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Growth, Yield and Nitrogen Utilization Efficiency of Quinoa (*Chenopodium quinoa*) under Different Rates and Methods of Nitrogen Fertilization

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TWO FIELD experiments were carried out in Tigzerti Research Station of Siwa Oasis, Desert Research Center, during two successive winter seasons of 2008 and 2009 to study growth, yield, yield components and N utilization efficiency of the pseudocereal quinoa *(Chenopodium quinoa)* under different rates and methods of N fertilization. Nitrogen fertilizer treatments were applied at four N rates of mineral fertilizer at the rate of 10 kg N/fed (as the control), 60, 80 and 100 kg N/fed; three split up doses of half the rates of mineral nitrogen (30, 40 and 50 kg N/fed with 10 m^3 of organic manure for each as soil application) and foliar application of nitrogen at the concentrations 1, 2 and 3%. The results indicated that plant height, number of basal branches and grain yield/fed were gradually increased with increasing the rate of nitrogen fertilizer up to the highest whether in case of mineral application only, or in split dose of mineral with organic nitrogen or when nitrogen was applied as foliar spray. Data also revealed that while the split dose of mineral with organic treatments was associated with highest values of these traits, foliar spray with nitrogen resulted in least values. The effect of the treatment imposed on nitrogen, protein, phosphorus and potassium contents in quinoa grains followed the general tendency of the treatment effect on growth and yield. N use efficiency was decreased with increasing mineral or foliar spray. On the other hand, there were relative increases in (NUE) when half mineral N dose with organic manure was applied. Foliar application was associated with lower response as compared with other methods.

Keywords: Soil, Nitrogen, Fertilization, Quinoa crop, Seed yield.

Quinoas belong botanically to the chenopodiacea family which is found worldwide and the major of this family are weedy plants. The interest of quinoa as a valuable crop has been renewed because of its versatility. Quinoa is able to grow under conditions normally in hospitable to other grains. These conditions include low rainfall, high altitude, subfreezing or high temperatures (Ahmed *et al.*, 1998).

Several investigators reported the importance of N fertilizer to pseudo cereals (Johnson & Wards, 1993 and El-Behri *et al*., 1993). The latter examined five nitrogen rates (0, 45, 90,135 and 180 kg N/ha) on yield of amaranth. They found

that the grain yield ranged from 794 to 1980 kg ha^{-1} and yield gradually increased with increasing nitrogen rate.

They observed also that nitrogen fertilizer increased preflowering nitrogen accumulation but not post flowering and increased lodging plant stems. Jacobsen *et al*. (1994) and Risi & Galaway (1994) supported these trends. They found that the grain yield of quinoa was significantly increased by increasing nitrogen fertilization from 40 to 160 kg N ha^{-1} . Meyers (1998), evaluated the effect of N fertilization on amaranth growth, development, grain yield and yield components. Five level of nitrogen fertilizer in the from of NH_4NO_3 were broadcasted at 0, 45, 90, 135 and180 kg N ha^{-1}. Nitrogen fertilizer at the top rate of 180 kg N ha^{-1} produced a yield increase estimated to 42 percent relative to plants receiving no-nitrogen fertilizer. Yields were consistently improved by addition of 45 and 90 kg N ha^{-1} but when additional nitrogen fertilizer above the 90 kg N ha^{-1} , the increase was not appriacable. The increase in seed yield was due to increase in seed number/ plant whereas seed weight remained unaffected. He further added that N use efficiency (NUE) averaged 22.2 kg N ha^{-1} and did not decrease with increasing nitrogen rate. In recent investigations, *Schulte et al*. (2005) and Pospisil *et al*. (2006), studied N fertility requirement and N use efficiency of some pseudo cereal species; amaranth, quinoa and buckwheat. Quinoa yielded between 1790 and 3495 kg N/ha and responded strongly to N fertilization. Poon pong (2008) reported that nitrogen and protein content in quinoa grain were increased with increasing nitrogen fertilizer rates.

Yassen *et al*. (2010) showed that additional nitrogen as foliar Spray (1% urea) gave significant increases in 1000 grain weight. Nitrogen concentration in grain , straw and protein in wheat grain also increased with increasing N rate. Wilfredo *et al.* (2004) reported the favorable response of different doses of organic fertilizer. Increases have been observed in quinoa yield by the application of sheep and llama manure. Further, nitrogen and protein content of the grain increased with increasing the volumes of sheep and llama manure. They concluded that the proper application is of 5 m^3 ha^{-1} when cattle, sheep or llama manure were distributed randomly before the soil is motivted to assist decomposition.

