 104.87 and 101.53 cm respectively.
Table 2. Effect of cultivars, seed rate, nitrogen levels and their interactions on plant height (cm).

| Level of nitrogen fertilizer kg ha⁻¹ | Rate of seeds (kg ha⁻¹) | Mean of nitrogen fertilizer level |
|--------------------------------------|-------------------------|----------------------------------|
|                                      | 60  | 80  | 100 | 120 |                  |
| 0                                    | 100.40 | 81.88 | 94.67 | 76.13 | 91.06 | 88.72 |
| 50                                   | 77.20 | 77.99 | 91.47 | 91.52 | 84.60 | 84.56 |
| 100                                  | 101.20 | 100.53 | 104.87 | 93.87 | 100.53 | 100.20 |
| 150                                  | 98.97 | 101.53 | 95.53 | 98.64 | 97.54 | 98.44 |
| Mean of rate of seeds                | 94.44 | 90.35 | 96.64 | 90.04 | 93.43 |
| L.S.D (0.05)                         |      |      |      |      |      |      |
| Seeds rate = (4.517)                 |      |      |      |      |      |      |
| Level of nitrogen fertilizer = (2.859) |      |      |      |      |      |      |
| Interaction = (8.384)                |      |      |      |      |      |      |

4.2 Flag leaf area (cm²)

The results showed in Table (3) that there was a significant effect of seed rate and nitrogen fertilization levels and their interaction in flag leaf area of plant for barley. The rate of seed 120 kg ha⁻¹ gave the highest mean of flag leaf area, which amounted to 23.67 cm², while the rate of seed 60 kg ha⁻¹, and the control treatment gave the lowest mean of the flag leaf area, which amounted to 19.46 and 19.67 cm², respectively. As for the levels of fertilization, the level of 100 kg ha⁻¹ exceeded it in giving the highest average for this trait, as it reached 24.38 cm², while the level of 50 kg ha⁻¹ and the control treatment gave the lowest averages for this trait, as they were 17.54 and 18.21 cm² respectively, that is may be due to increasing the level of nitrogen fertilization at a sufficient level led to an increase in the length and width of the flag leaf in barley plants, and this result agreed with [9,10]. As for the interaction, the combination (120 kg ha⁻¹ seed × 100 kg hax nitrogen) gave the highest level for this trait, reaching 28.97 cm², while the combination (60 kg ha⁻¹ seed × 50 kg ha⁻¹ nitrogen) gave the lowest average. For this trait, it reached 14.49 cm².

Table 3. Effect of cultivars, seed rate, nitrogen levels and their interactions on Flag leaf area (cm).

| Level of nitrogen fertilizer kg ha⁻¹ | Rate of seeds kg ha⁻¹ | Mean of nitrogen fertilizer level |
|--------------------------------------|-----------------------|----------------------------------|
|                                      | 40  | 60  | 80  | 100 | 120 |                  |
| 0                                    | 22.49 | 15.01 | 19.02 | 15.89 | 18.66 | 18.21 |
| 50                                   | 14.71 | 14.49 | 14.53 | 21.49 | 22.47 | 17.54 |
| 100                                  | 21.06 | 25.79 | 25.07 | 20.99 | 28.97 | 24.38 |
| 150                                  | 20.41 | 22.54 | 21.16 | 23.62 | 24.57 | 22.46 |
| Mean of rate of seeds                | 19.67 | 19.46 | 19.94 | 20.50 | 23.67 |
| L.S.D (0.05)                         |      |      |      |      |      |      |
| Seeds rate = (1.903)                 |      |      |      |      |      |      |
| Level of nitrogen fertilizer = (2.918) |      |      |      |      |      |      |
| Interaction = (4.190)                |      |      |      |      |      |      |

4.3 Number of tillers plant⁻¹

The results in Table (1) showed significant effect of nitrogen fertilization levels and the interaction between levels of nitrogen fertilizer on the number of tillers per plants, while the results were non-significant with regard to seed rate. As for the levels of fertilization, the level of 100 kg ha⁻¹ exceeded it in giving the highest average for this trait, which was 8.38 tiller. Plant⁻¹, whereas, the level of 50 kg ha⁻¹ and the control treatment gave the lowest averages for this trait, which were 6.88 and 7.15 tiller per plant respectively, this finding agreed with [11,12]. As for the interaction, the combination (100 kg ha⁻¹ seed ×100 kg ha⁻¹ nitrogen) gave the highest level for this trait, which reached 9.73 tiller per plant, whereas, the combination (120 kg ha⁻¹ seed × 0 kg ha⁻¹ nitrogen) gave the lowest mean for this trait, which was 5.53 tiller per plant.

