American-Eurasian Journal of Agronomy 13 (3): 70-77, 2020
ISSN 1995-896X

DOI: 10.5829/idosi.aeja.2020.70.77

Impact of Different Rates and Split Application of NPK Fertilizer on Quinoa (*Chenopoduim quinoa Willd*.) In Sandy Soil

[1]*Jacline F. Ibrahim*, [2]*S.A. Seif*, [2]*H.R.A. El-Deepah and* [2]*A.M. Saad*

[1]Crop Intensification Res. Sec., Field Crops Res. Inst., A.R.C, Giza, Egypt
[2]Department of Agronomy, Faculty of Agriculture, Benha University, Egypt

Abstract: A Two –year study was carried out at Ismailia Experimental Research Station, Agricultural Research Center (ARC), Ismailia Governorate, Egypt, during 2016/2017 and 2017/2018 seasons. This is to investigate the impact of different rates of NPK fertilizer and splitting on quinoa (*Chenopoduim quinoa Willd*.) yield and its components. Twelve treatments were the combination of three rates of NPK fertilizer (100:75:100), (150:100:150) and (200:150:200) kg/fed. They were applied in four splitting doses as follows: two equal doses (at 25 and 50 days after sowing [DAS]), three equal doses at 25, 40 and 52 DAS, four equal doses at 25, 40, 52 and 64 DAS, five equal doses at 25, 40, 52, 64 and 76 DAS. in sandy soil, under sprinkler irrigation system. A split plot design, with three replications, was used. Results indicated that the growth of quinoa plants progressively increased with increasing NPK fertilizer. In addition, the superiority of the number of branches per plant, grain yield per plant, grain yield/fed, straw yield and biological yield were achieved when NPK was applied at (150:113:150) rate and splitting in four doses. The maximum plant height was observed at the highest NPK rate in the combination (200:150:200) kg/fed and splitting in four doses. Grain content of N, P, K and protein were higher in the NPK fertilizer rate (150:113:150), recording (1.66, 0.98, 2.16 and 10.39 %), respectively regardless of the number of doses applied .Meanwhile, splitting the rate to four doses application recorded (1.75, 1.14, 2.24 and 10.96), respectively. It can be recommended that applying NPK fertilizer at the rate of (150:113:150) in four equal doses after 25, 40, 52 and 64 DAS, gave the best result of quality and quantity of quinoa (Chenopoduim quinoa Willd.) plants in sandy soil.

Key words: NPK Fertilizer rates % Split application % Quinoa Crop Chemical composition

INTRODUCTION

Cereals play an important role in human nutrition, contributing to the energy and protein intake. Wheat, barley, corn, sorghum and rice are the most important cereals worldwide. Other grains such as quinoa , amaranth and buckwheat are also an excellent source of energy and protein. They are also known for their high nutritional value of minerals [1].

Quinoa (*Chenopoduim quinoa Willd*), member of *Chenopodiaceae* family, is a seed crop that has been cultivated for thousands of years in the Andean region for its nutritious grains and leaves [2]. It belongs to the group of crops known as pseudo cereal [3, 4] which includes other domesticated chenopods, such as amaranths and buckwheat. It is gluten-free and contains high quality protein. That is why it can play an important role in the diet of people suffering from celiac [5, 6]. The importance of these proteins is based on their quality, with a balanced composition of essential amino acids similar to the composition of casein (the protein of milk). The Organization of the United Nations for Food and Agriculture [7] has declared the year 2013 as the year of quinoa [8]. Quinoa has been selected by the FAO as one of the crops destined to offer food security in the next century. It can be successfully grown in marginal soils showing its very low nutrient requirements [9].

Fertilizers of N, P and K are very important for the growth of quinoa and for the improvement of its production. According to [10], while quinoa's requirement for nitrogen (N) and calcium (Ca) is high, its need for phosphorous (P) and potassium (K) is moderate and minimal. Moreover, [11] observed that quinoa's response to N is highly notable. Etchevers and Avila, [12] noted

Corresponding Author: A.M. Saad, Department of Agronomy, Faculty of Agriculture, Benha University, Egypt.

that high levels of phosphorus and potash did not increase the seed yield of quinoa while increasing its vegetative growth. Gandaillas [13] on the other hand, observed that quinoa shows no response to both potassium and phosphorus.