The aim of this study is to examine different rates, methods and forms of nitrogen fertilizer on some growth characters, yield components, yield and nitrogen use efficiency of quinoa crop, newly introduced in Egypt.

Materials and Methods

A field experiments were carried out in Tigzerti Research Station, Desert Research Center, west of Siwa Oasis to study growth, yield, yield components and N utilization efficiency of the pseudocereal quinoa (*Chenopodium quinoa*) under different rates and methods of nitrogen fertilization during the two successive winter seasons of 2008 and 2009. The soil is sandy loam in texture

and low in nutritional status (Table 1). The experimental field was irrigated by flood irrigation system from the underground water. Soil samples were taken at 30 cm depth after harvesting of two seasons for the determination of soil N status according to Dahnke & Johnson (1990). Available phosphorus was also assessed according to Olsen *et al*. (1945). Available K was determined according to Onyers & Mc-Lean (1969). Available micronutrients, *i.e.,* Fe, Mn and Zn were determined according Lindsay & Norvell (1978).

TABLE 1a . Characters and nutritional status of investigated soil.

Soil properties	Soil depth		Available nutrients of soil experiment (ppm)		
	0-30 (cm)	30-60 (cm)	Macronutrients	0-30 (cm)	30-60 (cm)
pH	7.92	7.84	N	11.50	10.0
EC dS/m	4.80	3.92	P	2.94	1.90
OM %	1.02	0.89	K	63.30	65.5
$CaCO_3$ %	6.80	5.90	**Micronutrients**		
Sand %	84.42	83.20	Fe	10.50	11.40
Silt %	9.38	10.12	Mn	10.20	11.80
Clay %	6.20	6.68	Zn	0.85	1.00
Texture	SL	SL			

Treatments of nitrogen fertilizer were applied at four rates of mineral nitrogen fertilizer, *i.e.,* 10 kg N/fed (as the control), 60, 80 and 100 kg N/fed (as urea 46 % N); three split up doses of half the rates of mineral nitrogen, *i.e*., 30, 40 and 50 kg N as mineral with 10 tonnes of organic manure as soil application and foliar application of N at concentrations 1, 2 and 3%. Fertilization was applied in three equal doses at three dates; after 20, 50 and 70 day from planting (at 4 leaf stage, 8 leaf stage and prior flowering). Plot area was 42 $m^3$and plant density for quinoa plants was 30000 plants per feddan. Seeds of quinoa Giza cv 3075 obtained from Field Crop Research Institute, Agricultural Research Center, Giza, were sown on first of November in both seasons and harvested on mid of May. The treatments were laid out in completely randomized design with three replicates per treatment. Phosphatic fertilizer was added at the rate of 15.5 kg P_2O_5/fed and potasic fertilizer was added at the rate of 24 K_2O/fed. All other cultural treatments were practiced as recommended.

Environmental condition

Climate of Siwa Oasis during growth season of quinoa

According to the meteorological data (averages of both growing seasons of quinoa), the Oasis `falls under the extreme arid conditions characterized by hot dry weather at the initiation of summer and autumn and warm mainly day winter and spring. Rain fall in Siwa oasis is negligible. The highest monthly rain full is 2.1 mm/month in February and the lowest is zero in June and July.

TABLE 1b . Meteorological data of Siwa Oasis during the growing seasns of quinoa (averages of 2008 and 2009).

	Max ^{O}C	Min ^{O}C	Average ^{O}C	Wind speed (knot)	Rain fall rate (mm)
November	26.3	10.1	18.2	5.1	1.1
December	21.3	6.0	13.6	5.1	2.1
January	19.7	4.1	11.9	5.7	1.1
February	21.8	5.7	13.8	6.4	2.1
March	25.0	8.2	16.6	7.5	0.3
April	29.9	12.1	21.0	7.8	1.1
May	34.4	16.8	25.6	6.8	1.2
Jun	37.1	19.2	28.2	6.3	0.0
July	38.0	20.7	29.4	6.0	0.0

