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IMPACT OF SOWING DATE AND PLANT DISTRIBUTION ON GROWTH, YIELD, ITS ATTRIBUTES AND QUALITY CHARACTERS OF QUINOA (*CHENOPODIUM* QUINOA, WILLD.).

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ABSTRACT

Two trails were conducted during 2019/2020 and 2020/2021 seasons, to investigate the influence of four planting date and four plant distribution treatments on quinoa growth, yield, its attributes and quality. Each experiment was performed in randomized complete blocks design (RCBD) in a split-plot arrangement with three replications. Sowing dates were allocated in the main plots and plant distributions were assigned to the sub-plots in both seasons. The results indicated that, the planting date in both seasons significantly affected all studied traits except P.H.(cm.) and H.I. in the 1st one. The fourth planting date (a_4) recorded the highest seed yield /plant of 39.49 and 57.30 g., seed yield /fed. of 1.82 and 2.58 ton in both seasons., biological yield/fed. of 5.99 ton and harvest index43.18% in the second season, as well as improved all studied quality traits in both seasons except seed moisture% in the second one. Plant distributions treatment possessed highly significant effect on plan height, main panicle length cm., seed yield/plant (g.) and S.Y /f.(ton) in 2nd season, all quality parameters in both seasons and significant effect only on plan height in the first season, the third plant distribution treatment (b_3) improved seed yield/plant of 51.75 (g.) and S.Y /f. of 2.33(ton) in the 2nd one.

Keywords: Sowing date, Quinoa, plant distribution, yield components, protein % and saponin %.

INTRODUCTION

Quinoa (*Chenopodium quinoa,* Willd.) belongs to the Chenopodiaceae family and it is a dicotyledonous plant . Quinoa planting mainly for an edible purpose like cereals in South America in Colombia, Peru, Argentina, Chile, and Bolivia (**Fuentes *et al.*2012; Ruiz *et al.*2014 and Prager *et al.*2018**),. Being it is a seed crop rather than a true cereal, quinoa is termed a pseudo-cereal **(Valencia-Chamorro 2003; Graf *et al.*2015;Awadalla and Morsy 2017 and Rabbani *et al.*2022)**. Quinoa seeds have high nutritive value, and it is a food crop recently introduced in Egyptian lands. So, seeds could be used in the bread industry as a mixture or a substitute of wheat grains (**FAO 1998; Jacobsen, 2003; Bhargava *et al.*2007; Shams, 2010 and Sharma *et al.*2015**). Moreover, quinoa is considered a multi-purpose crop due to the high-quality protein seeds, while it is rich in essential minerals, carbohydrates, amino acids, antioxidant compounds such as vitamin C carotenoids, flavonoids and dietary fiber compared to that of cereals such as wheat , maize, oat and rice. **(Abugoch, 2009; Repo-Carrasco *et al.*2011 and Escuredo *et al.*2014)**. **Jancurová *et al.*2009; Maradini-Filho *et al.*2017 and Dakhili *et al.*2019** cleared that quinoa seeds had nearly 59% carbohydrates, 14 % protein, 6.5% crude fat and 3% ash in addition it is an alternative source to gluten-free cereals, **(Jancurová *et al.*2009 ; Maradini-Filho *et al.*2017 and Dakhili *et al.*2019)**. Thus, quinoa is a potential a promising crop that could play a vital role in climate change adaptation and mitigation in the Egypt's agriculture sector,