Despite the fact that quinoa shows strong response to N fertilizer, Oelke *et al*. [14] reported that if the levels of the available nitrogen are high, the yield of quinoa would decrease. This is because of slow maturity and intense lodging as he noted. The same conclusion concerning the side effects of N fertilizer – applied, however, to wheat was reached by [15]. They noticed that despite the importance of nitrogen for increasing wheat yield, it is not really that satisfactory efficient as the nitrogen applied is subjected to different forms of losses (runoff, ammonia, volatilization, leaching and denitrification). They even added that high levels of N fertilizer causes pollution for the environment. In order, however, to reduce such loss in the applied nitrogen and increase its efficiency, many researchers such as, [16-18] noted the importance of splitting and timing of N applications. They explained that the time elapsed between the application of N and crop uptake defines the length of exposure of fertilizer N to loss process.

However, [19, 11] observed that the yield of quinoa does not decrease with the increase of N fertilizer rate. Along similar lines, [20] reported that the application of Nitrogen increases both the seed yield and the seed content of protein.

Jacobsen *et al*. [21] reported that the response of quinoa to the application of nitrogen fertilizer was noted in both the increase of the crop growth and its yield, as well as in the quality of the grain. The yield increased with the increasing nitrogen fertilization rate from 40 to 160 kg N ha^{-1}. He found an increase in yield (with an average of 12%) at 80 to 120 kg N ha^{-1}. Thanapornpoong [22] investigated the impact of different rates of nitrogen fertilization on various aspects of quinoa (as plant height, grain yield per plant, harvest index) and noted a positive effect of high levels of nitrogen on these aspects. Schultc *et al*. [11] observed that with the application of N fertilizer, quinoa achieved yield up to 350 kg ha^{-1} at 120 kg N ha^{-1} and grain yield boosted by 94%.

Razzaghi *et al*. [23] noticed that when N fertilizer is applied at 120 kg N ha^{-1}, nitrogen uptake by quinoa is 134 kg N ha^{-1} in sandy clay loam and 77 kg N ha^{-1} in sandy soil. This affected quinoa seeds yield of 3300 kg ha^{-1} and 2300 kg ha^{-1} respectively. Shams [24] investigated the response of quinoa to five nitrogen fertilization levels (0, 90, 180, 270 and 360 kg ha^{-1}). He concluded that grain and biological yield progressively increased with increasing nitrogen levels up to the highest level. However, Basr *et al*. [25] found out that that the soil application of N at 75 kg N ha^{-1} achieved maximum economic harvest of quinoa.

There are many other researches on the impact of Nitrogen fertilization on the nutritional content of the seeds of quinoa. It is well-known that quinoa grain has higher contents of P and K mineral rather than wheat, barley or corn [26]. In effect, quinoa is a good source of protein and can be used as a nutritional ingredient in food products [27].

According to [28], N fertilization improved the process of photosynthesis in the leaves and played a great role in protein synthesis, cell structure and carbohydrate production. An increase in the crude protein content with the application of N fertilizer was observed by both [29, 30]. They noted that the application of 150 kg N ha^{-1} to quinoa raised the quality of crude protein content 16% and achieved maximum seeds yield (2.95 ton ha^{-1}).

Hamid and Sarwar [31] observed that nitrogen application greatly increased protein content in grain wheat. They added that splitting nitrogen into six doses further increased the protein content over single or two split application. Salmina and Makarova [32] also reported that the application of 60 Kg N + 60 Kg P2O5 gave highest crude protein in grain [29]. noticed that the application of nitrogen and phosphorus increased crude protein and nutrients content in quinoa seeds.

The same positive relationship between nitrogen levels and nutritional content was observed in oat. Tripathi [33] also observed that the application of 90 Kg N+ 30 Kg P2O5 ha^{-1}gave highest CP. Patel and Rajgopal [34] noted that the crude protein of oat yield was up to 75 Kg N and 60 Kg P_2O_5 ha^{-1}. According to [35] oat yield attributes, yield and quality parameters increased with nitrogen application but significant effect was found up to 120 kg N/ha. He added that inorganic sources (N: P_2O_5 @ 150:60) responded well for maximum crude protein of oat (10.76%). Finally, Jehangir *et al.* [36] observed that the fertility level of 150:70:40 (N: P_2O_5:K_2O kg ha^{-1}) significantly increased crude protein of oat content over 125:60:30 and 100:50:20 (N: P_2O_5:K_2O kg ha^{-1}).

It is true that many researchers have tackled the influence of nitrogen on quinoa, yet, the crop's requirement of N fertilizer is still studied. This may be due to the diversity of environmental conditions in which quinoa is grown. Therefore, this investigation was performed to study the effect of NPK fertilizer rates, timing and splitting on the growth yield, yield components and some chemical composition of quinoa (*Chenopoduim quinoa Willd*.) plants under Ismailia Governorate environmental conditions.

MATERIALS AND METHODS

A field experiment was conducted in Ismailia Governorate for two successive seasons (2016/2017 and 2017/2018) at Agriculture Research Station in sandy soil.

