Journal of Crop Nutrition Science
ISSN: 2423-7353 (Print) 2538-2470 (Online)
Vol. 10, No. 2, 2024
https://jcns.ahvaz.iau.ir/ **OPEN ACCESS**

Response of Effective Parameters of Wheat (*Triticum aestivum* L.) Yield to Apply Amino Acid and Nitrogen Chemical Fertilizer

Mohammad Hossein Ghanavati[1], Shahram Lak[*2]

1- *MSc. Graduated, Department of Agronomy, Ahvaz Branch, Islamic Azad University, Ahvaz, Iran.*
2- *Professor, Department of Agronomy, Ahvaz Branch, Islamic Azad University, Ahvaz, Iran.*

RESEARCH ARTICLE

ARTICLE INFO.
Received Date: *28 Mar. 2024*
Received in revised form: *30 Apr. 2024*
Accepted Date: *30 May. 2024*
Available online: *20 Jun. 2024*

To Cite This Article:
Mohammad Hossein Ghanavati, Shahram Lak. Response of Effective Parameters of Wheat (*Triticum aestivum* L.) Yield to Apply Amino Acid and Nitrogen Chemical Fertilizer. ***J. Crop. Nutr. Sci.,*** 10(2): 13-23, 2024.

ABSTRACT

BACKGROUND: Nitrogen is a crucial component of plant nutrition, and its deficiency limits productivity of crops more than any other element. Organic fertilizers have an effect on the quantity and quality of carbon and soil capacity in storing and releasing nutrients needed for plant growth during process of decomposition and mineralization.

OBJECTIVES: This study was done to assessment effect of different levels of amino acid and Nitrogen macro nutrient on seed yield and its components of Wheat crop.

METHODS: Current research was carried out via factorial experiment based on randomized complete blocks design (RCBD) with three replications along 2022-2023 agronomic year. The treatments included Amino acid (nonuse or control, 1.5, 3 and 4.5 $L.ha^{-1}$) and Nitrogen fertilizer from urea source (100% equal 300 $kg.ha^{-1}$, 70% equal 210 $kg.ha^{-1}$ and 40% equal 120 $kg.ha^{-1}$).

RESULT: Result of analysis of variance revealed effect of different level of Amino acid, Nitrogen fertilizer and interaction effect of treatments (instead harvest index) on all studied characteristics was significant. Assessment mean comparison result of interaction effect of treatments on all measured traits indicated the maximum amount of number of spike per m-2 (390.5), number of seed per spike (41.30), 1000 seed weight (42.75 g), seed yield (460.70 $g.m^{-2}$) and biologic yield (1377.44 $g.m^{-2}$) were noted for 4.5 $lit.ha^{-1}$ amino acid and 100% Nitrogen (Also it doesn't had significant differences with 70% Nitrogen) and lowest amount of mentioned traits belonged to nonuse of amino acid and 40% Nitrogen treatment.

CONCLUSION: The use of foliar application of amino acids along with nitrogen chemical fertilizer can reduce the consumption of nitrogen chemical fertilizer in addition to producing sufficient crops, which significantly contributes to the health of the environment and is an important strategy in the direction of moving towards sustainable agriculture. Therefore, by using 70% of urea fertilizer along with 4.5 liters per hectare of amino acid, it is possible to save the consumption of chemical fertilizers and produce economic yield in studied region.