Crops productivity in each region mainly depends on sowing date, so it is consider the critical step in the crop farming system for determining the most suitable sowing date. **Jacobsen *et al.*(2003); Ujiie *et al. (*2007); Hirich *et al. (*2014); Katsunori *et al.* (2016) and Awadalla, and Morsy (2017)** indicated that quinoa is a crop with a range of requirements for air temperature and humidity with diverse ecotypes adapted to different conditions, and quinoa seed yield varied according to sowing dates. Furthermore, planting dates playing a major role for some quinoa genotypes in its production (**Rabbani *et al.*2022)**. Quinoa response to sowing date led to the variance in genetic makeup, phonological and growth characteristics were high significantly affected by sowing date as compared to other crop characters **(Hinojosa *et al.*2018 and Jahanbkhsh *et al.*2020)**. In Egypt, **Nagib *et al.* (2020)** cleared that planting quinoa at the middle of November had improved growth, yield and its attributes. Moreover **Nurse *et al.* (2016)** illustrated that quinoa reached physiological maturity and produced yield when sowing date varied from 15 /5 to 30 / 6, however the yield decreased by more than 50% in late sowing date because it did not mature before the first frost.

Plant density plays a vital role for successful crop production to produce sufficient yield from the lowest possible area and energy inputs *i.e*., light intensity **(Cha *et al.*2016 and Rabbani *et al.*2022**). However, the amount of light reaching to plant canopy and absorbed by the photosynthesis process determined by plant distribution (**Francescangeli *et al.*2006 and Eisa *et***

***al.* 2018)**. Under high planting densities intra-species competition increased so, quinoa seed yield was reduced (**Xia *et al.*2019)**. On the contrary, in low planting densities, seed yield was reduced because the environmental facilities (*i.e.,* light, space, water and soil) are not optimally used**. Van Minh *et al.* (2020)** indicated that plant density had a significant effect on seed yield, number of panicle/plants and seed quality traits and they revealed that eight plants /m^2 is the optimal planting density for quinoa. **Sangoi *et al.* (2000**) indicated that to maximize the utilization of available resources and improving potential yield, optimum plant population should be adopted. However, the maximum economic grain yield varies depending on various factors like variety, plant growth habit, climatic conditions and soil fertility as well as agronomical practices so, there is no single recommendation for all environments (**Carbone-Risi, 1986; Santos, 1996)** . Consequence, **Gęsiński, (2018)** indicated tha**t** the seeding rate was increased from 2 kg./ha to 3 kg./ha resulting higher yield of quinoa. **Al Jbawi *et al.* (2020)** recorded that the best morphological and production characters achieved by sown quinoa on 0.5m between hills using 100.000, 133.000 and 200.000 plants / ha. **EL-Tahan *et al.*(2019)** exhibited that seed yield/ ha increased by 68.17 and 59.60% in the 1^{st} and 2^{nd} seasons, respectively when increasing of plant spacing from 15 to 25 cm.

Therefore, this investigation aimed to explore the effect of sowing date and plant distributions on growth, seed yield and its attributes, as well as seed quinoa quality traits under El-Minia Governorate conditions.

MATERIALS AND METHODS

Two field experiments were conducted at the Experimental Farm of Faculty of Agriculture, Minia University, Egypt latitude of 28º18'16"N and longitude of 30º34'38"E and altitude of 49 m above sea level during 2019/20 and 2020/21 seasons.

The following factors were investigated:

1. Sowing dates: four sowing dates were tasted: 15Oct. (a_1), 1 Nov. (a_2), 15 Nov. (a_3) and 1 Des. (a_4).
2. Plant distribution treatments: four patterns were used: two plants/hill 20cm. apart on one side of furrow 60cm in width (b_1), one plant/hill 10cm. apart on one side of furrow 60cm in width (b_2), one plant/hill 20cm. apart on both side of furrow 60cm in width (b_3) and two plants/hill 40cm. apart on both sides of furrow 60cm in width (b_4).

Each experiment was designed as randomized complete block design (RCBD) in a split plot arrangement with three replications. sowing date was assigned to the main plots, while sub-plots were devoted to plant distribution treatments. Experimental plots consisted of 5 ridges; they were 3.5 m long and 60 cm wide (10.5 m^2). Quinoa seeds variety Denish KVL 3704 was supplied from the Royal Faculty of Agriculture, Copenhagen. Quinoa plants were harvested at the beginning of maturity when seeds can barely be dented with a fingernail and plants began turned to pale yellow or red color where leaves dropped, and the seeds threshed easily by hand. The preceding summer crop was soybean (*glycine max* L. Merr.) in both seasons. All the other agronomic practices were applied according to the recommendations.

