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Response of Quinoa Yield and Seed Chemical Composition to Planting Dates and Densities under the Climatic Conditions of Aswan Governorate.

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ABSTRACT

A field experiment was carried out at the experimental farm, faculty of Agriculture and Natural Resources,Aswan University during2018-19 and 2019-20 seasons to identify the suitable planting date and the optimum plant density on growth, yield and its quality of quinoa cv.Regalona under sandy soil using drip irrigation system.The experiment was carried out in(RCBD)using split-plot plot design with three replications, where planting dates (P_1: 10[th]October, P_2: 25[th]October and P_3: 10[th]November)were occupied main plots and plant density (D_1:56.000, D_2:70.000 and D_3:84.000 plant fed^{-1})were arranged sub-plots. Results revealed that planting quinoa on 10[th] October resulted in maximum plant height, number of inflorescence plant^{-1}, 1000-seed weight, seed yield fed^{-1}and chemical compositions in both seasons.The delay of sowing led to increased carbohydrate concentration in seeds. The impact of plant density was significant for all studied traits in both seasons. Seed yield increased by(39.83 and 50.38%)with increase of plant density from 56.000 to 84.000 plant fed^{-1} in the 1[st] and 2[nd] seasons, respectively. The increase of plant density significantly decreased both weight of 1000-seed and protein percentage in both seasons. Interaction between sowing date and plant density(D×P)showed that the highest seed yield fed^{-1}obtained in the 1[st] date(10-October)with density84.000 plant fed^{-1}(753.60 and 767.93 kg fed^{-1})in both seasons. The highest seed protein content resulted from sowing at 10-October with density56.000plant fed^{-1}.Ultimately, it can be concluded that planting quinoa(*cv.* Regalona)on 10[th]October with sowing density 84 thousand plant fed^{-1} could be recommend to maximize quinoa productivity and its quality of seeds under the climatic condition prevailing of Aswan Governorate

Keywords: Quinoa, Planting date, Plant densities, yield and its Quality.

INTRODUCTION

Quinoa (*Chenopodium quinoa* Willd.) is a dicotyledonous plant. It belongs the family *Chenopodiaceae* and triple carbon plants (C_3), moreover is well adapted to the harsh conditions of the Andean highlands, which has very high drought, cold and salinity as well as able to grow in marginal soils (Jacobsen *et al.*, 2003). It's gaining importance globally owing to its nutritional quality and adaptability in a wide range of conditions. Quinoa seeds have a wide range of colors, gluten-free, oil content varies between 10 and 18%, high in protein (from 13 to 21%) and one of the few plant foods that contain all nine essential amino acids, which are rare in plant origin (Escuredo *et al*., 2014). It is also the seed that provides a rich source of a high in fiber, magnesium, B-vitamins, iron, potassium, calcium, phosphorus, vitamin E and various beneficial antioxidants. (Abugoch *et al.*, 2009 and Vega-Galvez *et al*., 2010). Due to its high nutritional value, it has been chosen by the Food and Agriculture Organization of The United Nations (FAO, 2013) as one of the crops destined for confirming food security in this century.

Planting date and stand plant density are the main factors interacting with high-yielding genotypes which play a prominent role on quinoa production. Planting quinoa at a suitable time maximizes the growth period and completes the seed ripening process to maximize the yield and reduce the risk of unfavorable environmental conditions for grain quality. In early planting, plants stay in the field longer, compared to late plants, and make optimum use of environmental conditions. Miri, (2014) examined four sowing dates of 10 and 25 October and 10 and 25 November and found that the heaviest seed yield of quinoa (4.2 ton ha^{-1}) was resulted from the first sowing date 10[th] October. Yarnia *et al*. (2011) and Parvin *et al*. (2013) showed that delay in sowing reduced plant height, number of inflorescence plant^{-1}, leaf area plant^{-1}, shoot dry weight, and grain yield plant^{-1} because the plant life cycle is limited with temperature and photoperiod. The sowing date on 1[st] December had the highest values for all studied traits as compared with the rest dates during the two growing seasons (Shoman, 2018). Many investigators showed in this connection Abdel-Rheem *et al*., (2014), Awadalla and Morsy, (2017), Biswas and Tanni, (2020) and Temel and Yolcu, (2020).