Plant growth parameters as plant height and number of basal branches were recorded and seed yield per plot (ton/fed) was also determined. Plant shoot were collected at maturity on an area of 4 m^2 .Grain yield was threshed by a stationary thresher. Dry matter was determined separately for stems, grains and green and yellow leaves. Plant samples were cleaned, dried at 60 C^{o}, ground and kept in plastic bags for analysis. One half gram powder of each plant sample was digested in a mixture of sulfuric (H_2SO_4) and perchloric (HCL_4) acids as recommended by Peterburgski (1968). N concentrations were analyzed using micro - Kjeldahl procedure, (Chapman & Pratt , 1961). N uptake was calculated as N in the above ground dry matter at time of maturity, P was determined according to Troug & Meyer (1934) and K according to Brown & Lilleland (1946).

Data obtained were processed by the analysis of variance using the MSTAT-C program (Michigan State University, 1990). Mean separation was obtained using a LSD test at 0.05 probability level when significant F. tests ($P<0.050$) was observed.

Results and Discussion

Effect of N application on growth characters of quinoa

Data in Table 2 indicated clearly that plant height was increased gradually with increasing nitrogen dose from 60 kg N/fed up to 100kg/fed. These observations were fairly true in both seasons and their averages. The major role of nitrogen is stimulating meristematic activity and consequently lead to internode elongation and increased plant height with increasing N dose. Application of mineral nitrogen and organic fertilizer in split up dose had favorable effect on quinoa plant height when compared with the same respective dose of mineral fertilizer which only indicating the favorable effect when adding organic source of N. These results are in agreement with these obtained by Pospisil *et al.* (2006), who reported nitrogen fertilization affected quinoa plant height. Differences were also significant. Wilefredo *et al.* (2004) also showed the favorable effect of organic fertilizer on growth of quinoa plants.

TABLE 2. Effect of N application on some growth characters of quinoa plants.

Treatments	Plant height/cm			No. of basal branches		
	First season	Second season	Mean	First season	Second season	Mean
Control	43.0	45.0	44.00	5.00	6.33	5.67
N_1	48.0	51.0	49.50	7.00	80.0	7.50
N_2	58.2	59.3	58.75	10.33	11.00	10.67
N_3	60.3	61.0	60.67	11.33	11.67	11.50
Mean	55.5	57.1	56.30	9.55	10.22	9.89
½ N_1+ OM	49.3	51.5	50.42	7.33	8.33	7.83
½ N_2+ OM	58.8	59.8	59.30	11.00	11.67	11.33
½ N_3+ OM	61.3	64.0	62.67	11.33	12.33	11.83
Mean	56.6	58.4	57.46	9.88	10.78	10.33
F_1	48.0	50.5	49.25	7.33	8.00	7.67
F_2	58.4	58.8	58.60	10.33	9.00	9.67
F_3	61.3	61.5	61.42	11.33	10.11	10.72
Mean	55.9	56.9	56.42	9.66	9.04	9.35
LSD 5%	0.94	0.82		0.99	0.84	

N_1: 60 kg N/fed , N_2: 80 kg N/fed , N_3: 100 kg N/fed , OM : organic manure10m^3/fed
F_1: foliar application 1% urea , F_2: foliar application 2% urea , F_3: foliar application 3% urea

Foliar application with urea at concentrations 1, 2 and 3% increased quinoa plant height with increasing urea concentration up the heaviest concentration. These results were true in both seasons and their averages. Differences in height were great enough to reach the 5% level of significance. Differences between the average of the three categories; mineral fertilizer only, mineral and organic fertilizer in split up dose and foliar application with nitrogen only was not appreciable but with slight increases in height of quinoa plant when both mineral and organic nitrogen were added in split doses. In other word, addition of nitrogen at any rate or method of application resulted in significantly higher plant height than the control plants (which received only 10 kg N/fed). Data also revealed that addition of 100 kg of nitrogen fertilizer with 15 m^3 of organic fertilizer stimulated quinoa plants to maximum, whereas foliar application with the lowest concentration of urea (1%) resulted in shortest quinoa plants.