The soil of each experimental unit was fertilized with calcium super phosphate 15.5% P_2O_5 at the rate of 100 kg /fed. added during soil preparation. Nitrogen fertilizer was used in the form of ammonia nitrate (33.5 % N) at rate of 33.5 kg N /fed, in 2 equal doses, the 1st dose after thinning and the 2nd was applied after one month later. Potassium (K) was applied with the 1st nitrogen dose at the rate of 50 kg K_2O/fed in form of potassium sulfate 48-52% K_2O.

Weeding was conducted manually by hand hoeing and/or by heading until quinoa plants reached its full growth, controlling of best and disease were regularly carried out.

To estimate some physiochemical characteristics of the studded site, samples of soil were taken from zero to 30cm depth before sowing and were analyzed according to **Page (1982).**

Some physiochemical analysis of the experimental soil in both seasons are shown in Table (1).

The climatic data of the investigation site during the two seasons was obtained from the meteorological station of Mallawy Agric. Res., station as shown in Table (2).

Table 1 : Some physiochemical analysis of the tested soil samples.

Chemical analysis	**Value**	**Physical analysis**	**Value**
PH (1:2.5 water)	7.70	Field Capacity %	42.46
CaCo3(g kg-1)	17.90	Permanent wilting point %	13.77
CEC (cmolc kg-1)	37.88	Water Hold Capacity %	48.77
EC (dS m-1 at 25 0C)	1.34	Available water %	28.68
Organic Matter (g kg -1)	28.60	Sand %	28.90
Total N (g kg -1)	1.28	Soil texture	Clay loam
Organic N (g kg -1)	0.75		

Table 2: Meteorological parameters for El-Minia region during the growing seasons 2019/20 and 2020/21.

Season / **Month**	**2019/20**			**2020/21**		
	Air temperature (T)		**Relative Humidity (RH%)**	**Air temperature (T)**		**Relative Humidity (RH%)**
	Min-T	Max-T		Min-T	Max-T	
September	18.52	31.70	58.42	21.3	33.30	75.11
October	16.50	30.72	62.40	12.60	27.60	79.40
November	4.10	29.70	79.90	8.80	23.90	77.10
December	7.46	21.80	75.30	5.30	21.80	71.20
January	3.58	20.53	73.16	6.30	20.30	67.50
February	5.44	21.70	67.80	7.30	24.20	80.90
March	7.90	25.70	56.30	11.90	29.12	69.60
April	21.80	28.80	53.70	18.50	36.30	41.80
May	18.30	36.90	42.90	17.10	35.30	75.10

Recorded data:

I- Yield and yield components characters:

At maturity, two inner furrows from each plot were harvested and ten plants were taken randomly to record the following yield components traits:

1- Plant height (cm.)P.*H*: The length of the main stem from the soil surface up to the top of plant.

2-Main panicle length (cm.)M.P.L .

3- Number of panicles /plant N.P/P.

4- Seed yield/plant (g.)S.Y/P.

5- Weight of 1000-seed (g.)S.I: The average of three samples/plot.

6- Seed yield/fed. (ton)S.Y: Estimated on the basis of two inner furrows of $4.2m^2$ of each sub-plot in kg. , then transformed into ton/fed.

7- Biological yield/fed.(ton) B.Y: Determined by weight the plants of two inner furrows of $4.2m^2$ of each sub-plot in kg. , then transformed into ton/fed.

8- Foliage yield/fed. (ton) FOL.Y: Estimated by subtracting seed yield (ton/fed.) from biological yield (ton/fed.).

9- Harvest index H.I: Was estimated according the following equation:

Harvest index= seed yield ton/fed. /biological yield ton/fed. ×100.