Plant density is one of the most important agricultural practices to ensure high quinoa seed yield (Spehar and Rocha, 2009 and Eisa *et al.*, 2018). Different quinoa growth habits are directly dependent on plant density, that is, simple branched to bottom third, branched to second third and branched with a main panicle undefined (Rojas and Pinto, 2013). An appropriate seeding rate allows to development of strong, well-branched plants. A higher yield of quinoa was obtained applying the seeding rate of 3 kg ha^{-1} as compared with 2 kg·ha^{-1} Gęsiński (2018). Also, Al JBawi *et al.* (2020)

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exhibited that the distance between the plants 50 cm for sown quinoa using 100, 133 and 200 thousand plants ha^{-1} to get the best morphological and production traits. EL-Tahan *et al.* (2019) evidenced that the increase of plant spacing from 15 to 25 cm led to increased seed yield ha^{-1} by (68.17 and 59.60%) in the 1st ans 2nd seasons, respectively.

Therefore, the present investigation has been conducted to study the effects of planting date, plant density and their interaction on seed yield and its components, as well as some quality traits of quinoa (cv. Regalona) under the environmental conditions of Aswan Governorate .

MATERIALS AND METHODS

1- Experimental site and soil analysis:

The present study was carried out in the experimental farm, faculty of Agriculture and Natural Resources, Aswan University at Aswan Governorate, during the winter of 2018-19 and 2019-20 seasons to identify the suitable planting date and the optimum plant density on growth, yield and its quality of quinoa cv. Regalona under drip irrigation system. Physical and chemical analysis of the soil of the experimental sites indicated that the soil was sandy and containing available NPK were N= 129.16, P= 9 and K= 177.5 mg kg^{-1} soil, pH 7.67 and EC 0.33 ds cm^{-1}.

2- Experimental design and treatments:

A field experiment was carried out in a randomized complete block design (RCBD) using a split-plot with three replications. Sowing dates were arranged in the main plots, and plant densities assigned to sub-plots. The experiment included two factors:

A- Sowing dates (D):

D_1: 10th October. D_2: 25th October. D_3: 10th November

B- Plant density (P): Seeds were drilled and planted in hills spaced 10, 15 and 20 cm. with two plants /hill in P1, P2 and P3 respectively.

P_1: 56.000 plant fed^{-1}.

P_2: 70.000 plant fed^{-1}.

P_3: 84.000 plant fed^{-1}.

3- Cultural practices:

Plants of quinoa sown the first time in area of the study. The experimental unit area was 18 m^2 (3.6×5m). Each plot consisted of 6 ridges with 5 m length and 0.6 m widths. The drip irrigation system was used. At soil preparation, 8 m^3 of chicken manure mixed with 50 kg of NH_4NO_3 (33.5% nitrogen) +37.5 Kg P_2O_5 + 48 kg K_2O fed^{-1} were applied. In addition, 120 kg of nitrogen fertilizer (supplied from NH_4NO_3 33.5%) was applied in equal 6 doses (20 Kg N $weak^{-1}$) after thinning (12 days from planting) as a solution with irrigation. The seeds of quinoa were obtained from the Desert Research Center, Cairo, Egypt. The ordinary cultural practices for growing quinoa were adopted as recommended, except the experimental treatment. Four seeds $hill^{-1}$ were hand planted and thinned to two plants per hill. All plots were irrigated one hour daily. The field experiment was hoed twice after 12 and 20 days from planting. Data were recorded on plants grown in the inner two rows.

4- Characters studied:

The following data recorded in both seasons:

A. Measurements of yield and its attributes:

Ten guarded plant samples/sub-plot were taken randomly after 75 days from sowing to determine plant height (cm), number of leaves $plant^{-1}$ and total chlorophyll (SPAD) according to Mielke and Schaffer (2010). At harvest, ten guarded plants from each sub-sub plot were chosen randomly to estimate the number of inflorescence $plant^{-1}$, 1000-seed weight (g) and seed yield fed^{-1} 1 m^2 was harvested after maturing, weighed and adjusted based on of moisture 14%, and then converted to kg fed^{-1}.