KEYWORDS: *Cereal, Crop Production, Nutrition, Seed weight, Urea.*

***Corresponding Author:** Shahram Lak ✉ Sh.lack@yahoo.com

1. BACKGROUND

Nitrogen increases the production of biomass and increases the possibility of retransmission of photosynthetic materials, producing more seeds per spike and better filling them after flowering, which will increase seed yield (Shanggan *et al*., 2000). Nitrogen fertilizer is a key nutrient in the production of non-legume crops. It is a component in many biological compounds that plays a major role in photosynthetic activity and crop yield capacity (Cathcart and Swanton, 2003) and its deficiency constitutes one of the major yield limiting factors for cereal production (Shah *et al*., 2003). A low nitrogen content in the soil leads to poor absorption of micronutrients by plants, which may be insufficient for the complete development of the plant tissue (Szulc, 2013). On the other hand, an excessive accumulation of mineral nitrogen in the soil poses a risk of water pollution as a result of nitrate leaching by precipitation (Ladha *et al*., 2005). The impact of increased fertilizer use on crop production has been large and important (Hossain and Singh, 2000). Naseri *et al*. (2010) reported that the highest seed yield and biologic yield were obtained in 160 and 240 kg $N.ha^{-1}$ with 5100 and 14360 $kg.ha^{-1}$, respectively. The correct and proportional nitrogen application rate of fertilizers increases wheat grain yield by increasing the number of spikes per unit area, and increasing the number of seeds per spike has a lower role in raising the yield (Fowler and Brydon, 2001). Researchers reported that the increase in nitrogen consumption increases the number of spikes per unit area, which can increase vegetative growth and, consequently, increase the amount of tillering due to nitrogen consumption. In such a situation, the number of fertilized tillers per unit area increases and the number of spikes per unit area also increases (Mosanaei *et al*., 2017). The use of amino acids will save energy to carry out a set of metabolic processes, which will lead to an increase in crop production and agricultural products (El-Naggar *et al*., 2009). Rafi *et al*. (2021) investigated the effect of amino acid, fulvic acid and seaweed extract on the quantitative and qualitative characteristics of wheat under normal conditions and drought stress and reported that growth stimulants caused a significant increase in grain yield compared to the control. Salva and Osama (2014) reported that spraying amino acid solution in drought stress conditions increases yield, yield components and improves quality traits of wheat grain. They stated that amino acids can directly or indirectly affect physiological activities on plant growth and crop production.

2. OBJECTIVES

This study was done to assessment effect of different levels of amino acid and Nitrogen macro nutrient on seed yield and its components of Wheat crop.

3. MATERIALS AND METHODS

3.1. Field and Treatments Information

Current research was carried out via factorial experiment based on randomized complete blocks design with three replications along 2022-2023 agro-

nomic year. Place of research was located in Omidieh city at longitude 49°43'E and latitude 30°45'N in Khuzestan province (Southwest of Iran). The treatments included Amino acid (nonuse or control, 1.5, 3 and 4.5 lit.ha^{-1}) and Nitrogen fertilizer from urea source (100% equal 300 kg.ha^{-1}, 70% equal 210 kg.ha^{-1} and 40% equal 120 kg.ha^{-1}). The physical and chemical properties of studied soil was mentioned in table 1.

Table 1. Physical and chemical properties of studied soil

Soil depth (cm)	EC (ds.m^{-1})	pH	Nitrogen (%)	OC (%)	P (mg.kg^{-1})	K (mg.kg^{-1})	Soil texture
0-30	3.95	7.88	0.05	0.77	11.5	219	Clay loam

3.2. Farm Management

Base fertilizers (150 kg.ha^{-1} phosphorus from Triple superphosphate and 100 kg.ha^{-1} potassium from potassium sulfate) were added to the soil based on soil tests and the recommendations of the Iranian Soil and Water Research Institute at the planting stage. The amount of nitrogen fertilizer from the source of urea was used based on the experimental treatments and it was used in two stages as base fertilizer and stem elongation. Aminox amino acid consisting of 18 types of amino acids, which was obtained from the Green Biotechnology Company and was used as a foliar spray in the two stages of the end of tillering and booting. Amino acid foliar spraying was used in the amount of 150, 300 and 450 cc in one hundred liters of mixed water respectively. Also, the ingredients in Aminox amino acids were introduced in table 2.