The average number of basal branches followed the same pattern of change as influenced by N rate and method of application. Soil application stimulated number of basal branches rather than foliar application. The split up dose of mineral nitrogen and organic fertilizer was also slightly superior rather than mineral fertilizer only. There were also increases in number of basal branches with increasing the N dose of soil or foliar application up to the highest. These results are in agreement with those recorded by Pospisil *et al*. (2006). Ahmed *et al.* (2011), explained that foliar application of urea has been proved to be an effective technique of N fertilization and it is distributed quickly from the treated leaves to other plant parts. They added that urea sprays may help reduce the losses due to denitrification, leaching and immobilization, often associated with

N fertilization to the soil especially, when root capacity for absorption is impaired by low soil moisture or saline soil condition. Nitrogen applied as sprays increased chlorophyll synthesis in the leaves.

Effect of rate and method of N application on grain yield

Application of mineral nitrogen fertilizer increased grain yield/fed compared with the control treatment. These results were true in both seasons and their averages (Table 3). The increases of the high rate (100 kg N/fed),moderate rate (80 kg N/fed) and the lower rate (60 kg N/fed) over the control were estimated to 114.3 , 88.1 and 35.1% in the first seasons and 115.2 , 89.1 and 47.8% in the second season and 113.6 , 88.6 and 43.2% in the averages of both seasons. Similar increase in grain yield of quinoa were observed in the split up dose treatments (mineral and organic N) up to heaviest were observed. Such increases in grain yield were estimated by 35.1, 88.1 and 114.3% over the control treatment, when N was applied at the rate of 60 , 80 and100 kg/fed in the 1^{st} season, respectively and by 47.8 , 89.1 and 115.2% in the 2^{nd} season. These results are in agreement with those obtained by El-Behri *et al.* (1993), Jacobsen *et al.* (1994), Meyers (1998**)** and Schulte *et al.* (2005) who reported that with increasing nitrogen rate grain yield increased in case of soil application and with Yassen *et al.* (2010) in case foliar application. There were significant differences in grain yield between soil and foliar application and between addition of mineral nitrogen fertilizer only and mineral with organic nitrogen fertilizer in split up doses at the lowest rates. However, foliar application seemed to produce slight increases in grain yield of quinoa in comparison with soil application whether with mineral fertilizer only or with split dose of mineral nitrogen and organic fertilizer in most cases.

TABLE 3. Effect of the rate and method of nitrogen application on grain yield of quinoa (ton/fed).

Treatments	First seasons	Second seasons	Mean
Control	0.42	0.46	0.44
N_1	0.57	0.68	0.63
N_2	0.79	0.87	0.83
N_3	0.90	0.99	0.94
Mean	0.75	0.85	0.86
½ N_1+ OM	0.63	0.68	0.65
½ N_2+ OM	0.79	0.86	0.83
½ N_3+ OM	0.97	1.05	1.01
Mean	0.80	0.86	0.83
F_1	0.70	0.74	0.72
F_2	0.82	0.87	0.84
F_3	0.97	0.99	0.98
Mean	0.83	0.87	0.85
LSD 5%	0.06	0.04	

N_1: 60 kg N/fed , N_2: 80 kg N/fed , N_3: 100 kg N/fed , OM : organic manure10m^3/fed.
F_1: foliar application 1% urea , F_2: foliar application 2% urea , F_3: foliar application 3% urea.

Nitrogen, phosphorus and potassium contents of quinoa grain

Data presented in Table 4 indicated that N concentration in the tissue of quinoa grain was increased with increasing nitrogen fertilizer rate whether mineral only, or in split doses between mineral and organic fertilizer or with foliar spray with nitrogen. These results are in agreement with those obtained by Pospisil *et al.* (2006). On the other hand, nitrogen content in quinoa grains when plants were fertilizered with the split up dose or foliar spray were rather higher than plants received only mineral nitrogen fertilizer. Interpretation for these results might be attributed much to the rapid leaching of mineral nitrogen fertilizer. The highest nitrogen content of grains was associated with addition of the highest rate of mineral nitrogen and organic nitrogen in split dose; whereas the least N concentration was found in grains of the control plants. These results were supported by Poon pong *et al.* (2008).

Increasing N concentration with increasing nitrogen fertilizer rate in the grain tissue was also associated with protein increases. This would add valuable nutrition value which characterized the quinoa grain rather than other cereal.

TABLE 4. Effect of N application on mineral content of quinoa grains.