The experiment was arranged in split plot design using three replicates. Each main plots included three fertilizer rates A_1(100: 75: 100), A_2(150:113:150) and A_3 (200:150:200) kg/fed. The sub plots were four splitting doses of each NPK rate (1st splitting was divided to two equal doses 50 and 50% at 25 and 55 days after sowing (DAS) B_1, 2nd splitting was divided to three equal doses at 25, 40 and 52 DAS) B_2, 3rd was divided to four equal doses at 25, 40, 52 and 64 days after sowing (DAS) B_3 and 4th splitting was divided to five equal doses at 25, 40, 52, 64 and 76 days after sowing (DAS) B_4. Nitrogen fertilizer was applied in the form of ammonium nitrate (33.5%), phosphorous fertilizer was applied in the form of Calcium super phosphate (15.5% P_2O_5) and Potassium fertilizer was applied in the form of Potassium sulphate (48% K_2O). Quinoa seeds variety Q26 was sown on 21st and 27th of November in first and second seasons, respectively. Experiment unit plot area was 12 m^2square meter of 4 length and 3 width. the preceding crop was peanut in both seasons. Quinoa seeds were sown at a distance of 25 cm between plants spacing in rows of 60 cm apart at 3 cm depth and covered with sands. Then immediately irrigated using sprinkler irrigation system using 5- days irrigation intervals during the first 45 DAP (days after planting). Then extend to 10-15 days interval till the end of seasons and before harvest. Quinoa plants were harvested on the 10th and 20th of April in the first and second seasons respectively.

Data Recorded

Grain Yield and its Components: Samples of ten plants were taken from each two inner rows of each sub plots and taken immediately to the laboratory to determine:

- Plants height (cm).
- Number of branches/plant.
- Grain Yield /plant (g).
- Grain yield (kg/fed).
- Straw yield (kg/fed).
- Biological yield (kg/fed.).

Chemical Analysis of Quinoa Grains

Determination of Nitrogen Contents: Total protein content was calculated from the nitrogen content using a conversion factor of 6.25 was used [37].

Determination of Phosphorus Contents: Phosphorus was determined using spectro photometer in an acid digest according to the method described by [38].

Determination of Potassium Contents: Potassium was flame metrically determined in the acid digest, where the method of [39] was followed.

Statistical Analysis: The estimated variables were statistically analyzed using ANOVA MSTATC Statistical Packing [40]. Using the Least Significant Differences (LSD) at 5% level [41].

Table 1: Mechanical and chemical analysis of the experimental soil

Clay %	Slit%	Sand%	Soil texture
8.64	0	91.36	Sandy

				Macro nutrient		
PH	EC (dS/m)	OM%	CaC3 (%)	N (mg/Kg)	P (mg/Kg)	K (mg/Kg)
8.45	0.20	0.15	0.64	10	18	84

Soluble Cations (meq/L)				Soluble Anions (meq/L)			
K+	Na+	Mg++	Ca++	So4-	Cl-	HCO3-	CO3-
0.09	0.7	0.9	0.9	1.37	0.78	0.45	-

RESULTS AND DISCUSSION

Plant Height (cm): Data in Table (2) indicated that plant height increased by increasing (NPK) rates. At harvest time, it showed significant variation for different fertilizer doses. The result showed that the highest plant height (98.1- 99.68 cm) was obtained from (200 -150 - 200 NPK kg/ fed), in the 1th and 2 nd seasons respectively while the lowest plant height (91.93 - 95.85 cm) was recorded by the treatment (100 -75 -100 NPK kg fed^{-1}) in the 1st and 2nd seasons respectively) The plant height increased linearly with each successive increase in NPK, which was attributed to the Nitrogen mainly. These results are in agreement with [42-44]. The highest plant height (98.17-103.37cm) was obtained in four split doses in the 1st and 2nd seasons respectively, while the lowest value was obtained in two split application doses (89.57 – 92.36 cm) in the 1st and 2nd seasons respectively.

The interaction between NPK rates and split application had a significant influence on plant height in both seasons. The highest plant height (105.46 -102.16) was obtained from (200 -150 -200) NPK kg/ fed with split doses in the 1st and 2nd seasons, respectively. The lowest plant height (85.33 -90.70) was obtained from (100 -75 -100) NPK kg/fed^{-1} with two doses in the 1st and 2nd seasons.

Number of Branches per Plant: Number of branches plant^{-1} at harvest are presented in Table 2. The data showed significant differences among different fertilizer doses and the highest branch number (13.67-18.59) was obtained from (150 -113 -150(NPK kg fed^{-1}. The lowest branch number (12.88 -17.93) was obtained from (200 -150 -200 NPK kg fed^{-1}) in the 1st and 2 nd seasons. Splitting NPK fertilizer to four-split doses was not significant in the 1st and 2nd seasons.