Table 2. The ingredients in Aminox amino acids

Compounds	(%)	Compounds	(%)
Total Nitrogen	10	**Alanine**	2.88
Organic matter	55	**Proline**	7.27
Total amino acid	50	**Tyrosine**	0.44
Free amino acid	25	**Valine**	3.82
Serine	6.43	**Methionine**	0.18
Histidine	0.39	**Cystine**	0.45
Aspartic acid	4.13	**Isoleucine**	1.72
Glutamic acid	5.76	**Leucine**	2.28
Glycine	5.6	**Phenylalanine**	2.02
Arginine	3.61	**Lysine**	0.75
Threonine	2.62	**Tryptophan**	0.04

3.3. Measured Traits

In order to determine the yield and yield components, the two side rows and half a meter of the beginning and end of each plot were eliminated as the marginal effects and finally the ultimate samples were taken from an area of 1 m^2. In order to determine the number of spikes per area unit, the spikes were taken from an area of 1 m^2 of then three middle lines of each plot after considering half a meter of beginning and end of each line as the margin and after counting the spikes their mean was considered as the number of spikes per area unit. As many as 10 spikes were randomly selected from the middle lines of each plot and the number of seeds was counted carefully and their mean was recorded. Two 500-seed samples were randomly selected from the produced seeds by each plot and if the weight difference of the two samples was less than 5%, the total weight of the two samples was considered as weight of 1000-seed. After full maturity of the seeds, the spikes were taken from the 3 middle lines of each plot in an area of 1 m^2 and the seed yield of each plot with moisture of 14% was calculated per area unit and then was recorded. Harvest index (HI) was calculated according to formula of Gardener *et al*. (1985) as follows: **Equ.1.** HI= (Seed yield/Biologic yield) ×100.

3.4. Statistical Analysis

Analysis of variance and mean comparisons were done via SAS (Ver.8) software and Duncan multiple range test at 5% probability level.

4. RESULT AND DISCUSSION

4.1. *Number of spikes per m^{-2}*

According result of analysis of variance effect of Amino acid, Nitrogen and interaction effect of treatments on number of spikes per m^{-2} was significant at 1% probability level (Table 3). Evaluation mean comparison result revealed in different level of Amino acid the maximum number of spikes per m^{-2} (379.76) was noted for 10 $lit.ha^{-1}$ and minimum of that (333.80) belonged to control treatment (Table 4). The higher number of spikes in nitrogen fertilizer application treatments can be seen as an increase in vegetative growth and as a result, an increase in tillering due to nitrogen consumption (Bavar *et al*., 2016). Eskandari Torbaghan and Fazeli Kakhki (2021) reported that the combined application of amino acid and humic acid was effective in increasing the number of spikes per square meter and the yield of wheat through a positive effect on the physiological and metabolic processes of the plant. Between different levels of Nitrogen, the maximum number of spikes per m^{-2} (385) was observed in 100% and the lowest one (334.2) was found in 40% treatment (Table 4). Based on the results of Yang *et al*. (2023), the highest number of seeds per spike, the seed weight and the number of spikes per square meter were obtained from the treatment of 240 $kg.ha^{-1}$ of nitrogen fertilizer.

Table 3. Results of analysis of variance of studied traits

S.O.V	df	No. Spike per m^{-2}	No. seed per spike	1000 seed weight	Seed yield	Biologic yield	Harvest index
Replication	2	41.10^{ns}	0.067^{ns}	3.15^{ns}	27.31^{ns}	116.4^{ns}	0.025^{ns}
Amino acid (A)	3	76033.2**	534.8**	200.01**	64102.11**	377326**	168.3**
Nitrogen (N)	2	10851.4**	366.17**	149.2**	31251.03**	218905**	129.54**
A × N	6	29711.3**	723.21**	101.8*	18116.20**	143257.1**	0.731^{ns}
Error	22	887.11	17.09	14.36	1458.1	10321.03	8.61
CV (%)		8.28	12	10.46	9.95	8.16	9.55

^{ns}, * and **: no significant, significant at 5% and 1% of probability level, respectively.

