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RESEARCH PAPER

Response of Ten Wheat Cultivars to Different Nitrogen Fertilization Batches to Improve Milling Ability

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A B S T R A C T:

This article investigates the impact of different nitrogen fertilization batches on the milling characteristics of ten bread wheat varieties, namely; Ebaa 99, Rashid, Buhuth, Mawada, Hawler2, Hawler 4, Koya 4, and Koya 18. The primary objective of this study was to determine the most suitable nitrogen fertilization rate for each cultivar in order to enhance the milling quality of the grains. The research was conducted in Grdarasha, Erbil, Kurdistan region, throughout the winter seasons of 2022, with the aim of observing the response of selected wheat cultivars (*Triticum aestivum* L.) to nitrogen fertilizer. A randomized block design was employed for the experiments, and the obtained results were subjected to statistical analysis using ANOVA and Duncan's multiple range tests. The traits of harvest index (HI), protein %, gluten %, and Falling Number (FN) were analyzed. Four different nitrogen fertilizer levels (T1 ;160 Kg ha-1 pre-planting and tillering stage and 0 Kg ha-1 at flowering, T2; 80 Kg ha-1 pre-planting, 160 Kg ha-1 at tillering stage and 80 Kg ha-1 at flowering, T3; 160 Kg ha-1 pre-planting and tillering stage and 1 Kg ha-1 amino acid at flowering, and T4; 80 Kg ha-1 pre-planting, 160 Kg ha-1 at tillering stage and 80 Kg ha-1 at flowering) were applied. The results indicated that nitrogen fertilization generally led to The highest HI (49.721%) was obtained from T1 , while T2 achieved the superior values of Protein (15.417%), gluten (49.778%) and FN (475.717 S) , Most of the cultivars produced higher HI (about 50%) except Ebaa (42.450%) and Babil (43.229%) , while the cultivars Babil , Koya4 and Ebaa possessed the highest significant values of protein (15.967%) , gluten (69.5795) and FN (579.25 s) respectively. The superiority of achieving higher results from cultivar- Nitrogen regime interaction arose from Mwadaa*T1 in HI (54.377%) , Koya 18*T2 in protein (16.828%) , Koya4*T2 gluten (82.667%) and Ebaa*T1 FN (635.167 s). The study concludes that it is essential to consider the cultivar-specific response to nitrogen fertilization to optimize the milling quality of wheat grains. We recommend adopting of the last three Cultivar*Treatment for bakery based on their propounding milling related traits.

KEY WORDS: Wheat cultivars, Nitrogen fertilization, Wheat quality, Grain yield, Kurdistan region, Iraq.
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1. INTRODUCTION

Bread wheat, scientifically known as *Triticum aestivum* L., is a globally consumed cereal crop that holds significant importance in the human diet. It contributes to approximately 30% of the world's grain production and 44% of overall cereal production, as reported by the Food and Agriculture Organization (FAO, 2009). This crop accounts for approximately 55% of the world's carbohydrate intake and provides around 20% of the total calories derived from food. The application rate and timing of nitrogen fertilizers play a crucial role in both wheat grain yield and quality, as highlighted in studies by Sohail et al. (2013) and Abedi et al. (2010).

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Estimates suggest that cereal crops utilize only about 33% of the applied nitrogen fertilizers efficiently. The unutilized nitrogen can be lost to the atmosphere through processes such as gaseous emission, soil denitrification, volatilization, or leaching below the root zone, as discussed by Matson et al. (1998) and Riley et al. (2001). To optimize nitrogen usage and maximize profitability, it is essential to ensure proper nitrogen delivery during the critical growth period of the crop, as emphasized by Mullen et al. (2003). This approach helps prevent excessive nitrogen application, benefiting both the environment and farmers' financial outcomes, as noted in studies by Lobell et al. (2004) and Christensen et al. (2006).