The interaction between NPK rates and split application was significant. The highest branch number (14.94-19.36) was obtained from (150 -113 -150) NPK kg/ fed with split four doses in the 1st and 2nd seasons, respectively. The lowest branch number (11.90 -17.33) was obtained from (200 -150 -200) NPK kg/fed^{-1} with split five doses in the 1st and 2nd seasons.

Grain Yield per Plant: Results in Table (2) show that the effect of NPK fertilizer rates on grain per plant was significant in both seasons. NPK rate (150-113-150) gave the highest grain yield per plant (30.0 – 38.79) in the 1st and 2nd seasons respectively. The effect of NPK four doses split application recorded (30.23 - 40.86 g) in the 1st and 2nd seasons respectively and it was highly significant than other treatments. The interaction between NPK rates and split application had a significant influence in both seasons. The highest value of grain per plant (32.60 - 44.53) was obtained in NPK rates (150-113-150) with splitting NPK fertilizer to 4 doses in the 1st and 2nd seasons respectively, compared with other treatments.

Grain Yield/Fed: Grain yield was significantly influenced by the treatment in both seasons as shown in Table (3). The greater significant grain yield (1065.38-1426.21 kg/fed) was recorded in treatment (150-113-150 kg/NPK) in the 1st and 2nd seasons respectively. Higher grain yield (1085.65-1530.58 kg/fed) was obtained in four split doses in the 1st and 2nd seasons respectively, compared with other treatments. The lowest value was obtained in two split application doses (929.16-1141.76). All interactions showed significant effect in both seasons for (150-113-150 kg/NPK) giving the highest grain yield (1180.84- 1628.90 kgfed^{-1}) in four split doses compared with other treatments. These results are supported by those obtained by [45, 18, 21].

Straw Yield: Results presented in Table (3) show that the effect of NPK fertilizer rates on straw yield was significant. NPK rate (150-113-150) gave the highest straw yield (178.53– 246.93) in the 1st and 2 nd seasons respectively. The effect of NPK four doses split application recorded (177.7- 272.0) in the 1st and 2nd seasons respectively. The interaction between NPK rates and split application had a significant influence in this respect in both seasons. Similar results were obtained by [46, 47, 18].

Biological Yield: Data in Table (3) show that the maximum biological yield (1243.91-1673.13) was recorded by treatment NPK rate (150-113-150), while the treatment (100-75-100) gave the minimum biological yield (1137.34-1386.47) in the 1st and 2nd seasons respectively. Higher grain yield (1263.39 -1762.1kg/fed) was obtained in four split doses in the 1st and 2nd seasons respectively, compared with other treatments. The interaction between NPK rates and split application had a significant influence in this respect in both seasons.

Nitrogen, Phosphorus, Potassium and Protein Contents of Quinoa Grain: Data presented in Table (4) indicated that N concentration in the quinoa grain increased with increasing nitrogen fertilizer. The percentage of N, P and K significantly increased with increasing NPK fertilizer at (150: 113 :150) NPK kg /fed. The percentage was 1.66, 0.98 and 2.16 % respectively. It decreased, however, at (200: 150: 200) NPK kg /fed. The percentage was (1.55, 0.85 and 1.94%) respectively. Such reduction in grain quality

Table 2 Effect of different rates of NPK fertilizer and splitting doses on vegetative growth of quinoa plant during 2016/2017 and 2017/2018 seasons

Rates of NPK (A)	Fertilizer splitting (B)	Plant height (cm) 1st	Plant height (cm) 2nd	Number of branches/plant 1st	Number of branches/plant 2nd	Yield of grains/ plant (g) 1st	Yield of grains/ plant (g) 2nd
N P K							
A1 (100: 75: 100)	2	85.33	90.70	12.85	18.23	26.63	24.66
	3	93.26	96.70	14.38	18.46	28.56	37.93
	4	93.60	98.96	14.57	19.10	28.61	40.30
	5	95.53	97.03	12.75	18.50	26.93	26.66
Mean		91.93	95.85	13.64	18.57	27.7	32.39
A2 (150: 113: 150)	2	90.96	92.76	12.66	18.26	27.16	31.76
	3	93.16	93.76	13.42	18.23	31.35	43.73
	4	95.46	109.0	14.94	19.36	32.60	44.53
	5	92.86	99.13	13.56	18.50	28.96	35.16
Mean		93.11	98.66	13.67	18.59	30.0	38.79
A3 (200: 150: 200)	2	92.43	93.63	12.80	17.83	26.14	31.92
	3	94.50	99.60	13.09	18.63	28.66	36.76
	4	105.46	102.16	13.75	17.93	29.48	37.76
	5	99.93	101.23	11.90	17.33	27.73	33.30
Mean		98.10	99.68	12.88	17.93	28.00	34.94
Average of Fertilizer splitting (B)	(B1) 2	89.57	92.36	12.77	18.11	26.64	29.46
	(B2) 3	93.64	96.68	13.63	18.44	29.52	39.47
	(B3) 4	98.17	103.37	14.42	18.79	30.23	40.86
	(B4) 5	96.10	99.13	12.73	18.11	27.87	31.70
L.S.D. at 0.05	A	1.59	1.95	0.50	0.44	1.71	1.13
	B	1.76	1.86	N.S	N.S	0.98	1.91
	AB	3.1	3.22	2.0	1.81	1.71	3.24