Evaluation mean comparison result of interaction effect of treatments indicated maximum number of spikes per m^{-2} (390.5) was noted for 4.5 $L.ha^{-1}$ Amino acid and 100% Nitrogen (Although it doesn't had significant differences with 70% amino acid) and lowest one (320.71) belonged to nonuse of Amino acid and 40% Nitrogen treatment (Table 5).

4.2. *Number of seed per spike*

Result of analysis of variance revealed effect of Amino acid, Nitrogen and interaction effect of treatments was significant on number of seed per spike was significant at 1% probability level (Table 3). Mean comparison result of different level of Amino acid indicated that maximum number of seed per spike (39.48) was noted for 4.5 $lit.ha^{-1}$ Amino acid and minimum of that (31) belonged to control treatment (Table 4). As for Duncan classification made with respect to different level of Nitrogen maximum and minimum amount of number of seed per spike belonged to 100% (40.39) and 40% (30.16) (Table 4). Assess mean comparison result of interaction effect of treatments indicated maximum number of spikes per m^{-2} (41.30) was noted for 4.5 $lit.ha^{-1}$ Amino acid and 100% Nitrogen (Although it doesn't had significant differences with 70% amino acid) and lowest one (28.11) belonged to nonuse of Amino acid and 40% Nitrogen treatment (Table 5). The research of Boulelouah *et al*. (2022) shows that the highest number of seeds per spike was obtained from the treatment of 150 kg per hectare of nitrogen fertilizer. It seems that the positive effect of amino acid on this trait may be due to its role in the construction of DNA, RNA and protein needed for the formation of enzymes. which is highly needed for vital activity and increasing cell division, which leads to the increase of these activities during flowering. Yaghoubian *et al*. (2016) stated that the use of nitrogen fertilizer increased the number of seeds in the spike and according to the results, the use of 100 kg per hectare of nitrogen fertilizer is recommended.

Table 4. Mean comparison effect of different level of amino acid and Nitrogen on studied traits

Treatment	No. Spike per m^{-2}	No. seed per spike	1000 seed weight (gr)	Seed yield ($gr.m^{-2}$)	Biologic yield ($gr.m^{-2}$)	Harvest index (%)
Amino acid						
Control	333.8c	31c	33.07c	329.50d	1120.39d	29.40c
1.5 $L.ha^{-1}$	356.66b	33.26b	35b	367.31c	1213.24c	30.27b
3 $L.ha^{-1}$	368.59ab	34.42b	36.23b	390.1b	1281.05b	30.45b
4.5 $L.ha^{-1}$	379.76a	39.48a	40.61a	448.20a	1363.43a	32.87a
Nitrogen						
100 (%)	385a	40.39a	41.05a	450.33a	1371.06a	32.84a
70 (%)	360.19b	33.07b	35.18b	370.19b	1233.20b	30.01b
40 (%)	334.2c	30.16c	32.45c	330.62c	1128.1c	29.30b

*****Means with similar letters in each column are not significantly differentt by Duncan's test at 5% probability level.