The composition of protein concentrations in wheat grain is crucial to the quality of bread made from wheat. However, the fluctuation in nutrient availability considerably affects the grain protein content of wheat crops (Daniel and Triboi et al., 2000), even though grain protein content is a genotypic property of wheat crops. The use of nitrogen fertiliser is a significant element influencing the quality of wheat grains. The production of high-quality wheat relies heavily on the careful control of nitrogen fertiliser (Abedi et al., 2010). Increases in both gliadins and glutenins caused by nitrogen application boost flour protein content (Dupont & Altenbach, 2003; Johansson et al., 2004). Ottman et al. (2000) observed that N fertilisation at flower initiation significantly enhanced protein levels.

The aim of this research was to evaluate the effect of nitrogen fertilization timing and doses on crop productivity and quality.

2.Materials and methods:

The experiment was conducted in Grdarasha, Erbil, Kurdistan region during the winter seasons 2022 to observe the response of ten wheat cultivars Triticum aestivum L (Ebaa 99, Babil, Rashid, Buhuth, Mawada, Hawler2, Hawler 4, Hawler 8, Koya 4 and Koya 18). to nitrogen fertilizer. The experiment was conducted in Randomized complete block Design (RCBD) with three replications, each replicates contain four plots. Each plot of land has been treated with different levels of nitrogen fertilizer, (T1 160 Kg ha^{-1} pre-planting and tillering stage and 0 Kg ha-1 at flowering, T2 80 Kg ha^{-1} pre-planting, 160 Kg ha-1 at tillering stage and 80 Kg ha-1 at flowering, T3 160 Kg ha-1 pre-planting and tillering stage and 1 Kg ha^{-1} amino acid at flowering, T4 80 Kg ha^{-1} pre-planting, 160 Kg ha^{-1} at tillering stage and 80 Kg ha^{-1} at flowering). To optimize wheat production and milling quality. The plot size was of 2 x 8 m containing 30 lines with 2 m length and the distance between line was 20 cm. harvest index percentage was defined as the seed weight divided by biological weight *100. protein content was calculated with Kjeldahl, Kjeldahl device used to analyze protein content at digestion temperature 400 °C. After determining the protein content. Gluten content when the protein is extracted, the sample is removed from starch and gluten remains, to obtain gluten index the sample was replaced to centrifuge device. To measure the activity of enzymes in flour and calculating the falling number FN in wheat samples, the falling number device was used. To Analyze the results, SAS software was utilized and Duncun multiple tests was conduct to compare the interaction between the means.

Appendices 1 and 2 show the soil properties as analyzed by Erbil directorate of agricultural research center and meteorological data obtained by the site meteorological station .

3.Results and discussions:

Nitrogen (N) is a key component of protein, and plays a crucial role in determining the protein content of wheat grain. The effect of nitrogen on HI, protein content, Gluten content and FN is a complex relationship, and can be influenced by a variety of factors, including the wheat cultivar, the nitrogen rate and their interaction. In this discussion, the effect of different nitrogen rates on HI, protein content, Gluten content and FN content in bread wheat cultivars, and their interaction was explored.

3-1- Harvest index (HI):

Harvest index (HI) is a crucial factor for assessing the yield and grain quality of wheat. HI is defined as the ratio of grain yield to total biomass yield and represents the proportion of dry weight allocated to the grain. Nitrogen fertilization is an essential component of wheat production as it can enhance grain yield and quality. However, the effect of nitrogen fertilization on HI can vary among wheat cultivars.