B-Chemical composition:

Seed samples from each replicate were taken in both seasons after harvesting and mixed together, left for air drying to 15% moisture content and used to chemical analysis as following.

1- **Saponin %:** according to (AOAC, 2007)
2- **Protein content %:** according to AOAC (2005).
3- **Carbohydrate %:** total carbohydrates was determined according to Herbert *et al.* (1971).

5- Statistical analysis:

Data obtained from experimental treatments were subjected to the statistical analysis of variance of the split-plot design for by means of MSTAT-C (1986) computer software package according to Gomez and Gomez (1984). The treatment means were compared using LSD at 5% level of probability.

RESULTS AND DISCUSSION

1- Vegetative growth traits:

Means of growth characters as influenced by sowing date, plant density and their interaction in both seasons are presented in Table 1.

Table 1. Means of Vegetative growth traits of quinoa as affected by planting dates, plant density and their interactions during 2018-19 and 2019-20 seasons.

Traits		Plant height (cm)		Number of leaves $plant^{-1}$		Total chlorophyll	
		2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
Planting dates (D)							
D1: 10th October		101.00	95.67	74.44	75.44	53.37	49.93
D2: 25th October		71.67	66.89	62.53	61.11	48.01	46.46
D3: 10th November		52.22	51.44	53.55	47.89	34.13	32.36
LSD at 5%		4.21	5.82	4.06	3.21	077	2.21
Plant density (P)							
P1: 56.000 plant fed^{-1}		69.55	67.67	61.87	60.11	44.29	42.21
P2: 72.000 plant fed^{-1}		73.00	68.34	69.78	66.00	47.48	45.32
P3: 84.000 plant fed^{-1}		82.33	78.00	59.11	56.33	43.74	41.21
LSD at 5%		2.20	3.44	3.87	5.47	3.00	1.73
Planting dates × plant density (D × P)							
D1	P1	89.33	80.67	74.67	73.33	52.33	49.03
	P2	101.33	96.67	82.67	79.67	56.03	53.01
	P3	112.33	109.67	66.67	67.33	51.73	47.67
D2	P1	68.67	69.33	60.60	58.00	47.67	46.47
	P2	70.33	61.67	68.66	69.00	49.93	47.93
	P3	76.00	69.66	58.33	56.33	46.43	44.97
D3	P1	50.66	53.00	50.33	49.00	32.87	31.13
	P2	47.33	46.67	58.00	49.33	36.47	34.93
	P3	58.67	54.67	52.33	45.33	33.07	31.00
LSD at 5%		3.81	5.96	6.70	NS	NS	NS

Sowing date had a significant impact on vegetative growth traits in the two growing seasons. The Planting quinoa on 10th October (D_1) recorded maximum value for plant height (101.00 and 95.67cm), number of leaves $plant^{-1}$ (74.44 and 75.44 leaves) and total chlorophyll (53.37 and 49.93) in 2018-19 and 2019-20 seasons, respectively.

While the lowest values (52.22 and 51.44 cm), (53.55 and 47.89) and (34.13 and 32.36) were determined in the last sowing date (D_3) on the aforementioned traits in both seasons, respectively. The desirable influence of sowing quinoa on 10th October mainly due to the seasonable environmental conditions prevailing during crop growth period which allow to positively affect the vegetative growth of quinoa. Decrease in height of plant on late sowing was due to less production of photosynthates due to shorter growing period. In this context, Temel and Yolcu (2020) indicated that the tallest plant height was observed in the first sowing date, while the shortest height was determined in the last sowing date. So, Ramesh (2017) evident that the vegetative growth traits depending on changing climate factors. These results agreed with the findings of Shams and Galal (2014), Biswas and Tanni (2020) and Nagib *et al.* (2020).