4.3. *1000 seed weight*

According result of analysis of variance effect of Amino acid, Nitrogen and interaction effect of treatments was significant on 1000 seed weight was significant at 1% probability level (Table 3). According result of mean comparison maximum of 1000 seed weight (40.61 g) was obtained for 4.5 $lit.ha^{-1}$ Amino acid and minimum of that (33.07 g) was for control treatment (Table 4). The use of nitrogen and amino acids in comparison with their non-use lead to an increase seed weight by increasing the length of the flowering period, prolonging the grain filling period and decreasing percentage of seed porosity (Soleymani, 2009). Evaluation means comparison result indicated in different level of Nitrogen the maximum 1000 seed weight (41.05 g) was noted for 100% Nitrogen and minimum of that (32.45 g) belonged to 40% Nitrogen treatment (Table 4). Evaluation mean comparison result of interaction effect of treatments indicated maximum 1000 seed weight (42.75 g) was noted for 4.5 $lit.ha^{-1}$ Amino acid and 100% Nitrogen (Although it doesn't had significant differences with 70% amino acid) and lowest one (30 g) belonged to nonuse of Amino acid and 40% Nitrogen treatment (Table 5). The availability of nitrogen fertilizer in reproductive growth stages of and none nutrient limitation leads to an increase in the seed weight. The reason for this is attributed to the increase in nutrients absorption by the plant, as a result, to the increase in the process of photosynthesis (Hanan *et al*., 2008). According to the reports of Litke *et al.* (2018), nitrogen fertilizer had a significant effect on the 1000 seed weight and this significant increase was observed in traits up to the treatment of 150 $kg.ha^{-1}$. Sohail *et al*. (2018) studied effect of nitrogen fertilizer on wheat yield and reported that the application of 120 $kg.ha^{-1}$ nitrogen achieved the highest 1000 seed weight (44 g), which was consistent with the results of this research.

Table 5. Mean comparison interaction effects of different levels of amino acid and Nitrogen on studied traits

Amino acid	Nitrogen	No. Spike per m^{-2}	No. seed per spike	1000 seed weight (gr)	Seed yield ($gr.m^{-2}$)	Biologic yield ($gr.m^{-2}$)
Control	**100 (%)**	335.4ef	33.12c	33.1d	341.5e	1170.24f
	70 (%)	331.23f	31.05d	31.9e	334.7ef	1163.05f
	40 (%)	320.71g	28.11e	30.0e	326.13f	1139.16g
1.5 $L.ha^{-1}$	**100 (%)**	361.01d	33.72c	35.41cd	371.4cd	1200.1e
	70 (%)	352.5de	32.26cd	34.32cd	364.10d	1189.63ef
	40 (%)	341.62e	34.1c	33.18d	349.06e	1174.2f
3 $L.ha^{-1}$	**100 (%)**	385.29b	38.19b	39.07b	425.51ab	1325.7b
	70 (%)	379.45c	36.3bc	38.6b	412.30b	1291.36c
	40 (%)	355.18de	34.27c	37.0c	373.18cd	1248.1d
4.5 $L.ha^{-1}$	**100 (%)**	390.5a	41.30a	42.75a	460.70a	1377.44a
	70 (%)	387.46a	40.26a	41.00a	451.20a	1369.2a
	40 (%)	369.8d	37.1b	38.30b	390.04c	1280.71c

*****Means with similar letters in each column are not significantly differentt by Duncan's test at 5% probability level.

4.4. *Seed yield*

Result of analysis of variance revealed effect of Amino acid, Nitrogen and interaction effect of treatments was significant on seed yield was significant at 1% probability level (Table 3). Assessment mean comparison result indicated in different level of Amino acid the maximum seed yield (448.20 $g.m^{-2}$) was noted for 4.5 $lit.ha^{-1}$ and minimum of that (329.50 $g.m^{-2}$) belonged to control treatment (Table 4). Brankov *et al*. (2020) in research stated that the application of nitrogen fertilizer in the form of a complex with amino acids had a positive effect on grain yield, leaf area index and plant fresh weight. Compare different level of Nitrogen showed that the maximum and the minimum amount of seed yield belonged to 100% (450.33 $g.m^{-2}$) and 40% (330.62 $g.m^{-2}$) treatments (Table 4). Ebrahimi *et al*. (2022) stated that the use of growth stimulants such as amino acids improved crop production and also reduced the use of chemical fertilizers required by plants by 25%, without reducing seed yield. Assess mean comparison result of interaction effect of treatments indicated maximum 1000 seed weight (460.72 $g.m^{-2}$) was noted for 4.5 $lit.ha^{-1}$ Amino acid and 100% Nitrogen (Although it doesn't had significant differences with 70% amino acid) and lowest one (326.13 $g.m^{-2}$) belonged to nonuse of Amino acid and 40% Nitrogen treatment (Table 5). The increase in seed yield was mainly due to the higher number of seeds per spike, the 1000 seed weight in high amounts of nitrogen and higher photosynthetic level. Hatfield and Prueger research (2004) also confirm it.

