J. Plant Production, Mansoura Univ., Vol. 9 (4): 327 - 332, 2018

Effect of Sowing Dates and Nitrogen on Productivity of Quinoa (*Chenopodium quinoa* Willd.) at Desert Areas

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ABSTRACT

Two field experiments were carried out in the Desert Research Center (D.R.C.), Agricultural Experiment Station at EL-Kharga Oasis, New Valley Governorate (27°47.7 42 N, 30°24.7 63 E) during the two growing seasons of 2015/ 2016 and 2016/ 2017 to study the effect of sowing dates and rates of nitrogen fertilizer on productivity and quality of quinoa. Results showed that the effect of sowing dates on all studied parameters was significant except, number of inflorescence/ plant, carbohydrates % and oil % don't affect significantly by sowing dates during the two growing seasons. Sowing date in 1st December had the highest values for all studied traits as compared with the rest dates during the two growing seasons. There were significant increases in values of studied parameters with increasing nitrogen fertilizer rate up to 150 Kg N fed.$^{-1}$but without significant in number of inflorescence/ plant and saponin % during both seasons. The interaction between different sowing dates and nitrogen fertilizer levels had a significant effect on yield and quality of quinoa except, number of inflorescence/ plant and saponin % which did not any significant by the interaction between sowing dates and nitrogen fertilizer during the two growing seasons. Cultivation of quinoa on 1st December and fertilization by150 kg N fad^{-1} gave maximum values of studying parameters during the two growing seasons at the desert area under New Valley conditions.

Keywords: Quinoa, sowing dates, nitrogen, yield components and quality.

INTRODUCTION

Quinoa (*Chenopodium quinoa* Willd) is an original food crop can replenish part of foodstuff gap. It is a food crop recently introduce in Egyptian lands. Because of its high nutritive value seeds can be utilized for human food, in flour production and in animal feedstock (Bhargava *et. al.,* 2007). Quinoa could be used in bread in combination or substitution of wheat and other seed products (Shams, 2010). Moreover, quinoa is considered as a multipurpose crop because of the high-quality protein seeds, especially rich in essential amino acids, minerals, carbohydrates, antioxidant compounds as carotenoids, flavonoids, vitamin C and dietary fiber compared to that of cereals such as corn, oat, rice and wheat (Repo-Carrasco *et. al.,* 2011). Quinoa crop was chosen by FAO as one of the important crops which play major role in food security, assuring in the 21th century due to its high nutritional value and its good tolerance to adverse climatic conditions (Jacobsen, 2003). However, the seeds of most quinoa varieties contain saponins, located in the outer layers of the seed coat (Jacobsen, 2003), most of which are bitter-tasting constituents (chiefly saponin) in the seed's outer layer, this can be removed by washing the seeds in cold water or milled to remove the seed coat. Due to the chemical composition of quinoa, it is recommended to use quinoa flour for replenishing part of cereals gap by replacement of wheat or maize with quinoa flour specially for poor areas in deserts, low income people, school students and babies whom suffering from insufficient protein, essential amino acids and minerals specially calcium and iron in their foods and also for people whom suffering from celiac disease hence quinoa is gluten-free and considered easy to digest (Doweidar and Kamel, 2011).

In Egypt, little information is known about quinoa and it's ideally suited as a potential new crop option for Egyptian producers. One of the most important determinants of the productivity of any new crop in a particular area is the identification of the optimal planting time that satisfies the plant with its environmental needs whereas, Optimum planting time exhibited as a first step in crop production system and considered to be a base that leads to development of a proper production technology package especially for a new crop in a region (Rauf *et. al.,* 2010 and Sajjad *et. al.,* 2014). In this respect, Jacobsen (2003) demonstrated that the quinoa is a crop with a range of requirements for humidity and temperature, with different ecotypes adapted to different conditions. Awadalla and Morsy, (2017) showed that the effect of planting dates on yield characters of quinoa was a significant during both seasons. Quinoa has been tested under different climate conditions with varied yield according to sowing dates (Ujiie *et. al.,* 2007, Hirich *et. al.,* 2014 and Katsunori *et. al.,* 2016). Planting date for quinoa is one of the main factors which play a prominent role in quinoa production, Variation in germplasm of quinoa is clear in its response to planting date under native conditions of New Valley.