Table 3: Effect of different rates of NPK fertilizer and splitting doses on quinoa yield, Straw yield and Biological yield during 2016/2017 and 2017/2018 seasons

Rates of NPK (A)	Fertilizer splitting (B)	Grain yield Kg/fed 1s	Grain yield Kg/fed 2nd	Straw yield Kg/fed 1s	Straw yield Kg/fed 2nd	Biological yield Kg/fed 1s	Biological yield Kg/fed 2nd
N P K							
A1 (100: 75: 100)	2	922.83	1059.10	155.66	165.8	1078.49	1224.9
	3	1019.82	1140.16	164.33	191.1	1184.15	1331.26
	4	1020.49	1387.0	167.06	272.7	1187.55	1659.7
	5	941.02	1064.23	158.16	265.8	1099.18	1330.03
Mean		976.04	1162.62	161.30	223.85	1137.34	1386.47
A2 (150: 113: 150)	2	944.23	1183.56	160.0	216.0	1104.23	1399.56
	3	1109.93	1575.83	187.33	267.9	1297.26	1843.73
	4	1180.84	1628.90	191.23	274.0	1372.07	1902.9
	5	1026.53	1316.53	175.56	229.8	1202.09	1546.33
Mean		1065.38	1426.21	178.53	246.93	1243.91	1673.13
A3 (200: 150: 200)	2	920.44	1182.63	153.03	205	1073.47	1387.63
	3	1028.36	1341.86	166.1	267.2	1194.46	1609.03
	4	1055.63	1498.66	174.94	269.3	1230.57	1767.96
	5	974.91	1195.86	163.5	185.2	1138.41	1381.06
Mean		994.83	1304.75	164.39	231.67	1159.22	1536.42
Average of Fertilizer splitting (B)	(B1) 2	929.16	1141.76	156.23	195.6	1085.39	1337.36
	(B2) 3	1052.70	1192.21	172.58	242.1	1225.29	1594.67
	(B3) 4	1085.65	1530.58	177.7	272.0	1263.39	1762.12
	(B4) 5	980.82	1326.89	165.74	226.9	1146.56	1433.87
L.S.D. at 0.05	A	68.28	57.47	9.89	10.9	77.77	87.40
	B	45.48	43.61	5.79	31.37	50.37	121.0
	AB	78.78	87.22	10.04	54.35	87.24	209.59

Table 4: Effect of NPK fertilizer different rates and splitting doses on chemical composition of quinoa grains (g/100g dry matter) average two seasons.

Rates of NPK (A)	Fertilizer splitting (B)	N%	Protein %	P%	K%
A1 (100: 75: 100)	2	1.69	10.56	1.23	1.77
	3	1.71	10.71	0.87	1.74
	4	1.73	10.79	0.90	2.24
	5	1.47	9.19	0.75	1.06
Mean		1.65	10.31	0.94	1.70
A2 (150: 113: 150)	2	1.70	10.63	0.79	2.06
	3	1.22	7.62	0.84	1.99
	4	1.88	11.76	0.87	2.5
	5	1.83	11.54	1.42	2.09
Mean		1.66	10.39	0.98	2.16
A3 (200: 150: 200)	2	1.39	8.88	1.05	2.08
	3	1.79	11.20	0.11	2.06
	4	1.65	10.33	1.66	1.99
	5	1.39	8.69	0.57	1.65
Mean		1.55	9.77	0.85	1.94
Average of Fertilizer splitting (B)	(B1) 2	1.59	10.02	1.02	1.97
	(B2) 3	1.57	9.84	0.61	1.93
	(B3) 4	1.75	10.96	1.14	2.24
	(B4) 5	1.56	9.80	0.91	1.60
L.S.D. at 0.05	A	0.006	0.08	1.49	0.34
	B	0.019	0.23	0.22	0.38
	AB	0.033	0.40	1.25	0.66

could be attributed to the fact that there is a negative relationship between the rate of nitrogen in the soil and its utilization by the grain. The higher the rate of nitrogen in the soil is, the lower its utilization is. This is in agreement with [48, 49]. In addition, the highest percentage of N, P and K was obtained at split 4 doses. It was as follows: N (1.75%), P (1.14%) and K (2.24%). These results were in agreement with [50]. Moreover, increasing the rate of nitrogen fertilizer added another advantage to its nutritive value as it enhances the concentration of P and K in the grain tissues of quinoa.