II- Chemical characters:

A sample of 100 g. seeds from each unit taken randomly to estimate the following traits:

1- Protein percentage:

Calculate the protein nitrogen (mg N/ g sample) according to **Beljkas, *et al.*(2010)** as follows-:

Protein nitrogen= $(b-a) \times 0.1 \times 14.00 / W_s$

Where:

W_s = volume (ml) of sample or weight (g).

a = the volume (ml) of 0.1N H2SO4 used in blank titration.

b = the volume (ml) of 0.1N H2SO4 used in sample titration.

14.00 = nitrogen atomic weight .

2- Saponin percentage (S%):

Extraction the saponin read it at 528 nm in a spectrophotometer (Spectronic20D). Quantification was performed with a standard saponin% curve (50–350 μg/mL) and the results were expressed as % dry sample. According to **Nickel, *et al*.(2016).**

3- Moisture percentage in quinoa seeds (S.M%):

Moisture % was calculated as the following equation:

Moisture (g /100 g) = (Sample before drying - sample after drying) / Sample before drying * 100. According to the manner of **A.O.A.C.,(2002)**.

Statistical analysis:

Regular analysis of the variance of the split-plot design with three replications for the recorded data of each season was performed for each trait using the MSTAT-C Statistical Package. Treatment means were compared by the least significant differences (L.S.D) test at a 5% level of probability to compare differences between the means according to **Gomez and Gomez (1984).**

RESULTS AND DISCUSSION

I- Effect of sowing date on seed yield and quality attributes of quinoa.

I-1- Quinoa seed yield and components

Data in Table (3) showed that planting date exhibited significant and highly significant effects for all studied yield traits in both seasons except plan height cm. and harvest index in the first season. The first planting date (a_1) recorded tallest M.P.L (12.21 cm) and P.H (144.43 cm) in the first and second seasons, respectively, while recorded lower yield of seed/plant (27.90$_g$ and 45.65$_g$), seed/fed. (1.39 and 2.05 ton) and foliage/fed. (1.64 and 2.87 ton) in 1st and 2nd seasons, respectively. The 2nd planting date (a_2) recorded the highest seed index (2.53g) and foliage yield /fed. (3.69 ton) in the 2nd season, but recorded the shortest panicle length (10.64cm) in the 1st season . The 3rd sowing date (a_3) showed the highest number of panicles/ plant (7.39 and 28.98) in both seasons, whereas recorded the highest SI (2.31g), B.Y (3.88 ton) and Fol. Y (2.13 ton) in the 1st season. The fourth planting date (a_4) improved seed yield /plant of 39.49 and 57.30 g., seed yield /fed. of 1.82 and 2.58 ton in both seasons, biological yield/fed. of 5.99 ton and harvest index43.18% in the second season, also recorded less values for plant height of 137.58 cm., seed index of 2.06g. in the second season and number of panicles/ plants of 6.64and 19.33 in both seasons. It may be concluded that the performance of quinoa traits is differently influenced by seasonal changes in environmental conditions. These results coincided with those obtained by **Jacobsen *et al.*2003; Ujiie *et al.*2007; Hirich *et al.*2014 ; Katsunori *et al.*2016 ; Awadalla and Morsy 2017 and Rabbani *et al.*2022**

I-2- Seed quality parameters

The effects of planting dates were significant and highly significant for all studied seed quality traits in both seasons (Table 3). The 4th sowing date (a_4) improved all quality attributes in both seasons except S.M% in the second one, whilst exhibited favorable percentages for P% (17.10&17.65%) and S% (1.15 &1.38%) in the first and second seasons, respectively. The 3rd sowing date recorded unfavorable percentages for P % (16.41 & 16.96%) and the lowest S.M% (6.47& 6.90%) in 1st and 2nd season, respectively. These results might be attributed to climatic conditions; high air and soil temperature and low relative humidity at early planting date are suitable for increase of saponin content, moisture percentage and decreased protein percentage in quinoa seeds, thus It may be concluded that delaying quinoa planting to the beginning of December leads to a decline of seed saponin percentage. These results are in harmony with those obtained by **Nurse *et al.*2016; Jahanbkhsh *et al.*2020 and Nagib *et al.*2020.**

Table 3: Effect of sowing date on yield, yield components and quality of quinoa in 2019/2020 and 2020/2021 seasons.