Table 1 indicates that HI was significantly different between treatments. It is shown that T1 (T1 160 Kg ha-1 pre-planting and tillering stage and 0 Kg ha-1 at flowering) had the highest HI (%49.721) while T4 (80 Kg ha-1) had the lowest HI amongst all the other treatments. In agreement with our study, Hassan, A. M., & Noori, S. H. A. (2023) who investigated the effect of split nitrogen fertilization on three bread wheat cultivars indicated that nitrogen fertilization significantly increased grain yield and HI in all cultivars. Furthermore, table 2 shows the effect nitrogen fertilization rate on different cultivars. It can be seen that apart from Ebaa and Babil cultivar, there were no significant differences between the other studied cultivars. The data also indicated that there was a significant effect of the interaction between cultivars and nitrogen fertilization on harvest index (Table 3). Fadhil, A. H. (2020) who studied effectiveness of nitrogen Fertilization on some wheat cultivars for Growth and Yield Traits found similar results. The highest HI (% 54.377) was obtained by Almwadaa cultivar with the addition of 160 kg ha-1 while the lowest HI (%36.842) was recorded in Babil cultivar. Table 3 also reveals that even though the effect of the interaction between cultivars and nitrogen fertilization on harvest index were significant in some cultivars, the others were not significantly. While the results of current study agrees with Omar, A. et al., (2014) and El-Hawary, M. and A.M. Shahein, (2015), it disagrees with Said, M. and A. Abd El-Moneem,(2016)

3-2- Protein content:

The protein content of wheat can be significantly influenced by nitrogen fertilization. Nitrogen is an essential macronutrient required for plant growth and plays a crucial role in the production of proteins in wheat. However, the response of different wheat cultivars to nitrogen fertilization can vary significantly, and it is essential to identify the cultivars that respond best to different levels of nitrogen fertilization.

Table1 indicates that the T1 and T3 (160 kg ha-1) had lower protein content compared to T2 and T4 (80 kg ha-1). The table also shows that T2 contained the highest level of protein while T1 contained the lowest protein amount. This indicates that the level of nitrogen fertilization has to some extend have negative impact on protein content in bread wheat. The relationship between nitrogen and protein content in wheat grain is not always linear. According to Sohail et al. (2013), applying nitrogen fertilizer at appropriate levels during the early vegetative growth stages of wheat crop resulted in a significant increase in tiller formation. However, it was found that this practice did not guarantee improvements in grain weight and protein contents.

In contrast to the results to our study Sohail, M et al., (2018) reported that applying nitrogen fertilizer in four split doses at sowing, tiller formation, stem elongation, and grain filling stages had a positive impact on grain yield, as well as grain protein content and quality. In addition, Litke, L., Gaile, Z., and Rua, A. (2018) demonstrated that nitrogen fertilizer substantially increased the grain's protein content. It coincides with the findings of another study indicating that nitrogen treatment has a significant effect on protein levels. The average amount of CP per trial period in wheat grain increased as the nitrogen rate increased. When the greatest fertilizer rates were utilized, the highest protein content was achieved. CP content in grain increased substantially until N180 nitrogen fertilizer rate (Weber et al., 2008).

Furthermore, table 2 explains that the level of nitrogen significantly impacts the protein content in different wheat cultivar. It is found Babil cultivar had the highest percentage of protein (%15.967) compared to the other studied cultivars. In addition, the lowest protein found in Hawler 2 had minimum protein content (%12.757). The effect of nitrogen on protein content is not always straightforward, and can be influenced by the interaction between nitrogen rates and wheat cultivars. Ghimire, D et al, (2021) stated that some cultivars responded more strongly to nitrogen fertilization than others, suggesting that the effect of nitrogen on protein content is influenced by cultivar-specific factors.

The interaction between nitrogen fertilization rate and cultivar on the level of protein is significant (table 3). It is found that the content of protein was the highest (% 16.828) in Koya 18 by the addition of 80 kg ha-1, while at the same time it was the lowest (%12.123) in Hawler 2 as a result of applying 80 kg ha-1. Similar results were found by Vazquez, D. et al., (2019), Abedi, T., Alemzadeh, A., & Kazemeini, S. A. (2011) and Hussain, M. A., Dohuki, M. S., & Ameen, H. A. (2017). They asserted that while increasing nitrogen fertilizer rates generally increases yield, it may have a negative effect on protein content in some Iraqi wheat cultivars. The extent of this effect may depend on the specific cultivar being grown.