As for the content of crude protein in grain, the highest level was (10.39%). It was obtained at (150: 113: 150) NPK kg/fed. There was no significant difference between this treatment and the (100: 75: 100) NPK kg/fed treatment. The level obtained at this treatment was (10.31%). However, there was a significant difference between the (150: 113: 150) NPK kg/fed treatment and that of (200 : 150: 200) kg/fed.

In general, the grain content of N, P, K and protein was higher in four doses split application. It recorded (1.75, 1.14, 2.24 and 10.96%) respectively. The interaction between NPK rates and split application had a significant influence on macronutrients concentration in seeds in both seasons. These results were in agreement with several investigators [29-35] and [51-55].

CONCLUSION

Based on our two –year study to investigation the impact of different rates of NPK fertilizer and splitting on quinoa (Chenopoduim quinoa Willd.) yield, its components and chemical composition, it can be concluded that applying NPK fertilizer at the rate of (150:113:150) in four equal doses after 25, 40, 52 and 64 DAS, gave the best result of quality and quantity of quinoa plants in sandy soil.

REFERENCES

1. Filho, A.M., 2017. Quinoa: Nutritional Aspects. J. Nutraceuticals Food Sci., 2: 1-3.
2. Pearsall, D.M., 1992. The origins of plant cultivation in South America. In: C.W.Cowan, P.J.Watson (Eds.), The Origins of Agriculture. Smithsonian Institute Press, Washington, DC, pp: 173-205.
3. Susack, D.F., 1984. Quinoa: grain of the Incas. Ecologist, 14: 21-31.
4. Koziol, M., 1993. Quinoa: A Potential New Oil Crop. New Crops. Wiley, New York.
5. Kuhn, M., S. Wagner, W. Aufhammer, J.H. Lee, E. Kübler and H. Schreiber, 1996. Effect of cultivation on the mineral content of amaranth, buckwheat, quinoa and oats. Dtsch Lebensm Rundsh, 92: 147-152.
6. Doweidar, Mona M. and A.S. Kamel, 2011. Using of quinoa for production of some bakery products (gluten-free). Egyptian J. Nutrition, 26(2): 21-52.
7. FAO, 2011. Quinoa: An ancient crop to contribute to world food security. Regional office for Latin America and the Caribbean.