Nitrogen is a key input element in agriculture that increases yield than other elements (Marschner, 1995). A nitrogen fertilization requirement of quinoa crop is still under study in the world widely because of variability of ecological conditions. Quinoa responses to nitrogen addition not only increase the crop growth and total plant mass production but also the to enhance seed quality (Finch, 1982). Shams, 2017), explored the effect of different nitrogen rates (0, 37.5, 75, 112.5 and 150 kg N fed^{-1}) on plant height, grain yield, biological yield and NUE of quinoa and he found that a significant increases of quinoa with increasing nitrogen fertilizer rate up to150 Kg N fed^{-1}resulted in maximum plant height of 72.73 and 71.78 cm, grain yield of 17.070 and 15.177 g plant^{-1}, grain yield. of 1203 and 1088 Kgfed^{-1}, biological yield of 2787 and 2322 Kg fed^{-1}and nitrogen use efficiency (NUE) values of 5.367 and 3.417 Kg Kg^{-1} N during first and second season, respectively. These results are in agreement with those obtained by Schulte *et. al.,* (2005), Ebrahim *et. al.,* (2014), Kakabouki *et. al.,* (2014), Hakan (2015)and Awadalla and Morsy (2017), their results demonstrated that quinoa grain yield increased with the increasing of

N-levels from 50 to 150 kg N fed^{-1}.The objective of this experiment was to determine the optimum sowing date and the optimum level of nitrogen fertilizer for getting maximum productivity and quality of quinoa (*Chenopodium quinoa* Willd.) under the desert areas conditions of the largest Egyptian governorates in area.

MATERIALS AND METHODS

Location of Experiment

Two field experiments were carried out in the Desert Research Center (D.R.C.), Agricultural Experiment Station at EL-Kharga Oasis, New Valley Governorate (27°47.7 42 N, 30°24.7 63 E) during the two growing seasons of 2015/ 2016 and 2016/ 2017, to study the effect of sowing dates and rates of nitrogen fertilizer on productivity and quality of quinoa. The soil was sandy clay loam texture and its characters were pH vary from 8.73 and 8.67, organic matter 0.54 and 0.59 %, EC 617 and 589 ppm, available nitrogen 61 and 64 ppm, available phosphorus 0.52 and 0.55 ppm and available potassium 33 and 36 ppm during the first and second seasons respectively.

Treatments and experimental design

A Regalona cultivar of quinoa (*Chenopodium quinoa* Willd.) was examined for its productivity response as affected by three dates of sowing (1st October, 1st November and 1st December) and four different nitrogen levels (0, 50, 100 and 150 kg fed^{-1}) under drip irrigation system. The split plot design was used, planting dates were assigned in the main plots and N-levels were randomly distributed in sub plots with three replications. Nitrogen fertilizer was added in the form of ammonium sulfate (20.5%) in four equal doses, the first after four weeks from planting date and the other doses every two weeks. Seeds were sown by hand in rows 35 cm apart at a depth of 2-3 cm at a rate of 5 kg fed^{-1}. Each plot consisted of 6 rows with 5 m length (10.5 m^2).Seeds of quinoa were sown on one side of the drip irrigated ridge in hills spaced 15 cm apart then thinned to two plants per hill. Plots were kept free of weeds through hand hoeing. The other cultural practices were performed for quinoa production according to the recommendations that were mentioned in the bulletin of the Denmark National Organization (2008).

Soil preparation

The experimental field was prepared as recommended in experiment region and calcium super phosphate (15% P_2O_5) was applied during soil preparation at the rate of 100 fed^{-1}. Potassium sulfate (K_2SO_4 48 %) was applied when plants aged 45 days from sowing date at the rate of 50 kg fed^{-1}. The preceding summer crop was millet during both seasons.