Treatment	N%			Protein	P%			K%		
	First season	Second season	Mean		First season	Second season	Mean	First season	Second season	Mean
Control	1.98	2.00	1.99	12.44	0.24	0.25	0.27	0.41	0.63	0.52
N_1	2.02	2.22	2.12	13.26	0.38	0.35	0.37	0.63	0.77	0.70
N_2	2.42	2.56	2.49	15.56	0.42	0.50	0.46	0.72	0.93	0.83
N_3	2.98	3.02	3.00	18.75	0.58	0.54	0.56	0.77	0.93	0.85
Mean	2.47	2.60	2.52	15.75	0.40	0.46	0.46	0.71	0.88	0.79
½ N_1+ OM	2.00	2. 20	2.10	13.13	0.46	0.42	0.44	0.70	0.81	0.76
½ N_2+ OM	2.63	2.81	2.72	17.0	0.50	0.59	0.55	0.75	0.95	0.85
½ N_3+ OM	3.02	3.32	3.17	19.81	0.60	0.63	0.62	0.79	0.96	0.88
Mean	2.55	2.78	2.66	16.63	0.52	0.55	0.54	0.75	0.91	0.87
F_1	2.06	2.13	2.10	13.13	0.38	0.33	0.36	0.60	0.66	0.63
F_2	2.56	2.58	2.57	16.06	0.44	0.41	0.42	0.70	0.72	0.71
F_3	3.03	3.25	3.14	19.63	0.52	0.48	0.50	0.75	0.81	0.78
Mean	2.55	2.65	2.60	16.25	0.45	0.41	0.43	0.68	0.73	0.71
LSD 5%	0.08	0.06			0.06	0.04		0.07	0.08	

N_1: 60 kg N/fed , N_2: 80 kg N/fed , N_3: 100 kg N/fed , OM : organic manure10m^3/fed.
F_1: foliar application 1% urea , F_2: foliar application 2% urea , F_3: foliar application 3% urea.

Phosphorus and potassium concentrations in grain tissues of quinoa behaved the same as N concentrations behaved by the treatment imposed with significant differences. P and K concentrations were increased with increasing N rate in either method of application (soil and foliar application). It is evident that the split up dose of mineral nitrogen with organic fertilizer increased both P and K

concatenations in grain tissue and resulted in relatively higher values under the same respective rates as compared with mineral fertilizer only. The average values when mineral fertilizer was applied were also higher than were when foliar spray was applied. The lowest values were also evident with the check plants. It is known that quinoa grain has higher contents of P and K mineral rather than wheat, barley or corn (Ahmed *et al.*, 1998). The increases in P and K concentration in the grain tissues of quinoa with increasing nitrogen fertilizer rate add another advantage to its nutritive value.

Effect on nitrogen uptake and nitrogen use efficiency (NUE)

Data in Table 5 indicated that there was a tendency to increase the green weight/plant with increasing the rate of nitrogen fertilizer whether in soil application as well as foliar spraying. It was also evident that the average weights of quinoa plant when received half the mineral fertilization and organic manure were relatively higher than both plants received mineral nitrogen fertilization only or foliar spray at any respective rate. On other hand, the dry weight behaved a reversed trend. This might be due to the fact the nitrogen fertilization is always associated with increasing moisture content in plant tissues. The average nitrogen percent in the tissues of quinoa plants were also influenced by the treatment imposed. Nitrogen percent increased with increasing the nitrogen rate whether in case of soil application or foliar spray method. A fact that has been confirmed by several investigators such El-Behri *et al*. (1993), Meyers (1998), Pospisil *et al.* (2006) and Schulte *et al*. (2005). Nitrogen uptake per fed was also parallel to nitrogen concentration as affected by the treatment imposed.

TABLE 5. Nitrogen uptake and nitrogen use efficiency (NUE) as influenced by different rates and methods of N fertilization (averages of both seasons).