3-3- The Falling number (FN):

It is an important measure of the quality of wheat flour for baking. It indicates the extent of alpha-amylase activity in the wheat grain, which is responsible for the breakdown of starch into sugar. A low FN value indicates high alpha-amylase activity, which can lead to sticky and gummy dough, resulting in poor quality bread.

It is noticed that the nitrogen fertilization rate had a significant difference on FN (table 1). It seems that T2 (80 kg ha-1) had the highest FN. Thus, it can be stated that the increase in the amount of nitrogen ferilization results in a decrease in the FN. In addition, in terms of the effect of nitrogen fertilization rate on different cultivars, it had significant impact (table 2). The highest and the lowest FN were found in Ebaa (579.250) and Koya 4(418.333) respectively. The interaction between nitrogen fertilization rate and cultivars were varied as indicated in table 3. It is unveiled that FN was the highest (635.167) in T1 (160 kg ha-1) in Ebaa cultivar and the lowest (346.833) in Babil cultivar by the application of (80 kg ha-1) nitrogen fertilizer. Grausruber et al., (2000) indicated in that the value of falling number is largely controlled by genetic and environmental factors, especially climatic conditions at maturation stage. Similar to our study, Litke, L., Gaile, Z., & Ruža, A. (2018) found that increasing of nitrogen fertilizer rate significantly increase falling number until nitrogen fertilizer rate 180 kg/ha. Unlike our research, Erekul, O., Götz, K. P., & Koca, Y. O. (2012) and Liniņa, A., & Ruža, A. (2012) reported that increasing the nitrogen fertilization rate resulted in a significant decrease in FN values in bread wheat cultivars. These variation in the effect of nitrogen fertilization on FN in bread wheat cultivars appears to be dependent on various factors, such as the wheat genotype, nitrogen application rate, and environmental conditions.

3-4-Gluen content:

Gluten is an important protein complex in wheat that contributes to dough quality and bread-making properties. Nitrogen fertilization is a primary method for increasing gluten content in wheat, but the response to nitrogen can vary among cultivars.

Table 1 displays that there is a substantial variance in the gluten content between the treatment. It can be seen that T2 (80 Kg ha-1 pre-planting, 160 Kg ha-1 at tillering stage and 80 Kg ha-1 at flowering)contained the highest (49.778) amount of gluten however the lowest amount of gluten was found in T4 (43.6820). Horvat, D.et al., (2021) testified that the fertilization of nitrogen significantly increased gluten content and in all cultivars. However, the effect of nitrogen fertilization on gluten content varied among cultivars. In addition, Wazir, M. S., & Akmal, M. (2019) found that split nitrogen application of 100 Kg ha-1 significantly increase gluten content in grain

Table 1: displays the effect of cultivar harvest index, protein, gluten and FN.

Nitrogen/ha	HI%	Protein%	Gluten%	FN (seconds)
T1	49.721a	14.097d	44.590b	441.817b
T2	47.430ab	15.417a	49.778a	475.133a
T3	47.772ab	14.528c	44.332b	446.717b
T4	48.051b	15.039b	43.682b	446.600b

* Means with the same letter are not significantly different

Table 2: displays the effect of different level of nitrogen on harvest index, protein, gluten and FN in different cultivars.

cultivar	HI	Protein	Gluten	FN
Ebaa	42.450b	15.536b	40.904ef	579.250a
Babil	43.229b	15.967a	39.508f	363.792f
Bhuth	48.921a	13.542e	39.446f	436.625de
Rashid	48.328a	14.728c	40.792ef	493.958b
Mwadaa	51.640a	14.088d	40.283f	446.875d
Hawler 2	48.641a	12.757f	51.483b	442.958d
Hawler 4	50.668a	15.575ab	45.817c	442.667d
Hawler 8	49.201a	15.464b	43.225de	434.583de
Koya 4	49.641a	14.579c	69.579a	418.333e
Koya18	49.716a	15.468b	44.917cd	466.625c

* Means with the same letter are not significantly different

Table 2: displays the interaction between different level of nitrogen fertilization and cultivars on harvest index, protein, gluten and FN.