A- planting date	P.H	M.P.L	N.P/P	S.Y/P	S.I	S.Y	B.Y	Fol. Y	H.I	P%	S%	S.M%
	2019 /2020 season											
a_1	32.63	12.21	6.77	27.90	1.74	1.39	3.03	1.64	46.26	16.74	1.70	6.66
a_2	34.05	10.64	6.75	36.01	1.92	1.74	3.79	2.05	45.99	16.93	1.39	6.80
a_3	34.09	11.35	7.39	36.28	2.31	1.75	3.88	2.13	45.04	16.41	1.26	6.47
a_4	36.59	11.46	6.64	39.49	1.87	1.82	3.86	2.04	47.19	17.10	1.15	6.55
F-test	NS	*	*	**	**	**	**	**	NS	*	**	**
LSD $_{0.05}$	-	1.18	0.44	4.90	0.17	0.08	0.27	0.28	-	0.41	0.25	0.15
	2020/ /2021season											
a_1	144.43	22.86	22.08	45.65	2.51	2.05	4.92	2.87	42.32	17.29	1.92	7.09
7.23	1.61	17.48	36.43	3.69	5.80	2.11	2.53	46.97	22.99	26.39	142.19	**a_2**
6.90	1.48	16.96	39.34	3.62	5.96	2.35	2.37	52.16	28.98	29.32	142.04	**a_3**
6.98	1.38	17.65	43.18	3.41	5.99	2.58	2.06	57.30	19.33	28.29	137.58	**a_4**
**	**	*	**	**	**	**	**	**	**	**	*	**F-test**
0.15	0.25	0.41	1.45	0.16	0.19	0.10	0.07	2.31	0.39	1.21	3.65	**LSD $_{0.05}$**

P.H =Plant height at harvest (cm.) ; M.P.L = Main panicles length at harvest (cm.); N.P/P = Number of panicles /plant at harvest ; S.Y/P = Seed yield/plant at harvest (g.); S.I =1000 seed weight at harvest (g.) ; S.Y = Seed yield /fed.(ton); B.Y = Biological yield /fed.(ton); Fol. Y= Foliage yield /fed.(ton); H.I= Harvest index; P%= Protein percentage; S%=Saponin percentage and S.M%= Seed moisture %.

Ns, *and ** indicate insignificant, significant at 0.05 and significant at 0.01 level, respectively.

II- Effect of plant distribution patterns on yield, yield components and quality of quinoa:

II-1- Quinoa seed yield and components

The plant distribution patterns were highly significant for P.H, whereas they didn't reach the level of significance for studied yield attributes in the 1st season (Table 4). For the 2nd season, the patterns of plant distribution did not significantly affect most of the quinoa yield traits. The tallest plants were obtained by b_1 and b_4, while the shortest plants were detected by b_3 in both seasons. The 3rd plant distribution (b_3) recorded the highest N.P/P and S.Y/P in both seasons, while the 1st plant distribution (b_1) exhibited lower performance for all tabulated traits than all other investigate patterns in 2nd season. However, the 2nd plant distribution treatment (b_2) recorded the tallest main panicle of 27.45cm. followed without significant differences by b_3 meanwhile, the shortest main panicle of 26.04cm. obtained by b_4 in the second season. Such effect may be due to the competition between two quinoa plants in the same hill and side of the furrow for nutrients and light, decreasing the individual plant's ability to increase seed size and weight which is reflected in seed yield /plant and seed yield /fed, also increase plant height and panicle length. These results are in agreement with those obtained by **Francescangeli *et al.*2006; Eisa *et al.*2018**; **EL-Tahan *et al.*2019; Xia *et al.*2019; Van Minh *et al.*2020**; **Nagib *et al.*2020 and** Rabbani ***et al.*2022.**