4.4 Spike length (cm)

The results in Table (5) indicate that there was a significant effect of seed rate and nitrogen fertilization levels on the Spike length of the barley, whereas showed non-significant effect on their interaction. The seeds rate 40 kg ha⁻¹ gave the highest mean length of the spike, which reached 7.06 cm, while the seed rate 60 kg ha⁻¹ gave the lowest mean for this trait, which reached 6.40 cm, this result agreed with [13], who indicated a decrease in the length of the spike when the seed rate was increased. As for the levels of fertilization, the level of 100 kg ha⁻¹ exceeded to giving the highest mean for this trait, which
was 6.920 cm, whereas, the control treatment gave the lowest mean for this trait, which reached 6.200 cm, respectively. The reason for this is attributed to the role of structural nitrogen, cell elongation and spike length increase. This result agreed with [5, 9], who found significant differences in spike length.

Table 4. Effect of cultivars, seed rate, nitrogen levels and their interactions on number of tillers per plant.

| Level of nitrogen fertilizer kg ha\(^{-1}\) | Rate of seeds kg ha\(^{-1}\) | Mean of nitrogen fertilizer level |
|------------------------------------------|-------------------------------|----------------------------------|
| 0                                        | 40                            | 9.20                            | 6.40                           | 7.87                           | 7.73                           | 5.53                           | 7.15                           |
| 50                                       | 60                            | 7.00                            | 6.87                           | 7.40                           | 6.80                           | 9.33                           | 8.38                           |
| 100                                      | 80                            | 7.80                            | 8.23                           | 6.80                           | 9.73                           | 9.33                           | 8.38                           |
| 150                                      | 100                           | 6.53                            | 8.93                           | 8.20                           | 8.12                           | 7.10                           | 7.78                           |

Mean of rate of seeds: 7.63 6.61 7.57 7.85 7.07
L.S.D (0.05): Seeds rate = n.s, Level of nitrogen fertilizer = 0.652, Interaction = 1.355

Table 5. Effect of cultivars, seed rate, nitrogen levels and their interactions on Spike length (cm).

| Level of nitrogen fertilizer kg ha\(^{-1}\) | Rate of seeds kg ha\(^{-1}\) | Mean of nitrogen fertilizer level |
|------------------------------------------|-------------------------------|----------------------------------|
| 0                                        | 40                            | 6.97                            | 5.97                           | 5.90                           | 6.10                           | 6.07                           | 6.07                           | 6.07                           |
| 50                                       | 60                            | 7.27                            | 6.23                           | 7.07                           | 6.70                           | 7.77                           | 7.77                           | 7.77                           |
| 100                                      | 80                            | 7.23                            | 6.60                           | 6.90                           | 7.00                           | 6.87                           | 6.87                           | 6.87                           |
| 150                                      | 100                           | 6.77                            | 6.80                           | 6.53                           | 6.07                           | 6.90                           | 6.90                           | 6.90                           |

Mean of rate of seeds: 7.06 6.40 6.60 6.47 6.65
L.S.D (0.05): Seeds rate = 0.464, Level of nitrogen fertilizer = 0.255, Interaction = n.s

4.5 Weight of dry stem (g)

The results showed in Table (6) that there was a significant effect of seed rate and nitrogen fertilization levels and their interaction on the weight of the dry stems in plant. The rate of seed 80 kg ha\(^{-1}\) gave the highest average reaching 10.34 (g), while the rate of seed 120 kg ha\(^{-1}\) gave the lowest average for this trait, reaching 7.54 (g), which did not differ significantly from the rate of seed 60 kg ha\(^{-1}\), which gave an average which was 7.67 (g), this is due to large rate of seeds led to competition and reduced the number of tillers, thus reducing the dry weight of stems, while the ideal seed rate led to increase in the production of dry matter and increase in the number of tillers. As for the levels of fertilization, the level of 100 kg ha\(^{-1}\) exceeded it in giving the highest mean which amounted to 10.84 (g), while the control treatment gave the lowest mean for this trait, which was 7.73 (g), the reason for this is attributed to the structural and functional role of nitrogen in increasing vegetative growth, cell division, expansion and elongation, these result agreement with [5, 1] who indicated that the amounts of nitrogen fertilizer differed in the dry weight of the stems. As for the interaction, the combination (80 kg ha\(^{-1}\) seed × 100 kg ha\(^{-1}\) nitrogen) gave the highest level which reached 13.20 (g), while the combination (120 kg ha\(^{-1}\) seed × 50 kg ha\(^{-1}\) nitrogen) gave the lowest mean for this trait which reached 5.42 (g).