Data in Table 1 it was show that the plant density significantly affected on all vegetative growth traits in both seasons. The highest values of plant height (82.33 and 78.00 cm) produced with plant density (84.000 plant fed^{-1}) in both seasons, while plant density (72.000 plant fed^{-1}) recorded maximum value for number of leaves plant^{-1} (69.78 and 66.00 leaves) and total chlorophyll (47.48 and 45.32) in the 1st and 2nd seasons, respectively. Increasing density from 56.000 to 84.000 plant fed^{-1} leads to increased height of plant with (18.69 and 15.27%) in the first and second seasons, respectively. Quinoa plant has the capability to repay for the height to sowing density (Spehar and Rocha, 2009). Sief *et al*. (2015) they evidenced that plant height increased with the increase in the plant population. Sokoto and Johnbosco (2017) reported that the impact of seed rate on plant height for amaranths increased with increase in seed rate. Height of plant by increasing plant density may be due to the competition on inputs among the plants such as light, radiation, water and etc. under the stress of density. Additionally, Moshaver *et al.* (2017) reported that in high plant density, the size of leaf was lower. Several investigators support our results such as Yarnia *et al.* (2011), Ciftci *et al*. (2020), Minh *et al.* (2020) and Nagib *et al*. (2020).

Concerning the interaction between sowing dates and plant density (D×P) had a significant effect on plant height in both seasons, number of leaves plant^{-1} in 1st season (Table 2 and Fig. 1). On contrary, number of leaves plant^{-1} did not significantly response to sowing date in 2nd season and total chlorophyll in both seasons. Nagib *et al.* (2020) found that interaction among sowing dates and plant spacing was significant on plant height in both seasons.

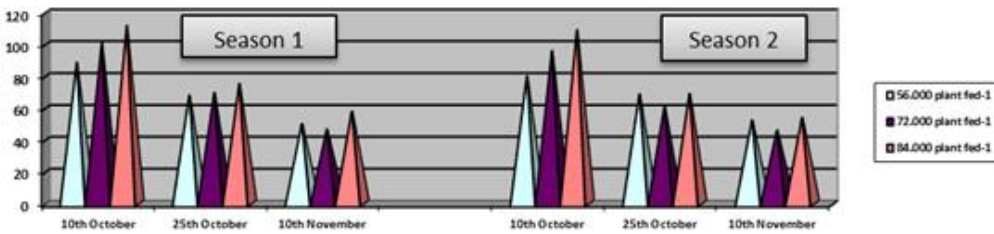

Fig. 1. Effect of interaction between planting dates and plant density on plant height during 2018-19 and 2019-20 season.

2- Yield and its components:

Data presented in Table 2 the three tested sowing dates significantly affected number of inflorescence plant^{-1}, 1000-seed weight and seed yield in both seasons. The highest mean values of mentioned traits were recorded by the plants sown at the first sowing date (10th October) in both seasons. The lowest mean values of all traits were obtained by quinoa plants sown on 10th November (the 3rd sowing date).

The earlier sowing date of 10th October (D_1) leads to increased number of inflorescence plant^{-1} with (59.72 and 74.66%), 1000-seed weight (21.57 and 17.94%) and seed yield (87.18 and 78.91%) compared with the sowing on 10th November (D_3), in the 1st and 2nd seasons, respectively. Miri (2016) showed that the highest seed yield was obtained from sowing quinoa on 10-October. Zamin (2017) tested three sowing dates (10th November, 10th December, 10th January and 10th March) on seed weight of quinoa and found that the maximum seed weight (131.76 kg ha^{-1}) was recorded by (November-10) and the minimum seed weight (11.40 kg ha^{-1}) was recorded by (March-10). The increase in yield and its components at the first sowing date might be ascribed to prolonging vegetative growth stage resulting in more leaf number, tillers formation and leaf area, which led to in more photosynthetic production and consequently increased yield components (number of inflorescence plant^{-1} and 1000-seed weight) and in turn increased seed yield. Moreover, seed yield is a complex character, which is controlling by a many genes and is strongly affected by the climatic conditions. Biswas and Tanni (2020) revealed that the highest 1000-seed weight (2.56 g) and seed yield (1.09 ton ha^{-1}) were exhibited by November-10 sowing. Similar results were recorded by Hakan *et al*. (2014), Sajjad *et al*. (2014), Ramesh *et al*. (2017), Nagib *et al*. (2020), Temel and Yolcu (2020) and Khanalizadegan *et al*. (2021).