4.5. *Biologic yield*

According result of analysis of variance effect of Amino acid, Nitrogen and interaction effect of treatments was significant on biologic yield was significant at 1% probability level (Table 3). Mean comparison result of different level of Amino acid indicated the maximum and the minimum amount of biologic yield belonged to 4.5 $lit.ha^{-1}$ (1363.43 $g.m^{-2}$) and control treatment (1120.39 $g.m^{-2}$) (Table 4). It seems that

the biological yield increased with the increase of nitrogen consumption. The presence of high amounts of nitrogen, due to the intensification of vegetative growth, causes the nutrients absorbed by the plant to reach the vegetative points instead of being used in the storage and strengthening of the seeds (Soleymanzadeh *et al*., 2010). Researchers attributed this positive effect to the role of free amino acids as an important source in plant protein synthesis (Raeisi *et al*., 2014). In a study, researchers stated that spraying amino acids and making this resource available to the plant causes better plant growth, increases the leaf area, and consequently increases photosynthesis. All of these factors affect the biological yield of the wheat crop and increase it (Taheri Asghari, 2021). Among different level of Nitrogen the maximum biologic yield (1371.06 $g.m^{-2}$) was obtained for 8 $kg.ha^{-1}$ and minimum of that (1128.1 $g.m^{-2}$) was for control treatment (Table 4). The results showed a positive and significant effect of amino acids on biological yield. Assess mean comparison result of interaction effect of treatments indicated maximum 1000 seed weight (1377.44 $g.m^{-2}$) was noted for 4.5 $lit.ha^{-1}$ Amino acid and 100% Nitrogen (Although it doesn't had significant differences with 70% amino acid) and lowest one (1139.16 $g.m^{-2}$) belonged to nonuse of Amino acid and 40% Nitrogen treatment (Table 5).

4.6. *Harvest index*

Harvest index is also an important factor in increasing yield, in grains, the increase in biomass has reached its final limit, hence the increase in seed yield through the allocation of more photosynthetic materials to the sink (seeds) is possible, in which case the harvest index will significantly increase (Krishnan *et al*., 2003). Result of analysis of variance revealed effect of Amino acid, Nitrogen and interaction effect of treatments was significant on harvest index was significant at 1% probability level (Table 3). Yield is a complex character, which depends upon many independent contributing characters. Knowledge on type of association between yield and its components themselves greatly help in evaluating the contribution of different components towards yield, information on the nature of association between yield and its components help in simultaneous selection for many characters associated with yield improvements (Kumar *et al*., 2012). Mean comparison result of different level of Amino acid indicated the maximum harvest index (32.87%) was obtained for 4.5 $lit.ha^{-1}$ and minimum of that (29.40%) was for control treatment (Table 4). Compare different level of Nitrogen showed that the maximum and the minimum amount of harvest index belonged to 100% (32.84%) and 40% (29.30%) treatments (Table 4).

5. CONCLUSION

The use of foliar application of amino acids along with nitrogen chemical fertilizer can reduce the consumption of nitrogen chemical fertilizer in addition to producing sufficient crops, which significantly contributes to the health of the environment and is an important strategy in the direction of Moving to-

wards sustainable agriculture. Therefore, by using 70% of urea fertilizer along with 4.5 liters per hectare of amino acid, it is possible to save the consumption of chemical fertilizers and produce economic yield in studied region.

ACKNOWLEDGMENT

The authors thank all colleagues and other participants, who took part in the study.

FOOTNOTES

AUTHORS' CONTRIBUTION: All authors are equally involved.

CONFLICT OF INTEREST: Authors declared no conflict of interest.