Table 6. Effect of cultivars, seed rate, nitrogen levels and their interactions on weight of dry stem (g).

| Level of nitrogen fertilizer kg ha\(^{-1}\) | Rate of seeds kg ha\(^{-1}\) | Mean of nitrogen fertilizer level |
|------------------------------------------|-------------------------------|----------------------------------|
| 0                                        | 40                            | 7.80                            | 5.60                           | 9.50                           | 7.97                           | 7.80                           | 7.80                           | 7.73                           |
| 50                                       | 60                            | 7.15                            | 10.33                          | 10.60                          | 6.20                           | 5.42                           | 7.94                           |
| 100                                      | 80                            | 9.93                            | 9.27                           | 13.20                          | 10.80                          | 11.00                          | 10.84                          |
| 150                                      | 100                           | 9.37                            | 5.50                           | 8.07                           | 10.87                          | 5.93                           | 7.95                           |

Mean of rate of seeds: 8.56 7.67 10.34 8.96 7.54
L.S.D (0.05): Seeds rate = 0.760, Level of nitrogen fertilizer = 0.670, Interaction = 1.461
4.6 Weight of dry leaves (g)

The results in Table (7) showed significant effect of seed rate and nitrogen fertilization levels and their interaction of dry weight of leaves. The rate of seed 80 kg ha\(^{-1}\) gave the highest average which reaching 7.20 (g), while the rate of seed 60 kg ha\(^{-1}\) gave the lowest average for this trait, which amounted to 4.82 (g). As for the levels of fertilization, the level of 100 kg ha\(^{-1}\) exceeded it in giving the highest average that amounted to 7.29 (g), while the treatment of 150 kg ha\(^{-1}\) gave the lowest average of 5.42 (g), the reason for this can be attributed to the role of nitrogen in increasing vegetative growth, cell division, expansion and elongation, which was reflected in the increase in leaf area and consequently an increase in its weight and the amount of dry matter. This result agreed with [13] who indicated the difference in the amounts of fertilizer in the dry leaf weight of plant\(^{1} (g)\). As for interaction the combination (80 kg ha\(^{-1}\) seed × 100 kg ha\(^{-1}\) nitrogen) gave the highest level for this trait, reaching 10.51 g, while the combination (120 kg ha\(^{-1}\) seed × 50 kg ha\(^{-1}\) nitrogen) gave the lowest average for this trait which reached to 4.05 (g).

Table 7. Effect of cultivars, seed rate, nitrogen levels and their interactions on weight of dry leaves (g).

| Level of nitrogen fertilizer kg ha\(^{-1}\) | Rate of seeds kg ha\(^{-1}\) | Mean of nitrogen fertilizer level |
|------------------------------------------|-----------------------------|----------------------------------|
|                                          | 40  | 60  | 80  | 100 | 120 |                              |
| 0                                       | 6.03| 4.37| 6.53| 5.60| 5.27| 5.56                           |
| 50                                      | 5.75| 5.00| 6.97| 6.30| 4.05| 5.61                           |
| 100                                     | 5.40| 5.73|10.51| 6.80| 8.00| 7.29                           |
| 150                                     | 6.40| 4.20| 4.78| 6.97| 4.73| 5.42                           |
| Mean of rate of seeds                   | 5.89| 4.82| 7.20| 6.42| 5.51|                               |
| L.S.D (0.05)                             |     |     |     |     |     | Interaction = (1.371)          |