The statistical analysis showed significant differences among plant density number of inflorescence plant^{-1} and 1000-seed weight in both seasons, but seed yield was insignificant in the first season (Table 2). The obtained results clearly showed that the increase in plant density led to significant increase in yield and its components. seed yield under high plant density (84.000 plant fed^{-1}) significantly increased by (39.83 and 50.38%) as compared with the low plant density (56.000 plant fed^{-1}) in the 1st and 2nd seasons, respectively. The increase in seed yield fed^{-1} by increasing the plant density from 56.000 to 84.000 plant fed^{-1} may be attributed to increases in number of inflorescence per unit area as the result of increased plant density. These differences may be due to that the high density under 84.000 plant fed^{-1} would allow more efficient available sunlight, moisture and nutrients, as well as tend to increase in height rather than developing branches and leaves plant^{-1}. Decrease in the number of plants m^{-2} led to a decrease in seed yield of quinoa (Geren *et al*., 2015). Pourfarid *et al*. (2014) revealed that the grain yield of amaranth recorded significantly higher at plant density of 140 plants m^{-2} (1.04 kg ha^{-1}) than plant density was 17 plants m^{-2} (0.18 kg ha^{-1}), 35 plants m^{-2} (0.29 kg ha^{-1}) , 70 plants m^{-2} (0.73 kg ha^{-1}) plants m^{-2}. In else study (Oduwaye *et al*., 2016) also found seed yield increased ha^{-1} gradually with densities increase. These results are in harmony with those obtained by Eisa *et al*. (2018), EL-Tahan *et al*. (2019), Ebisa *et al*. (2020), Ciftci *et al*. (2020) and Zulkadir *et al*. (2020). Contrariwise, planting 56.000 plant fed^{-1} increased number of inflorescence plant^{-1} by (35.41 and 19.80%) and 1000-seed weight by (17.11 and 21.40%) in the first and second seasons, respectively, compared with 84.000 plant fed^{-1} treatment. The reduction of number of inflorescence plant^{-1} under sowing density of 84.000 plant fed^{-1} was probably due to increased competition plant to plant led to decreased branching in the plants. Minh *et al*. (2020) they found that number of inflorescence plant^{-1} was increase at lower sowing density. The superiority of 56.000 plant fed^{-1} treatment in 1000-seed weight may be due to low intra-specific competition among seed quinoa plants under low plant density in turn enhancing the most plant growth traits consequently. Furthermore, this enables plants to make good use of the environmental resources, that is reflected on yield components. Size of seed of quinoa is very important trait for world market demand (Eisa *et al*., 2018). Correspondingly (Oduwaye *et al*., 2016) ascribed that increasing plant density led a significant decrease in the weight of 1000-seeds. These results are supported by findings of Pourfarid *et al*. (2014), Sief *et al*. (2015), Ebisa *et al*. (2020), Minh *et al*. (2020), Nagib *et al*. (2020) and Diaz *et al*. (2021).

The interaction effect of sowing dates (D) and plant density (P) on number of inflorescence plant^{-1} and seed yield were significant in both seasons, but 1000-seed weight in first season only (Table 2 and Fig.2). Data in Table 4 showed that early sowing date (10th October) combined with plant density (84.000 plant fed^{-1}) gave the highest values in seed yield (753.60 and 767.93 kg fed^{-1}) in 2018-19 and 2019-20 seasons, respectively, while early sowing date (10th October) combined with plant density (56.000 plant fed^{-1}) obtained the highest values in 1000-seed weight (3.47 and 3.36 g) and number of inflorescence plant^{-1} (11.33 and 12.33) in both seasons. Ramesh *et al*. (2017) mentioned that sowing quinoa at 1st date (15th October) along with narrow (15×10 cm) spacing gave the maximum seed yield .