8. Anonymus, 2013. Cereal's of mother: Quinoa, Journal of Tubitak Sci. & Tech., June 2013, 547: 34-35.
9. Jacobsen, S.E., 2003. The Worldwide Potential for Quinoa (*Chenopodium quinoa* Willd.). Food Reviews International, 19(1): 167-177.
10. Mujica, A., A. Canahua and R. Saravia, 2001. Agronomía del cultivo de la quinua, Santiago de Chile, pp: 20-48.
11. Schultc auf'm Erley G., H.P. Kaul, M. Krus and W. Aufhammer, 2005. Yield and nitrogen utilization efficiency of the pseudo cereals amaranth, quinoa and buckwheat under differing nitrogen fertilization. Eur. J. Agron., 22: 95-100.
12. Etchevers, B.J. and T.P. Avila, 1979. Factors que afectan el crecimiento de quinua (*Chenopodium quinoa* Willd.) en el centro-sur de Chile. In: 10th Latin American meeting of Agricultural Sciences.
13. Gandaillas, H., 1982. Quinoa production. IBTA-CIID (Trans.by Sierra-Blanca Association, Denver, CO, 1985).
14. Oelke, E.A., D.H. Putnam, T.M. Teynor and E.S. Oplinger, 1992. Quinoa in Alternative Field Crops Manual, University of Wisconsis - Extension, Cooperative Extension, University Of Minnesota - Center for Alternative Plant and Animal Products, Minnesota Extension Service.
15. Prasad, R. and J.F. Power, 1997. Soil fertility management for sustainable agriculture CRC. Lewis Publication, Boca Raton, USA.
16. Borghi, B.M. Corbellini, C. Minoia, M. Palumbo, N. Di Fonzo and M. Perezin, 1997. Effect of Mediterranean climate on wheat bread-making quality of wheat (*Triticum aestivum* L.). Eur. J. Agron., 4: 145-154.
17. McKenzie, R., 2010. Wheat nutrition and fertilizer requirements: nitrogen. Adapted from the Canada Grains Council's Complete Guide to Wheat Management. Extracted on 19.10.2013 http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/crop1273/.
18. Youssef, S.M., S.E.D. Faizy, S.A. Mashali, H.R. EL-Ramady and Sh. Ragab, 2013. ffect of different levels of NPK on wheat crop in North Delta. Jahrestagung der Deutschen Bodenkundlichen Gesellschaft Vom 07. Bis 12.
19. Berti, M., R. Wilckens, F. Hevia, H. Serri, I. Vidal, and C. Mendez, 2000. Nitrogen Fertilization in quinoa (*Chenopodium quinoa Willd*). Cien. Investig. Agr., 27(2): 81-90.
20. Johnson, D.L. and S.M. Ward, 1993. Quinoa, pp: 219-221. In: J. Janick and J.E. Simon (eds.), New crops. Wiley, New York.
21. Jacobsen, S.E., I. Jørgensen and O. Stølen, 1994. Cultivation of quinoa (*Chenopodium quinoa*) under temperate climatic conditions in Denmark. J. Agrc. Sci., 122: 47-52.
22. Thanapornpoong, Sa-N, 2004. Effect of nitrogen fertilizer on nitrogen assimilation and seed Quality of amaranth (*Amaranthus* spp.) and quinoa (*Chenopodium quinoa willd*). Ph.D. Thesis. Faculty of Agricultural Sciences. Georg-Auguth - University of Gohingen.
23. Razzaghi, F., S.H. Ahmadi, C.R. Jensen, S.E. Jacobsen and M.N. Andersen, 2011. The salt tolerance of quinoa measured under field conditions. International Commission on Irrigation and Drainage, pp: 149-153.
24. Shams, A.S., 2012. Response of quinoa to nitrogen fertilizer rates under sandy soil conditions, Proc. 13th International Conf. Agron., Fac. of Agric., Benha Univ., Egypt, 9-10 September 2012, pp: 195-205.
25. Basra, S.M.A., S. Iqbal and I. Afzal, 2014. Evaluating the response of nitrogen application on growth, development and yield of quinoa genotypes. Int. J. Agric. Biol., 16(5): 886-892.
26. Ahmed, N.T., R.S. Singhal, P.R. Kul Karni and M. Pal, 1998. A Lesser known grain Chenopodium quinoa: Review of the chemical composition of its edible parts. Food and Nutr. Bull., 19: 61-70.
27. Gonzalez, J.A., Y. Konishi, M. Bruno, M. Valoy and F.E. Pradoc, 2012. Interrelationships among seed yield, total protein and amino acid composition of ten quinoa (*Chenopodium quinoa*) cultivars from two different agroecological regions. J. Sci. Food. Agric., 92: 1222-1229.
28. Weisany, W., Y. Raei and K.H. Allahverdipoor, 2013. Role of some of mineral nutrients in biological nitrogen fixation. Bull. Env. Pharmacol. Life Sci., 2(4): 77-84.
29. Gomaa, E.F., 2013. Effect of nitrogen, phosphorus and biofertilizers on quinoa plant, Journal of Applied Sciences Research, 9(8): 5210-5222.
30. Geren, H., 2015. Effects of different nitrogen levels on the grain yield and some yield components of quinoa (*Chenopodium quinoa* Willd.) under Mediterranean climatic conditions. Turkish Journal of Field Crops, 20(1): 59-64.
31. Hamid, A. and G. Sarwar, 1976. Effect of split application on N uptake by wheat from N15 labelled ammonium nitrate and urea. Expti. Agric., 12(2): 189-193.
32. Salmina, I.S. and V.V. Makarova, 1988. The content of nitrogen and phosphorus compounds in oats seed depending on level of mineral nutrition. Sibirskii-Vestnik-Sel' skokhozyaistvennoi-Nauki, 3: 18-20.