Data studied:

Data were recorded on five individual plants with respect to yield and quality parameters which taken at random from each plot representing the three replications. Recording the studied data was carried out in the following manner: plant height (cm) - number of inflorescence/ plant - main inflorescence weight (g) - seeds weight/ plant (g) - number of seeds/ inflorescence - 1000 seed weight (g) - seed yield kg/ (feddan) - stalk yield kg/ feddan - harvest index % - nitrogen use efficiency (NUE) kg/kg - protein % - carbohydrates % - oil % - saponin % - Nitrogen use efficiency (NUE): was calculated according to Craswell and Godwin, (1984) according to the following equation: NUE=(Seed yield of fertilized plots- Seed yield of unfertilized plots)/(Fertilizer N applied). Harvest index (%): HI: (seed yield plant^{-1})/(dry weight plant^{-1}). Seed yield (kg fed^{-1}): seed of each experimental plot were bulked, after threshing by a stationary thresher, weighed and seed yield/plot was then converted to kg per feddan as well as, stalk yield kg/ fed. Crude protein content (%) of seed was determined by using the Kjeldahl method (N%) as described by Peach and Tracey, (1956) with a conversion factor of 6.25. Total carbohydrates were extracted according to Smith *et. al.,* (1964). Seed oil percentage was determined according to A.O.A.C. (1995) using soxhlet apparatus using petroleum ether as a solvent. Seed saponin percentage was isolated and determined according to Dini *et. al.,* (2000).

Statistical analysis

All data were subjected to statistical analysis according to procedure outlined by Snedecor and Cochran, (1990). Means were compared using the least significant difference (LSD) test at P<0.05.

RESULTS AND DISCUSSION

1. Effect of sowing dates:

Data in Table (1) showed that the effect of sowing dates on all studied parameters i.e. plant height (cm), main inflorescence weight (g), seeds weight/ plant (g), number of seeds/ inflorescence, 1000 seed weight (g), seed yield kg/ feddan, stalk yield kg/ feddan, harvest index %, nitrogen use efficiency (NUE) kg/ kg, protein %, and saponin % was significant except, number of inflorescence/ plant, carbohydrates % and oil % don't affected significantly by sowing dates in the two growing seasons. The third planting date (1st December) had maximum values for all studied traits as compared with the rest dates during the two growing seasons. The results showed that planting of quinoa on first December was superior over other dates of sowing and met the environmental needs of plant. It is worthy to conclude that planting of quinoa in first December is a good time in order to explore its yield potential under New Valley conditions. Similar results were obtained by Jacobsen (2003) ;Ujiie *et. al.,*(2007) ; Rauf *et. al.,*(2010) ; Aamer *et. al.,* (2014) ; Hakan *et. al.,* (2014) ; Hirich *et. al.,*(2014) ; Sajjad *et. al.,*(2014) ; Katsunori *et. al.,*(2016) and Awadalla and Morsy (2017).

2. Nitrogen fertilizer rates:

Results in Table (2) indicate that there were significant increases in values of studied parameters with increasing nitrogen fertilizer rate up to 150 Kg N fed.$^{-1}$ but meanwhile, it did not reach significant level in number of inflorescence/ plant and saponin % during both seasons. Increases in productivity of quinoa with increasing nitrogen rates are mainly due to role of nitrogen in stimulating metabolic activity which contributed to the increase in metabolites which is used in building yield and its components Shams (2011). The increase in yield attributes gradually with increasing N-levels may be attributed to the role of nitrogen in improving quinoa growth by enhancement meristematic cell division and expansion, activity and metabolic, photosynthesis processes and forming filled grains consequently producing heavier grains (Basra *et. al.,* 2014; Ebrahim *et. al.,* 2014 and Hakan 2015).

Table 1. Effect of sowing dates on yield and quality of quinoa during 2015 / 2016 and 2016/ 2017 growing seasons under New Valley conditions.

Char. / Sowing Dates	Plant height (cm)	No. of inflores-cence/ plant	Main Inflores-cence Weight (g)	Seeds weight/ plant (g)	No. of seeds/ inflores-cence	1000 seeds weight (g)	Seed yield kg/ fed.	Stalk yield Kg /fed.	Harvest index %	NUE kg/ kg	Protein %	Carboh. %	Oil %	Saponin %
2015/ 2016 Season														
1st October	76.35	9.67	6.47	23.94	10458	2.79	876.31	1054.20	34.12	5.21	13.65	61.32	5.18	1.124
1st November	79.64	13.41	7.52	31.75	11894	3.63	942.45	1213.49	36.63	6.38	15.82	62.60	5.50	0.981
1st December	88.91	16.61	8.29	35.44	12314	3.85	1015.76	1285.05	37.42	7.95	16.73	63.45	6.26	0.635
LSD at 5%	2.47	NS	0.59	2.78	381	0.19	67.80	63.15	0.75	0.66	0.84	NS	NS	0.13
2016/ 2017 Season														
1st October	74.98	9.10	6.33	22.70	10376	2.71	860.34	1040.53	33.84	5.14	13.48	60.89	5.10	1.119
1st November	78.20	12.89	7.41	30.56	11740	3.55	903.18	1185.76	36.52	6.20	15.60	62.44	5.39	0.973
1st December	90.34	16.24	8.20	35.16	12207	3.80	989.49	1270.09	37.19	7.78	16.69	63.21	6.17	0.626
LSD at 5%	2.02	NS	0.42	2.85	403	0.23	73.22	79.52	0.63	0.87	0.94	NS	NS	0.12