FUNDING/SUPPORT: This study was done by scientific support of Department of Agronomy, Islamic Azad University, Ahvaz Branch.

REFRENCES

Bavar, M., H. Heidari Sharif Abad. and Gh. Noormohamadi. 2016. The Effects of different levels of nitrogen on yield and yield components of rainfed wheat in two regions of North Khorasan. Open J. Ecol. 6:443-451.

Brankov, M., M. Simi, Z. Dolijanovi, M. Rajkovi, V. Mandi. and V. Dragicevi. 2020. The response of maize lines to foliar fertilizing. Agriculture. 10(9): 365-376.

Boulelouah, N., M. R. Berbache, H. Bedjaoui, N. Selama. and N. Y. Rebouh. 2022. Influence of nitrogen fertilizer Rate on yield, grain quality and nitrogen use efficiency of durum wheat (*Triticum durum* Desf) under Algerian semiarid conditions. Agriculture. 12: 1937. https://doi.org/10.3390/ agriculture12111937.

Cathcart, R. J. and C. J. Swanton. 2003. Nitrogen management will influence threshold values of green foxtail (*Setaria viridis*) in corn. Weed Sci. 51: 975-986.

Ebrahimi, H., M. Nabi Ilkaee, M. M. Tehrani, F. Paknejad. and M. Basirt. 2022. Effect of some of growth stimulants and different levels of chemical fertilizer on yield and yield components of maize. Iranian J. Field Crop Sci. 53(1): 189-200.

El-Naggar, A., D. El-Araby. and H. Hogh-Jensen. 2009. Simultaneous uptake of multiple amino acids by Wheat. J. Plant Nutrition. 32: 725-740.

Eskandari Torbaghan., M, S. F. Fazeli Kakhki. 2021. An investigation of the effect of fertilizer enhancers on some yield components of wheat yield in the last irrigation cut in the field conditions. Plant Process and Function. 10(45): 89-106. (Abstract in English)

Fowler, B. D. and J. Brydon. 2001. No-till winter wheat production on the Canadian prairies. Agron. J. 81: 817-825.

Gardner, F. P., R. B. Pearce. and R. L. Mitchell. 1985. Physiology of crop plants. Ames, IA: Iowa State Univ. Press. USA. 121 pp.

Hanan, S. S., G. A. Mona. and H. I. El-Alia. 2008. Yield and yield components of maize as affected by different sources and application rates of nitrogen fertilizer. Res. J. Agri. Biol. Sci. 4: 399-412.

Hatfield, J. L. and J. H. Prueger. 2004. Nitrogen over-use, under-use, and

efficiency. Proceed.4th Intl. Crop Sci. Cong. Brisbane, Australia.

Hossain, M. and V. P. Singh. 2000. Fertilizer use in Asian agriculture: implications for sustaining food security and the environment. Nutr. Cycl. Agro-Eco-Sys. J. 57: 155-169.

Krishnan, P., S. Nagarajan, M. Dadlani. and A. V. Moharir. 2003. Characterization of wheat (*Triticum aestivum* L.) and soybean (*Glycine max* L.) seeds under accelerated aging conditions by proton nuclear magnetic spectroscopy. Seed Sci. Technol. 31: 541-550.

Kumar, N. V., C. V. C. M. Reddy. and P. V. R. M. Reddy. 2012. Study on Character Association in Rabi Sorghum (*Sorghum bicolor* L. Moench). Plant Arch. 12(2):1049-1051.

Ladha, K. J., H. Pathak, T. J. Krupnik, J. Six. and C. Van Kessel. 2005. Efficiency of fertilizer nitrogen in cereal production: Retrospect and prospects. J. Adv. Agron. 87: 85-156.

Litke, K., Z. Gaile. and A. Ruza. 2018. Effect of nitrogen fertilization on winter wheat yield and yield quality. Agron. Res. 16(2): 500-509.