33. Tripathi, S.N., 1993. Forage yield and quality of oats varieties as affected by intercropping and levels of fertility. Agric. Sci. Digest Karnal., 13(2): 111-114.
34. Patel, J.R. Rajgopal, 2002. Response of oats (Avena sativa) to nitrogen and phosphorus levels. Indian J. Agron, 47(1): 134-137.
35. Uma Devi, Dheeraj Panghaal, Pawan Kumar, Meena Sewhag and Parveen Kumar, 2019. Effect of nitrogen fertilizers on yield and quality of oats: A Review. International Journal of Chemical Studies, 7(2): 1999-2005.
36. Jahangir, A.A., R.K. Mondal, Katrun Nada, R. Sadia Afroze and M.A. Hakim, 2006. Response of nitrogen and phosphorus fertilizer and plant spacing on growth and yield contributing character of sunflower. Bangladesh J. Sci. Ind. Res., 41(1-2): 33-40.
37. AOAC, 2009. Official Maethods of Analysis (15th ed). Association of Official Analytical Chemists, Washington, DC.
38. Troug, E. and A.H. Meyer, 1993. Improvement in the deiness colorimetric method for phosphorus and arsenic. Ind. Eng. Chem., Anal. Ed., 1: 136-139.
39. Brown, J.D. and O. Lilleland, 1946. Rapid determination of potassium and sodium in plant material and soil extracts by phlame photometry. Proc. Amer. Soc. Hort. Sci., 48: 341-345.
40. Freed, R.D., 1991. MSTATC Microcomputer statistical program Michigan state university. East Lansing. M ichigan, U.S.A.
41. Steel, R.G.D and J.H. Torrie, 1980. Procedures of statistics, 2nd edition, Mc Graw-Hill Book Company.
42. Maqsood, M., A.M. Abid, A. Iqbal and M.I. Hussain, 2001. Effect of variable rate of nitrogen and phosphorus on growth and yield of maize (golden). Online Journal of Biological Sciences, 1: 19-20.
43. Ayub, M., M.A. Nadeem, M.S. Sharar and M. Mahmod, 2002. Response of maize (*Zea mays* L.) to different leveks of nitrogen and potassium fertilizer. Asian Journal of Plant Sci., 4(1): 352-354.
44. Abdul Latif Malghani A., A. Asmat Ullah Malik, A. Sattarb, Fiaz Hussaina, G. Abbasc and J. Hussaind, 2010. Response of growth and yield of wheat to NPK fertilizer, Sci. Int. (Lahore), 24(2): 185-189.
45. Risi, J. and N.W. Galwey, 1984. The chenopodium grains of the andes inca crops for Modern agriculture. Adv. Appl. Biol., 10: 145-216.
46. Faizy, S.E.D.A., M.S. Shams, M.M. Rizk and A.M. Hamissa, 1986a. Effect of the rate and time of urea application on yield and yield components of wheat plant. J. Agric. Res. Tanta Univ., 12(4): 1205-1217.
47. Faizy, S.E.D.A., T.M. El-Essawi, R.A. Ali and A. El-Shamly, 1986b. Splitting nitrogen and the effect of potassium fertilizer on grain yield of wheat. J. Agric. Res. Tanta Univ., 12(4): 1241-1247.
48. EL-Behri, A., D.H. Patnam and M. Schitt, 1993. Nitrogen fertilizer and cultivar effects on yield and nitrogen use efficiency of grain amaranth. AGRON. J., 85: 120-128.
49. Saini, J.P. and J. Shekhar, 1998. Effect of nitrogen fertilizer on growth and yield of grain amaranth (*Amaranthus hypochondriacus*) cultivars under dry-temperate condition. Indian J. Agronomy, 43(4): 743-746.
50. EL-Agrodi, M.W., A.M. EL-Ghamry and H.H. Ibrahim, 2011. Effect of nitrogen fertilizer rates, timing and splitting application on wheat plant grown on reclaimed soils. J. Soils Sci. and Agric. Eng., Mansoura Univ., 2(9): 915-924.
51. Finck, A., 1982. Fertilizer and fertilization "Introduction and practical guide to crop fertilization". Weinheim; Deerfield Beach, Florida; Basel: Verlag Chemie. ISBN 3-527-25891-4 (Weinheim).
52. Bhargava, A., S. Shukla and D. Ohri, 2006. *Chenopodium quinoa*-An Indian perspective, Industrial Crops and Products, 23: 73-87.
53. Abou-Amer, A.I. and A.S. Kamel, 2011. Growth, yield and Nitrogen Utilization Efficiency of Quinoa (Chenopodium quinoa) under different Rates and Methods of nitrogen fertilization Egypt. J. Agrion, 33(2): 155-166.
54. Jehangir, I.A., H.U. Khan, M.H. Khan, F.U. Rasool, R.A. Bhat, T. Mubarak *et al*., 2013. Effect of sowing dates, fertility levels and cutting managements on growth, yield and quality of oats. African Journal of Agricultural Research, 8(7): 648-651.
55. Miranda, M., A. Vega-Gálvez, E.A. Martínez, J. López, R. Marín, M. Aranda and F. Fuentes, 2013. Influence of contrasting environments on seed composition of two quinoa genotypes: Nutritional and functional properties, Chilean Journal of Agricultural Research, 73(2): 108-116.