Treatment	Green weight/ plant (g)	Dry wt g/ plant	Dry. wt kg/fed	Average N% per plant	N uptake kg/fed	Grain yield kg/fed	NUE kg/ha^{-1}
Control kg 10	360	90.0	11700	0.97	113.49	440	44.0
N_1 kg 60	510	100.0	13000	1.20	156.00	63	10. 5
N_2 kg 80	505.1	95.3	12389	1.47	182.12	830	10.3
N_3 kg 100	515.9	93.8	12194	2.04	248.76	940	9.4
Mean	**510.3**	**98.0**	**1252.76**	**1.53**	**191.36**	**611**	**9.9**
½ N_1+ OM	580.3	113.8	14794	1.18	174.57	650	10.0
½ N_2+ OM	685.5	113.8	14625	1.66	242.78	830	11.1
½ N_3+ OM	592.9	107.8	14014	2.24	313.91	1.01	11.9
Mean	**619.6**	**111.8**	**77.7**	**1.66**	**239.46**	**83.0**	**11.0**
F_1 1%	497.3	97.5	126625	1.11	140.64	720	6.0
F_2 2%	508.6	97.8	12714	1.54	184.35	840	3.5
F_3 3%	533.5	97.0	12610	2.25	270.23	980	2.7
Mean	**513.16**	**97.4**	**50649.7**	**1.60**	**202.54**	**846.7**	**4.1**
L.S.D 5%	N.S	N.S	N.S	0.230	---	0.05	---

* Nitrogen concentration% was determined on average basis of different parts of plants.
* Nitrogen quantities in organic manure 7.5 m^3= 10 ton . Each ton= 7 kg N (1/2 quantity are available to absorption). = 35.0 kg N.
* Foliar spray with 1% concentration of urea needed 12 kg (for three sprays).
* Foliar spray with 2% concentration of urea needed 24 kg (for three sprays).
* Foliar spray with 3% concentration of urea needed 36 kg (for three sprays).

Data obtained indicated that there were an increase in N uptake even under highest dose of nitrogen supporting the results obtained by Schulte *et al.* (2005). Higher value of the nitrogen use efficiency with the control plants was observed indicating severe nitrogen requirement at the lowest dose of nitrogen fertilizer (the control). Thereafter, there were slight decreases in nitrogen use efficiency with increasing mineral nitrogen fertilizer rate or with increasing the rate of foliar spray with nitrogen. On the contrary, data revealed that with increasing the mineral dose in the split dose (mineral+ organic), N use efficiency up to the highest dose (50 kg N +35 kg organic N) relatively increased. The slow release of available nitrogen for absorption associated with organic part in the mixture may be due to the effect to the continuing requirement for higher dose of nitrogen in the mixture (split dose).

Decreases in NUE values with increasing mineral N or foliar spray might be due to the initiation of self sufficiency of quinoa plant from N fertilizer. These results were supported by Schulte *et al.* (2005). It is also evident that there were relative increases in (NUE) when half mineral N dose + organic manure was applied indicating that mixture of different sources of nitrogen enhanced N utilization efficiency up to the highest dose. On the other hand, there were general slower responses to foliar application with nitrogen.

Effect of N fertilizer on mineral nitrogen content of soil and plants

The analysis of data revealed significant differences between N content of the control plots and all other treatments which received N doses whether as soil application or foliar spray (Table 6). Addition of mineral nitrogen increased soil nitrogen with increasing the rate of mineral nitrogen fertilizer up to the highest rate, (100kg N/fed). Similar trend was observed with soil application of half the rate of mineral nitrogen and organic fertilizer. Further, the same trend was observed with increasing nitrogen concentration in the foliar spray. Data also revealed that addition of the split dose of mineral and organic fertilizer resulted in highest content of soil N, while foliar spray with N resulted in the lowest content of soil nitrogen. These results were fairly true in both seasons and the averages of the two seasons.

The effect of the treatment imposed on N content in quinoa plant tissues followed the general trend of the treatment effect on soil nitrogen. However, the distinctive increase in nitrogen concentration in soil or in plant tissue in the split up dose might be due to a regular and constant supply of nitrogen. Mineral nitrogen represent the available short term supply of N whereas organic nitrogen represent the long term supply. In addition, mineral nitrogen enhance decomposition of organic manure and facilitate release nutritive elements in an available from easy to be absorbed by the plant. Similar results were reported by Wenhuizhong *et al*. (2010) who supported these results.

TABLE 6. Effect of N application on mineral content of soil and plants.