NUE: Nitrogen use efficiency; Carboh. % : Carbohydrates % and LSD: least significant difference.

Table 2. Effect of nitrogen fertilization rates on yield and quality of quinoa during 2015 / 2016 and 2016/ 2017 growing seasons under New Valley conditions.

Char. / Nitrogen	Plant height (cm)	No. of inflores-cence/ plant	Main Inflores-cence Weight (g)	Seeds weight/ plant (g)	No. of seeds/ inflores-cence	1000 seed weight (g)	Seed yield Kg /fed.	Stalk yield Kg /fed.	Harvest index %	NUE kg/ kg	Protein %	Carboh. %	Oil %	Saponin %
2015/ 2016 Season														
0 kg N/ fed.	71.03	6.42	5.71	21.50	9974	2.68	851.20	952.14	34.91	-	10.35	60.47	4.51	0.191
50 kg N/ fed.	78.56	10.56	7.84	29.06	11655	3.26	975.74	1258.61	36.12	5.41	12.90	62.91	5.11	0.173
100 kg N/ fed.	90.30	15.54	9.08	32.47	11974	3.74	1089.65	1494.06	40.06	6.76	15.98	64.10	6.19	0.148
150 kg N/ fed.	94.62	17.47	9.86	36.82	12471	3.90	1154.44	1581.64	41.50	8.15	17.58	65.02	6.94	0.122
LSD at 5%	3.68	NS	0.61	2.46	410	0.12	63.29	80.14	1.30	0.59	1.20	0.83	0.54	NS
2016/ 2017 Season														
0 kg N/ fed.	70.14	6.26	5.63	21.32	9867	2.66	845.11	945.47	34.85	-	10.31	60.32	4.47	0.186
50 kg N/ fed.	78.36	9.99	7.75	28.68	11577	3.15	964.16	1238.67	36.74	5.39	12.81	62.84	5.02	0.168
100 kg N/ fed.	87.59	14.97	8.82	31.58	11902	3.69	1072.09	1472.11	39.80	6.67	15.75	63.86	6.28	0.143
150 kg N/ fed.	92.88	17.32	9.71	35.49	12390	3.87	1140.84	1562.73	41.14	8.10	17.42	64.79	6.82	0.118
LSD at 5%	3.74	NS	0.55	2.60	421	0.15	69.65	83.56	1.22	0.61	1.36	0.85	0.39	NS

NUE: Nitrogen use efficiency; Carboh. % : Carbohydrates % and LSD: least significant difference.

The increases percentages outcome application of 150 Kg N fed.$^{-1}$compared with control in plant height (cm) were 32.21 and 32.42, for main inflorescence weight (g) were 72.68 and 72.47, seeds weight/ plant (g) 71.26 and 66.46, number of seeds/ inflorescence 25.64 and 25.57, 1000 seed weight (g) 45.52 and 45.49, seed yield kg/ fed. 35.63 and 34.99, stalk yield kg/ fed. 66.11 and 65.29, harvest index % 18.88 and 18.05, protein % 69.86 and 68.96, carbohydrates % 7.52 and 7.41 and oil % 53.88 and 52.57 as, well as, nitrogen use efficiency

(NUE) kg/ kg as compared with 50 Kg N fed.$^{-1}$ during the first and second seasons, respectively. Shams, (2011) revealed that fertilizing quinoa with 150Kg N fed.$^{-1}$resulted in maximum yield components in two successive seasons. Schulte *et. al.,* (2005) evaluated the response of quinoa to nitrogen fertilization at rates of 0, 75 and 150 Kg N fed.$^{-1}$, the results evidenced that quinoa responded strongly to N fertilization and quinoa yielded between 750 and 1500 kgN fed.$^{-1}$. These results were supported by several investigators as Schulte *et. al.,* (2005) ; Shams (2011) ; Abou-Amer and Kamel (2011) ; Hakan *et. al.,* (2014) ; Ebrahim *et. al.,* (2014) ; Kakabouki *et. al.,* (2014) ; Hakan (2015) ; Awadalla and Morsy (2017) and Kansomjet *et. al.,* (2017).