	Nitrogen Treatment	HI	Protein	gluten	FN
Ebaa	T1	48.326 a-g	14.565 h-l	41.717 h-n	635.167 a
	T2	40.833 ghi	16.533 ab	40.417 i-o	573.000 b
	T3	39.546 hii	16.493 abc	39.717 i-o	477.833 c-h
	T4	41.093 f-i	14.552 i-l	41.767 h-n	631.000a
Babil	T1	46.235 a-g	15.863 a-g	44.500 g-j	366.833 pq
	T2	44.766 d-h	16.055 a-e	36.733 mno	371.167 opq
	T3	36.842 i	15.382 d-j	40.933 h-o	370.333 opq
	T4	45.071 d-h	16.568 ab	35.867 no	346.833 q
Bhuth	T1	48.588	12.838 o-r	35.450 o	402.500 l-p
	T2	45.797 b-g	14.992 f-i	42.417 h-m	497.000 cd
	T3	53.013 a=d	12.678 pqr	42.383 h-m	458.667 d-j
	T4	48.287 a=g	13.660 l=o	37.533 l-o	388.333 nop
Rashid	T1	48.989 a-f	13.487 nop	40.583 i-o	487.667 c-f
	T2	47.920 a-g	15.500 d-i	41.767 h-n	507.167 c
	T3	49.581 a-e	14.418 j-m	40.333 i-o	489.667 cde
	T4	46.821 a-h	15.508 d-i	40.483 i-o	491.333 cde
Mwadaa	T1	54.377 a	12.512 qr	36.667 mno	410.833 k-o
	T2	43.771 e-i	15.295 e-j	40.783 i-o	466.833 c-i
	T3	54.348 a	14.000 k-n	40.517 i-o	453.333 e-j
	T4	54.065 ab	14.543 i-l	43.167 h-l	456.500d-i
Hawler 2	T1	49.547 a-e	12.280 qr	58.250 de	430.167 i-m
	T2	49.379 a-e	12.892 o-r	67.600 b	444.167 g-l
	T3	46.636 a-h	13.733 l-o	41.833 h-n	454.667 e-j
	T4	49.002 a-f	12.123 r	38.250 k-o	442.833g-l
Hawler 4	T1	51.280 a-e	15.267 e-j	45.517 ghi	436.167 g-l
	T2	50.761 a-e	14.947 g-k	45.000 ghij	506.000 c
	T3	50.809 a-e	15.552 c-h	43.900 g-k	441.500 nop
	T4	49.821 a-e	16.535 ab	48.850 fg	387.000 h-l
Hawler8	T1	49.166 a-f	14.960 g-k	39.017 j-o	398.167 m-p
	T2	47.056 a-h	15.940 a-g	46.817 gh	454.167 e-j
	T3	53.465 abc	14.995 fghij	42.667 h-m	441.667 h-l
	T4	47.117 a-h	15.960 a-f	44.400 g-j	444.333 g-l

Koya 4	T1	49.990 a-e	13.570 m-p	61.867 cd	372.667 opq
	T2	51.374 a-e	15.190 e-j	82.667 a	446.667 f-k
	T3	47.937 a-g	14.952 g-k	68.200b	418.167 j-n
	T4	49.261 a-e	14.605 h-l	65.583 bc	435.833 h-l
Koya18	T1	50.710 a-e	15.628 b-g	42.333 h-m	478.000 c-h
	T2	52.640 a-d	16.828 a	53.583 ef	485.167c-g
	T3	45.543 c-h	13.078 n-q	42.833 h-l	461.333 d-i
	T4	49.972 a-e	16.337 a-d	40.917 h-o	442.000 h-l
* Means with the same letter are not significantly different					