4.7 Weight of dry spikes (g)

The results showed in Table (7) that there was a significant effect of seed rate and levels of nitrogen fertilization and their interaction on weight of the dry spikes. The rate of seed 80 kg ha\(^{-1}\) gave the highest mean which was 4.78 (g), while the rate of seed 120 kg ha\(^{-1}\) gave the lowest mean for this trait which was 2.84 (g), the reason for this is due to the great competition of the branches in the production of dry matter due to the increase in the rate of seeds compared to the ideal rate of seeds, which gave the highest average dry weight. As for the levels of fertilization, the level of 100 kg ha\(^{-1}\) superior it in giving the highest average which reached 5.38 (g), while the treatment of 150 kg ha\(^{-1}\) gave the lowest average for this trait amounting to 2.33 (g), this is due to the role of nitrogen in increasing vegetative growth, cell division, expansion and elongation, which is reflected in the increase in the diameter of the stem and thus the increase in the weight and quantity of dry matter in the stem, this result agreed with [14], who indicated that the increase in nitrogen fertilizer led to an increase in dry matter in the spikes. As for the interaction the combination (80 kg ha\(^{-1}\) seed × 100 kg ha\(^{-1}\) nitrogen) gave the highest level for this trait, reaching 7.37 (g), while the combination (60 kg ha\(^{-1}\) seed × 150 kg ha\(^{-1}\) nitrogen) gave the lowest average for this trait. It reached 1.42 (g).

Table 8. Effect of cultivars, seed rate, nitrogen levels and their interactions on weight of dry spikes (g).

| Level of nitrogen fertilizer kg ha\(^{-1}\) | Rate of seeds kg ha\(^{-1}\) | Mean of nitrogen fertilizer level |
|------------------------------------------|-----------------------------|----------------------------------|
|                                          | 40  | 60  | 80  | 100 | 120 |                              |
| 0                                       | 3.87| 2.35| 3.77| 2.50| 2.31| 2.96                           |
| 50                                      | 3.15| 6.74| 6.21| 2.38| 2.42| 4.18                           |
| 100                                     | 6.57| 3.72| 7.37| 5.15| 4.12| 5.38                           |
| 150                                     | 3.03| 1.42| 1.77| 2.89| 2.51| 2.33                           |
| Mean of rate of seeds                   | 4.16| 3.56| 4.78| 3.23| 2.84|                               |
| L.S.D (0.05)                             |     |     |     |     |     | Interaction = (1.561)          |

4.8 The dry weight of plant (g)

The results showed in Table (7) that there was a significant effect of seed rate, nitrogen fertilization levels and the interaction on the dry weight of plant. The rate of seed 80 kg ha\(^{-1}\) gave the highest average which reaching 22.3 (g), while the rate of seed 120 kg ha\(^{-1}\) gave the lowest average for this trait, which reaching 15.89 (g). As for the levels of fertilization, the level of
100 kg ha\(^{-1}\) exceeded it in giving the highest average which was 23.51 (g), while the treatment of 150 kg ha\(^{-1}\) gave the lowest average for this trait which amounting to 15.69 (g), this result agreed with [11,9] who showed that an increase in nitrogen fertilization led to an increase in the total dry weight of the plant. As for the interaction the combination (80 kg ha\(^{-1}\) seed × 100 kg ha\(^{-1}\) nitrogen) gave the highest level for this trait, as it reached 31.07 (g), while the combination (60 kg ha\(^{-1}\) seed × 150 kg ha\(^{-1}\) nitrogen) gave the lowest average for this trait. It was 11.12 (g), which did not differ significantly from some treatments.

### Table 9. Effect of cultivars, seed rate, nitrogen levels and their interactions on the dry weight of plant (g).

| Level of nitrogen fertilizer kg ha\(^{-1}\) | Rate of seeds kg ha\(^{-1}\) | Mean of nitrogen fertilizer level |
|--------------------------------------|-----------------|----------------------------------|
|                                      | 40  | 60  | 80  | 100 | 120 | Mean of rate of seeds | L.S.D (0.05) |
| 0                                    | 17.71 | 12.31 | 19.80 | 16.07 | 15.39 | 16.25 | 18.61 | (1.192) |
| 50                                   | 16.05 | 22.07 | 23.77 | 14.88 | 11.89 | 17.73 | 16.06 | (1.665) |
| 100                                  | 21.90 | 18.72 | 31.07 | 22.75 | 23.12 | 23.51 | 22.32 | (1.912) |
| 150                                  | 18.80 | 11.12 | 14.63 | 20.73 | 13.17 | 15.69 | 18.61 | (1.589) |

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