3. Effect of the interaction between sowing dates and nitrogen fertilizer:

Results in Table (3 a and b) indicated that the interaction between sowing dates and nitrogen fertilizer levels had a significant effect on yield and quality of quinoa during the two seasons. Applying 150 kg N fad^{-1} at the third planting date (1stDecember) gave maximum values of plant height (91.89 and 91.74 cm), main inflorescence weight (9.20and 9.08 g), seeds weight/ plant (36.26 and 35.45 g), number of seeds/ inflorescence (12393 and 12299), 1000 seed weight (4.00 and 3.96 g), seed yield (1085.23and 1066.79 kg/ fed.), stalk yield (1433.47and 1416.54 kg/ fed.), harvest index (39.59 and 39.29 %), nitrogen use efficiency (NUE) (8.18 and 8.07 kg/ kg), protein (17.28 and 17.18 %), carbohydrates (64.36 and 64.13 %) and oil (6.73 and 6.62 %) during the two seasons, respectively. On the other hand, number of inflorescence/ plant and saponin % doesn't affected significantly by the interaction between sowing dates and rates of nitrogen fertilizer during the two growing seasons.

Table 3 a. Effect of the interaction between sowing dates and nitrogen fertilization rates on yield and quality of quinoa during 2015 / 2016 and 2016/ 2017 growing seasons under New Valley conditions.

Char. Treatments		Plant height (cm)	No. of inflores-cence/ plant	Main Inflores-cence Weight (g)	Seeds weight/ plant (g)	No. of seeds /inflores-cence/	1000 seed weight (g)	Seed yield kg/fed.
Sowing dates	N (kg fed.)				2015/ 2016 Season			
1st October	0	73.82	8.17	6.22	22.85	10216	2.86	863.88
	50	77.58	10.24	7.28	26.63	11057	3.15	926.15
	100	83.45	12.73	7.90	28.33	11216	3.39	983.11
	150	85.61	13.70	8.29	30.51	11465	3.47	1015.50
1st November	0	75.46	10.04	6.74	26.75	10934	3.28	896.95
	50	79.23	12.11	7.81	30.53	11775	3.57	959.22
	100	85.10	14.60	8.43	32.24	11934	3.81	1016.18
	150	87.26	15.57	8.82	34.41	12183	3.89	1048.57
1st December	0	80.10	11.64	7.13	28.60	11144	3.39	933.61
	50	83.86	13.71	8.19	32.38	11985	3.68	995.88
	100	89.73	16.20	8.81	34.08	12144	3.92	1052.83
	150	91.89	17.17	9.20	36.26	12393	4.00	1085.23
LSD at 5%		1.24	NS	0.25	0.89	77	0.10	23
				2016/ 2017 Season				
1st October	0	72.69	7.81	6.11	22.14	10122	2.79	851.35
	50	76.80	9.67	7.17	25.82	10977	3.06	912.38
	100	81.41	12.16	7.70	27.27	11139	3.33	966.34
	150	84.06	13.34	8.15	29.22	11383	3.42	1002.22
1st November	0	74.30	9.70	6.65	26.07	10804	3.21	872.77
	50	78.41	11.57	7.71	29.75	11659	3.48	933.80
	100	83.02	14.06	8.24	31.20	11821	3.75	987.76
	150	85.67	15.23	8.69	33.15	12065	3.84	1023.64
1st December	0	80.37	11.38	7.04	28.37	11037	3.34	915.93
	50	84.48	13.24	8.10	32.05	11892	3.60	976.95
	100	89.09	15.73	8.64	33.50	12055	3.87	1030.92
	150	91.74	16.91	9.08	35.45	12299	3.96	1066.79
LSD at 5%		1.36	NS	0.28	1.45	61	0.09	19

Table 3b. Effect of the interaction between sowing dates and nitrogen fertilization rates on yield and quality of quinoa during 2015 / 2016 and 2016/ 2017 growing seasons under New Valley conditions.