4.Conclusion:

The study thoroughly analyzes the impact of nitrogen fertilization levels on wheat cultivars. Based on assessed parameters, it shows that cultivar type and nitrogen levels significantly influence characteristics like harvest index, protein, gluten, and Falling Number. Some cultivars have inherent genetic traits leading to high harvest index ('Mwadaa'), while others can optimize protein yield at specific nitrogen levels ('Ebaa', 'Babil', 'Hawler 4', 'Koya18'). 'Koya 4' stands out with exceptionally high gluten content at T2 nitrogen level, suggesting a beneficial interaction effect. Falling Number responses vary across cultivars and nitrogen levels, requiring further study. This research provides valuable insights for improving wheat quality through nitrogen fertilization and cultivar selection, needing more research to explore underlying mechanisms.

References:

Abedi, T., Alemzadeh, A., & Kazemeini, S. A. (2010). *Effect of organic and inorganic fertilizers on grain yield and protein banding pattern of wheat*. *Australian journal of crop science*, *4*(6), 384-389.

Abedi, T., Alemzadeh, A., & Kazemeini, S. A. (2011). Wheat yield and grain protein response to nitrogen amount and timing. *Australian Journal of Crop Science*, *5*(3), 330-336.

Al-azawi, H. K., Al-Janabi, M. A. A., & Fakher-aldian, A. S. (2019). Effect of Different Levels of Nitrogen Fertilizer on the Grain Yield and its Components for Eight Varieties of Bread Wheat (Triticum aestivum L.). *Tikrit Journal for Agricultural Science*, *18*(1), 14-27.

Christensen, L., Riley, W. J., & Ortiz-Monasterio, I. (2006). Nitrogen cycling in an irrigated wheat system in Sonora, Mexico: measurements and modeling. *Nutrient Cycling in Agroecosystems*, *75*, 175-186.

Daniel, C. and E. Triboi, 2000. Effects of temperature and nitrogen nutrition on the grain composition of winter wheat: effects on gliadin content and composition. J. Cereal Sci., 32: 45–56.

El-Hawary, M. and A.M. Shahein, (2015). Response of some wheat cultivars to sowing on bed under different nitrogen levels on some agronomic and quality traits. J. Agr. Kafrelsheikh. Univ, 41(4): p. 1340-1354.

Erekul, O., Götz, K. P., & Koca, Y. O. (2012). Effect of sulphur and nitrogen fertilization on bread-making quality of wheat (Triticum aestivum L.) varieties under Mediterranean climate conditions. *Journal of Applied Botany and Food Quality*, *85*(1), 17-22.

Fadhil, A. H. (2020). Response of Wheat Cultivars of Triticum aestivum L to Nitrogen Fertilizer for Growth and Yield Traits. *Indian Journal of Ecology 47 Special Issue (10): 45-51.*

Ghimire, D., Das, S., Mueller, N. D., Creech, C. F., Santra, D., Baenziger, P. S., ... & Maharjan, B. (2021). Effects of cultivars and nitrogen management on wheat grain yield and protein. *Agronomy Journal*, *113*(5), 4348-4368.

Grausgruber, H., Oberforster, M., Werteker, M., Ruckenbauer, P., & Vollmann, J. (2000). Stability of quality traits in Austrian-grown winter wheats. *Field Crops Research*, *66*(3), 257-267.

Hassan, A. M., & Noori, S. H. A. (2023). Effect of cultivars and split application of nitrogen at the different growth stages on yield and its component of bread wheat (Triticum aes-tivum L.) under rain-fed conditions in Kurdistan, Iraq. *Journal of Kerbala for Agricultural Sciences*, *10*(3), 13-28.