Mosanaei, H., H. Ajamnorozi, M. R. Dadashi, A. Faraji. and M. Pessarakli. 2017. Improvement effect of nitrogen fertilizer and plant density on wheat (*Triticum aestivum* L.) seed deterioration and yield. Emir. J. Food Agric. 29(11): 899-910. *In*: Nourmohammadi, Gh., A. Siadat. and A. Kashani. 2010. Cereal Crops. Ninth Printing. Chamran University Press. Ahvaz. Iran. p. 48.

Naseri, R., A. Mirzaei, R. Soleimani. and E. Nazarbeygi. 2010. Response of bread wheat to nitrogen application in calcareous soils of western Iran. American-Eurasian J. Agric. Environ. Sci. 9(1): 79-85.

Raeisi, M., L. Farahani. and M. Palashi. 2014. Changes of qualitative and quantitative properties of radish (*Raphanus sativus* L.) under foliar spraying through amino acid. Intl. J. Biosci. 4(1): 463-468.

Rafie, M. R., M. Sohi. and M. Javadzadeh. 2021. Evaluation the effect of amino acid, fulvic acid and seaweed extract application in normal and drought stress conditions on quantitative and qualitative characteristics of wheat in Behbahan region. Environmental of Stresses in Crop Sci. 14(1): 131-141. (Abstract in English)

Salwa, A. R. H. and A. M. A. Osama. 2014. Physiological and biochemical studies on drought tolerance of wheat plants by application of amino acids and yeast extract. Annals Agri. Sci. 59: 133–145.

Shah, Z., S. H. Shah, M. B. Peoples, G. D. Schwenke. and D. F. Herriedge. 2003. Crop residue and fertilizer N effects on nitrogen fixation and yields of legume nitrogen cereal rotations and soil organic fertility. Field Crops Res. 83: 1-11.

Shanggan, Z. P., A. Shao. and J. Dychmans. 2000. Nitrogen nutrition and water stress effects on leaf photosynthetic gas exchange and water use efficiency in winter wheat. Environ. Exp. Bot. 44: 141-149.

Sohail, M., I. Hussain, S. Khan Tanveer, S. H. Abbas, M. Qamar, M. Sh. Ahmed. and S. Waqar. 2018. Effect of nitrogen fertilizer application methods

on Wheat yield and quality. Sci. Tech. Develop. 37 (2): 89-92.

Soleymani, R. 2009. Effect of rate and time of nitrogen application on grain yield and its components in spring safflower (*Carthamus tinctorius* L.). J. Crop Sci. 10: 47-59.

Soleymanzadeh, H., F. Rahmati. and S. Seyfzadeh. 2010. Effect of different nitrogen levels on grain yield, oil and yield components of safflower varieties in Saveh region. J. Dynamic Agri. 6: 303-313.

Szulc, P. 2013. Effects of soil supplementation with urea and magnesium on nitrogen uptake, and utilization by two different forms of maize (*Zea mays* L.) differing in senescence rates. Polish J. Environ. Stud. 22: 239-248.

Taheri Asghari, T. 2021. The Effect of Foliar Application of Amino Acids and Symbiosis with Mycorrhiza Species on the Characteristics of Pot Marigold (*Calendula officinalis* L.). J. Crop Improvement. 24(2): 615-629. (Abstract in English)

Yaghoubian, I., S. Ghassemi. and Y. Yaghoubian. 2017. Effect of sowing date and urea fertilizer on some morphological traits, yield and yield components of wheat in Hashtroud, Iran climate condition. Agro-Ecol. J. 13(2): 53-64. (Abstract in English)

Yang, Y., Q. Qin, Q. Li, V. Nangia, B. Lan, F. Mo, Y. Liao. and Y. Liu. 2023. Effect of nitrogen management on Wheat yield, water and nitrogen utilization, and economic benefits under ridge-furrow cropping system with supplementary irrigation. Agronomy. J. 13: 1708.