Table 2. Means of yield and its components of quinoa as affected by planting dates, plant density and their interactions during 2018-19 and 2019-20 seasons.

Traits		Number of inflorescence plant^{-1}		1000-seed weight (g)		Seed yield (kg fed^{-1})	
		2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
Planting dates (D)							
D1: 10th October		10.11	11.44	3.10	3.09	643.92	611.89
D2: 25th October		8.22	7.78	2.82	2.83	459.96	459.92
D3: 10th November		6.33	6.55	2.55	2.62	344.01	342.01
LSD at 5%		1.18	0.84	0.17	0.11	89.83	42.88
Plant density (P)							
P1: 56.000 plant fed^{-1}		9.33	9.44	3.08	3.12	400.87	376.58
P2: 72.000 plant fed^{-1}		8.33	8.44	2.78	2.86	486.48	470.96
P3: 84.000 plant fed^{-1}		6.89	7.88	2.63	2.57	560.54	566.29
LSD at 5%		0.69	0.84	0.13	0.10	NS	40.04
Planting dates × plant density (D × P)							
D1	P1	11.33	12.33	3.47	3.36	516.20	447.90
	P2	11.00	11.67	3.00	3.13	661.97	619.83
	P3	8.00	10.33	2.87	2.80	753.60	767.93
D2	P1	9.67	8.67	2.97	3.23	404.20	403.50
	P2	8.00	7.67	2.77	2.93	453.37	441.17
	P3	7.00	7.00	2.73	2.33	522.30	535.10
D3	P1	7.00	7.33	2.80	2.77	282.20	278.33
	P2	6.33	6.00	2.57	2.52	344.10	351.87
	P3	5.67	6.33	2.30	2.57	405.73	395.83
LSD at 5%		1.20	NS	0.23	0.17	138.30	70.16

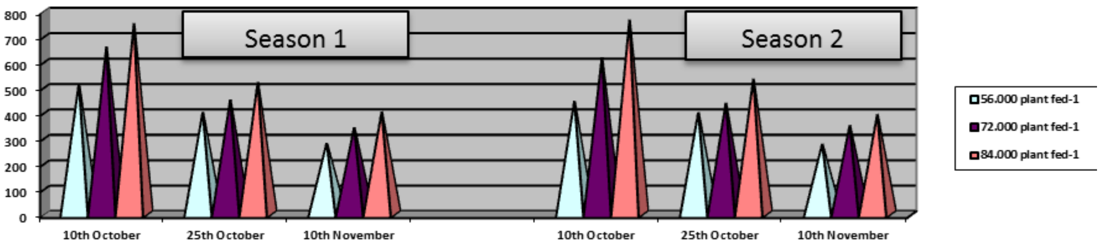

Fig. 2. Effect of interaction between planting dates and plant density on seed yield during 2018-19 and 2019-20 season.

3- Chemical composition of seed :

Data in Table (3) illustrate the impact of sowing dates and plant density on some chemical constituents *viz.* protein % and carbohydrates % of quinoa seed.

Significant differences were found among sowing dates, plant density and their interaction on all studied traits in both seasons. Sowing of quinoa at 10th October significantly ameliorated saponin and protein percentages of quinoa seeds (Table 3) by (47.19 and 27.00%) and (15.66 and 13.05%) as compared to the 3rd sowing (10th November) in the first and second seasons, respectively. Proper planting date may enhance biosynthesis processes, photosynthesis and completes the seed ripening process to obtain maximize the yield consequently, reduce the risk of unfavorable environmental conditions and improves the quality of the seeds (Ning *et al*., 2020). Yarnia *et al*. (2010) and Altuner *et al*. (2019) exhibited that the protein percentage in amaranth seeds decreased significantly by delay in sowing date. For the effect of sowing date, the data exhibited that the mean values of carbohydrate % were 35.14, 49.58 and 60.08% in the first season and 35.96, 48.83 and 58.69% in the second season under 1st , 2nd and 3rd sowing date, respectively.