Hussain, M. A., Dohuki, M. S., & Ameen, H. A. (2017). Response of some bread wheat (Triticum aestivum L.) cultivars to nitrogen levels. *Kufa Journal for Agricultural Sciences*, *9*(4), 365-390.

Johansson, E., Prieto-Linde, M. L., & Svensson, G. (2004). Influence of nitrogen application rate and timing on grain protein composition and gluten strength in Swedish wheat cultivars. *Journal of Plant Nutrition and Soil Science*, *167*(3), 345-350.

Liniņa, A., & Ruža, A. (2012). Cultivar and nitrogen fertiliser effects on fresh and stored winter wheat grain quality indices. In *Proceedings of the Latvian*

Academy of Sciences. Section B. Natural, Exact, and Applied Sciences. (Vol. 66, No. 4-5, pp. 177-184).

Litke, L., Gaile, Z., & Ruža, A. (2018). Effect of nitrogen fertilization on winter wheat yield and yield quality. Agronomy Research 16(2), 500 509.

Lobell, D. B., Ortiz-Monasterio, J. I., & Asner, G. P. (2004). Relative importance of soil and climate variability for nitrogen management in irrigated wheat. *Field Crops Research*, *87*(2-3), 155-165.

Mullen, R. W., Freeman, K. W., Raun, W. R., Johnson, G. V., Stone, M. L., & Solie, J. B. (2003). Identifying an in-season response index and the potential to increase wheat yield with nitrogen. *Agronomy Journal*, *95*(2), 347-351.

Omar, A., A. Mohamed, and M. Sharsher, A., El-hag, Walaa. AA (2014) Performance of some bread wheat genotypes under water regime and sowing methods. J. Agric. Res Kafrelsheikh Univ. 40(2): p. 327-341.

Ottman, M. J., Doerge, T. A., & Martin, E. C. (2000). Durum grain quality as affected by nitrogen fertilization near anthesis and irrigation during grain fill. *Agronomy Journal*, *92*(5), 1035-1041.

Riley, W. J., Ortiz-Monasterio, I., & Matson, P. A. (2001). Nitrogen leaching and soil nitrate, nitrite, and ammonium levels under irrigated wheat in Northern Mexico. *Nutrient Cycling in Agroecosystems*, *61*, 223-236.

Said, M. and A. AbdEl-Moneem,(2016). Response of Some Bread Wheat Cultivars to Nitrogen Fertilizer Splitting Under Sandy Soil Conditions. Journal of Plant Production. 7(9): p. 1013-1019.

Sohail, M., Hussain, I., Tanveer, S. K., Abbas, S. H., Qamar, M., Ahmed, M. S., & Waqar, S. (2018). Effect of nitrogen fertilizer application methods on wheat yield and quality. Science, Technology and Development, 37(2), 89-92.

Vazquez, D., Berger, A., Prieto-Linde, M. L., & Johansson, E. (2019). Can nitrogen fertilization be used to modulate yield, protein content and bread-making quality in Uruguayan wheat?. *Journal of Cereal Science*, *85*, 153-161.

Wazir, M. S., & Akmal, M. (2019). Nitrogen Split Application Timing Effect on Wheat Intercrop with Selected Species for Sustainable Production. *Sarhad Journal of Agriculture*, *35*(1).

Weber, E. A., Graeff, S., Koller, W. D., Hermann, W., Merkt, N., & Claupein, W. (2008). Impact of nitrogen amount and timing on the potential of acrylamide formation in winter wheat (Triticum aestivum L.). Field Crops Research, 106(1), 44-52.

Appendex (1) Soil test before and after sowing

Components	Before Sowing	After harvesting
k	194	143
P	4.5	3.2
O. M.	0.576	0.378
E. C.	0.2	0.2
PH	7.63	7.6
N	0.11	0.9

Appendex (2) meteorological data of Grdarasha location 2022