Treatments	Soil- N (ppm)			Plant N%		
	First seasons	Second seasons	Mean	First seasons	Second seasons	Mean
Control	12.80	15.23	14.02	0.95	0.99	0.97
N_1	19.40	25.30	22.35	1.06	1.34	1.20
N_2	25.60	31.50	28.55	1.33	1.61	1.47
N_3	29.20	35.20	32.20	1.93	2.14	2.04
Mean	24.73	30.67	27.70	1.44	1.67	1.54
½ N_1+ OM	20.10	33.73	26.92	1.10	1.25	1.18
½ N_2+ OM	26.27	32.53	29.40	1.55	1.77	1.66
½ N_3+ OM	30.10	42.73	36.42	2.28	2.40	2.34
Mean	25.49	36.33	30.41	1.64	1.81	1.73
F_1	13.60	20.10	16.85	1.11	1.10	1.11
F_2	14.30	21.15	17.73	1.45	1.44	1.45
F_3	14.80	23.03	18.92	2.19	2.30	2.25
Mean	14.23	21.43	17.83	1.58	1.61	1.60
LSD 5%	0.94	0.80		0.04	0.03	

N_1: 60 kg N/fed , N_2: 80 kg N/fed , N_3: 100 kg N/fed , OM : organic manure10m^3/fed.

F_1: foliar application 1% urea , F_2: foliar application 2% urea , F_3: foliar application 3% urea.

They stated that the importance of adding organic manure to a balanced ratio of mineral N, P and K, which render activate microbial mass in the soil and leads to improve crop productivity. It could be concluded the possibility of economizing half the quantity of mineral nitrogen fertilizer and substitute it by organic manure which improve physical and chemical properties of the soil and diminish loss of nitrogen.

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تأثير معدلات وطرق إضافة ومعدل كفاءة السماد النيتروجيني على نمو ومحصول الكينوا

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شعبة المياه والأراضي الصحراوية – مركز بحوث الصحراء و *معهد بحوث المحاصيل الحقلية – مركز البحوث الزراعية – القاهرة – مصر .

أجريت تجربة حقلية في محطة تجارب تجزرتى التابعة لمركز بحوث الصحراء بواحة سيوة لموسمين متتالين خلال عامى ٢٠٠٨،٢٠٠٩ وذلك لدراسة نمو ومحصول وكفاءة استخدام النيتروجين لمحصول الكينوا تحت تأثير صور مختلفة ومعدلات مختلفة من التسميد النيتروجيني وكانت معاملات السماد النيتروجيني عبارة عن أربعة معدلات للسماد النيتروجيني المعدني وهي ١٠ كجم نيتروجين/ف للقطع المقارنة ٦٠ ، ٨٠ ، ١٠٠ كجم نيتروجين/ف ، وثلاث معاملات من جرعات مخلوطة بين نصف المعدلات النيتروجينية المعدنية السابقة أي ٣٠ ، ٤٠ ، ٥٠ كجم نيتروجين/ ف ومضاف إلى كل ٧,٥ متر مكعب للفدان من السماد العضوي وهـذه المعاملات كإضافة أرضية وثلاث معاملات كإضافة ورقية بتركيزات ١ ، ٢ ، ٣٪ يوريا ووزعت المعاملات عشوائيا في تصميم كامل العشوائية. وأظهرت النتائج أن هناك زيادة تدريجية في ارتفاع النبات وعدد الأفرع القاعدية ومحصول الحبوب بالفدان بزيادة معدل السماد النيتروجيني إلى أعلى معدل سواء في حالة التسميد بالسماد النيتروجيني المعدني أو بمخلوط من السماد المعدني والعضوي أو في حالة التسميد الورقي. وأوضحت النتائج أيضا أن مخلوط السماد النيتروجيني المعدني والعضوي قد أعطى أعلى قيم لهذه الصفات في حين أعطى التسميد الورقي أقل هذه القيم . كذلك أوضحت النتائج أن تأثير المعاملات على محتوى حبوب الكينوا من النيتروجين والبروتين والفوسفور والبوتاسيوم كان مماثلا لتأثير تلك المعاملات على صفات النمو والمحصول. ومن ناحية أخرى كان هناك نقص في كفاءة استخدام النيتروجين بزيادة معدل السماد النيتروجيني المعدني أو بزيادة تركيز النيتروجين بالتسميد الورقي في حين كانت هناك زيادة نسبية في كفاءة إستخدام النيتروجين عندما استخدم مخلوط من النيتروجين المعدني والنيتروجين العضوي. أما التسميد النيتروجيني الورقي فقد اقترن بأقل معدل كفاءة استخدام للسماد النيتروجيني.