Char. Treatments		Stalk yield kg/fed.	Harvest Index %	NUE kg/ kg	Protein %	Carboh. %	Oil %	Saponin %
Sowing dates	N (kg fed.)			2015/ 2016 Season				
1st October	0	1003.30	34.64	2.73	12.13	61.02	4.97	0.658
	50	1156.53	35.25	5.44	13.40	62.24	5.27	0.649
	100	1274.26	37.22	6.11	14.94	62.84	5.81	0.636
	150	1318.05	37.94	6.81	15.74	63.30	6.19	0.623
1st November	0	1082.94	35.90	3.32	13.21	61.66	5.13	0.586
	50	1236.18	36.50	6.02	14.49	62.88	5.43	0.577
	100	1353.90	38.47	6.70	16.03	63.48	5.97	0.565
	150	1397.69	39.19	7.39	16.83	63.94	6.35	0.552
1st December	0	1118.72	36.29	4.10	13.67	62.09	5.51	0.413
	50	1271.96	36.90	6.81	14.94	63.31	5.81	0.404
	100	1389.68	38.87	7.48	16.48	63.90	6.35	0.392
	150	1433.47	39.59	8.18	17.28	64.36	6.73	0.379
LSD at 5%		33.41	0.35	0.50	0.43	0.41	0.14	NS
			2016/ 2017 Season					
1st October	0	971.63	34.47	2.70	11.95	60.73	4.89	0.653
	50	1139.73	35.42	5.37	13.27	61.99	5.19	0.644
	100	1256.45	36.95	6.03	14.74	62.50	5.82	0.631
	150	1301.76	37.62	6.75	15.58	62.97	6.09	0.619
1st November	0	1044.24	35.81	3.23	13.01	61.51	5.03	0.580
	50	1212.34	36.76	5.90	14.33	62.77	5.33	0.571
	100	1329.06	38.29	6.56	15.80	63.28	5.96	0.558
	150	1374.37	38.96	7.28	16.64	63.74	6.23	0.546
1st December	0	1086.41	36.15	4.02	13.56	61.89	5.42	0.406
	50	1254.51	37.09	6.69	14.88	63.15	5.72	0.397
	100	1371.23	38.62	7.35	16.35	63.66	6.35	0.385
	150	1416.54	39.29	8.07	17.18	64.13	6.62	0.372
LSD at 5%		36.17	0.30	0.52	0.44	0.34	0.11	NS

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تأثير مواعيد الزراعة والنيتروجين على إنتاجية الكينوا بالمناطق الصحراوية

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أقيمت تجربتان حقليتان بالمزرعة البحثية بالخارجة التابعة لمركز بحوث الصحراء بمحافظة الوادي الجديد خلال موسمي 2015/ 2016 و 2016/ 2017 لدراسة تأثير مواعيد الزراعة ومعدلات السماد النيتروجيني على إنتاجية وجودة الكينوا. وأظهرت النتائج أن تأثير مواعيد الزراعة على جميع الصفات المدروسة كان معنويا باستثناء عدد النورات / نبات بينما لم تتاثر نسبة كلا من الكربوهيدرات والزيت ببذور الكينوا معنويا بمواعيد الزراعة فى كلا الموسمين. أعطى ميعاد الزراعة فى الاول من ديسمبرأعلى القيم لجميع الصفات المدروسة مقارنة مع بقية المواعيد في كلا الموسمين. كانت هناك زيادة معنوية في قيم الصفات تحت الدراسة كلما زاد معدل السماد النيتروجيني حتى 150 كجم نيتروجين/ فدان بإستثناء عدد النورات / نبات ونسبة الصابونين لم تتأثرا معنويا بمعدلات النيتروجين في كلا الموسمين. وكان للتفاعل بين مواعيد الزراعة المختلفة ومعدلات السماد النيتروجينى تأثير معنوي على انتاجية وجودة الكينوا، إلا أن عدد النورات / النبات ونسبة الصابونين لم تتأثرا معنويا بالتفاعل بين مواعيد الزراعة ومعدلات النيتروجين في كلا الموسمين. وقد أعطت زراعة الكينوا في الأول من ديسمبر والتسميد بمقدار 150 كجم نيتروجين للفدان أعلى قيم للصفات التى تم دراستها في موسمي النمو بالمناطق الصحراوية تحت ظروف الوادي الجديد.