The effect of plant density on all studied traits in quinoa seeds were significantly in both growing seasons. Gradual increases in the concentrations of saponin and carbohydrates was associated with increasing plant density up to 84.000 plant fed^{-1}. Maximum saponin (3.55 and 3.50%) and carbohydrates (60.08 and 58.69%) were obtained under 84.000 plant fed^{-1} in the first and second seasons, respectively, which was significantly higher over other densities.

According to the values obtained in both seasons, the ration of protein content varies between (9.46 to 10.12%) in 2018-19 and (10.06 to 10.96%) in 2019-20, and the highest protein % (10.12 and 10.96%) was obtained from (P_1) 56.000 plant fed^{-1} and the lowest protein% (9.46 and 10.06%) was resulted from (P_2) 84.000 plant fed^{-1} in the 1st and 2nd seasons, respectively in the study of different plant density for quinoa plant. Increasing plant density led to decrease in the seed protein content of quinoa (Sief *et al*., 2015, Ciftci *et al*., 2020 and Minh *et al*., 2020). Protein concentration in seed increased at low planting density, whereas carbohydrate concentration decreased (Eisa *et al*., 2018). The increase in protein concentration might be due to more availability for nutrients in soil and less competition between plants under low density which led to better chance for quinoa plant to absorb such nutrients.Crude protein and carbohydrates contents of quinoa were 13.97 and 68.12%, respectively (Shams and Galal, 2014).

Table 3. Means of Chemical compositions of seeds quinoa as affected by planting dates, plant density and their interactions during 2018-19 and 2019-20 seasons.

Traits		Saponin %		Protein %		Carbohydrates %	
		2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
Planting dates (D)							
D1: 10th October		3.93	3.81	10.56	11.09	35.14	35.96
D2: 25th October		3.60	3.24	9.66	10.68	49.58	48.83
D3: 10th November		2.67	3.00	9.13	9.81	60.08	58.69
LSD at 5%		0.28	0.36	0.47	0.53	3.11	6.38
Plant density (P)							
P1: 56.000 plant fed-1		3.19	3.31	10.12	10.96	43.73	44.23
P2: 72.000 plant fed-1		3.44	3.49	9.77	10.55	47.40	46.82
P3: 84.000 plant fed-1		3.55	3.50	9.46	10.06	53.65	52.43
LSD at 5%		0.26	0.23	0.06	0.02	2.89	3.89
Planting dates × plant density (D × P)							
D1	P1	3.79	3.89	10.75	11.68	28.24	31.67
	P2	4.05	3.67	10.72	11.10	33.58	33.10
	P3	3.94	3.88	10.20	10.50	43.61	43.13
D2	P1	3.48	3.34	10.04	11.20	45.17	44.77
	P2	3.68	3.25	9.54	10.74	50.06	50.07
	P3	3.65	3.14	9.40	10.09	53.50	51.67
D3	P1	2.34	3.25	9.57	10.01	57.78	56.26
	P2	2.59	3.00	9.05	9.81	58.60	57.30
	P3	3.07	3.24	8.78	9.60	63.85	62.50
LSD at 5%		0.45	NS	1.10	1.08	5.01	NS

Interaction between sowing date and plant density showed on protein in both seasons, but saponin and carbohydrate on first season only (Table 3 and Fig.3). The highest protein % (10.75 and 11.68%) was found in $D_1 \times P_1$ in both seasons, carbohydrate % (63.85 %) was produced from $D_3 \times P_3$ in first season and saponin % (4.05) was obtained by $D_1 \times P_2$ in 1st season.

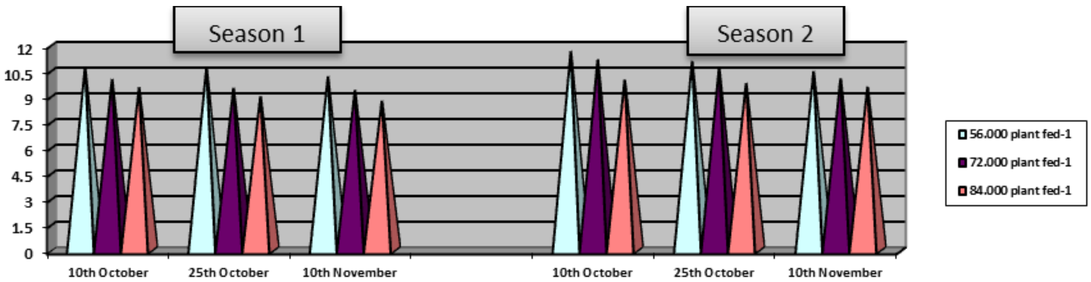

Fig. 3. Effect of interaction between planting dates and plant density on protein percentage during 2018-19 and 2019-20 season

CONCLUSION

According to the results of this study, it concluded that planting quinoa plants (*cv*. Regalona) on 10th October with density 84.000 plant^{-1} led to a significant increase in most of the studied traits of growth, production and quality of the quinoa crop under the climatic conditions of Aswan Governorate.

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إستجابة محصول الكينوا والمكونات الكيميائية للبذور لمواعيد الزراعة والكثافات النباتية تحت الظروف المناخية لمحافظة أسوان

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تم إجراء التجربة بالمزرعة البحثية بكلية الزراعة والموارد الطبيعية جامعة أسوان خلال موسمي الزراعة ٢٠١٨-٢٠١٩ ، ٢٠١٩- ٢٠٢٠وذلك لتحديد مواعد الزراعة المناسب والكثافة النباتية المثلى وتأثيرهم على نمو وإنتاجية وجودة صنف الكينوا ريجلونا تحت ظروف التربة الرملية واستخدام نظام الري بالتنقيط .حيث اشتملت الدراسة على ثلاث مواعيد زراعة و ثلاث كثافات نباتية. مواعيد الزراعة : (الميعاد الأول : ١٠ أكتوبر ، الميعاد الثاني: ٢٥ أكتوبر والميعاد الثالث: ١٠ نوفمبر). كثافات نباتية : (٥٦ ألف نبات لكل فدان ، ٧٠ ألف نبات لكل فدان و ٨٤ ألف نبات لكل فدان). أي مجموع المعاملات ٩ ونفذت بتصميم قطاعات كاملة العشوائية فى ثلاث مكررات مرتبة فى قطع منشقة حيث خصصت القطع الرئيسية لمواعيد الزراعة والقطع المنشقة للكثافات النباتية ز أوضحت النتائج أن زراعة الكينوا في العاشر من أكتوبر أعطت أعلى القيم لارتفاع للنبات ، وعدد النورات لكل نبات ، ووزن ١٠٠٠ بذرة ، ومحصول البذور للفدان ، وصفات الجودة في كلا الموسمين. أدى تأخير الزراعة إلى زيادة تركيز الكربوهيدرات في البذور. أظهرت الكثافة النباتية تأثير معنوي لجميع الصفات التي تم دراستها خلال الموسمين. زاد محصول البذور بنسبة (٣٩,٨٣ و ٥٠,٣٨٪) بزيادة الكثافة النباتية من ٥٦,٠٠٠ إلى ٨٤,٠٠٠ نبات للفدان في الموسمين الأول والثاني على التوالي. كما أدت زيادة الكثافة النباتية إلى انخفاض معنوي في وزن الألف بذرة ونسبة البروتين في موسمي الدراسة. سجل التداخل بين مواعيد الزراعة وكثافة النبات (D × P) أعلى محصول بذور للفدان في ميعاد الزراعة الأول (١٠ أكتوبر) بكثافة نباتية ٨٤ الف نبات للفدان (٧٥٣,٦٠ و ٧٦٧,٩٣ كجم لكل فدان) في كلا الموسمين. . أعلى محتوى بروتين للبذور نتج من الزراعة في ١٠ أكتوبر بكثافة ٥٦,٠٠٠ فدان نباتي. أخيرًا ، توصى الدراسة بزراعة صنف الكينوا Regalona في ١٠ أكتوبر بكثافة نباتية ٨٤ ألف نبات فدان لتعظيم إنتاجية وجودة البذور في ظل الظروف المناخية السائدة في محافظة أسوان.