II-2- Seed quality parameters

The effects of plant distribution treatments were highly significant on all quality parameters in both seasons (Table 4). The fourth plant distribution treatment (b_4) increased protein % in both seasons of 17.23 and 17.78%, while the 3rd plant distribution treatment (b_3) decreased this trait in both seasons of 16.16 and 16.71% However, b_3 recorded the favorable values of saponin and seed moisture % of 1.26 ,6.37, 1.48 and 6.80 in the 1st and 2nd seasons, respectively, without significant differences with b_4 in both seasons. The highest saponin% (1.37%) in the 1st season detected the (b_2) and (1.83%) in the 2nd season by the (b_1), as well as increased seed moisture % (6.83and 7.26%) in the 1st and 2nd seasons, respectively. These findings could be attributed to the presence of two plants/hill that reduce heat stress on panicles, thereby decreasing saponin and moisture percentage in seeds. These results are in good line with those obtained by **EL-Tahan *et al*. 2019; Al Jbawi *et al*. 2020; Van Minh *et al.*2020**; **Nagib *et al.*2020 and Rabbani *et al.*2022.**

Table 4: Effect of plant distribution patterns on yield, yield components and quality of quinoa in 2019/2020 and 2020/2021 seasons.

B- planting distribution treatments	2019 /2020 season											
	P.H	M.P.L	N.P/P	S.Y/P	S.I	S.Y	B.Y	Fol. Y	H.I	P%	S%	S.M%
b_1	36.04	11.43	6.88	34.72	2.06	1.68	3.64	1.97	46.06	17.11	1.61	6.83
b_2	34.70	11.56	6.49	34.26	1.91	1.67	3.61	1.94	46.47	16.68	1.37	6.77
b_3	31.75	11.34	7.12	35.37	2.04	1.62	3.58	1.96	45.24	16.16	1.26	6.37
b_4	34.87	11.34	7.06	35.35	1.84	1.73	3.71	1.99	46.71	17.23	1.27	6.51
F-test	*	NS	NS	NS	NS	NS	NS	NS	NS	**	**	**
$LSD_{0.05}$	2.71	-	-	-	-	-	-	-	-	0.43	0.21	0.15
	2020/ /2021season											
b_1	135.85	26.16	23.57	47.45	2.38	2.14	5.56	3.42	39.14	17.66	1.83	7.26
b_2	144.44	27.45	23.04	51.63	2.43	2.32	5.61	3.29	41.49	17.23	1.59	7.20
b_3	141.12	27.21	23.71	51.75	2.28	2.33	5.71	3.38	40.92	16.71	1.48	6.80
b_4	144.83	26.04	23.05	51.25	2.38	2.31	5.80	3.49	39.72	17.78	1.49	6.94
F-test	**	**	NS	**	NS	**	NS	NS	NS	**	**	**
$LSD_{0.05}$	3.04	0.80	-	2.71	-	0.12	-	-	-	0.43	0.21	0.15

P.H =Plant height at harvest (cm.) ; M.P.L = Main panicles length at harvest (cm.); N.P/P = Number of panicles /plant at harvest ; S.Y/P = Seed yield/plant at harvest (g.); S.I =1000 seed weight at harvest (g.) ; S.Y = Seed yield /fed.(ton); B.Y = Biological yield /fed.(ton); Fol. Y= Foliage yield /fed.(ton); H.I= Harvest index; P%= Protein percentage; S%=Saponin percentage and S.M%= Seed moisture %.

Ns, *and ** indicate insignificant, significant at 0.05 and significant at 0.01 level, respectively.

III- The interaction of planting date and plant distribution treatments on quinoa yield, yield components, and quality:

III-1- Quinoa seed yield and components

The interaction effects of planting date and plant distribution treatments on yield and yield components of quinoa are presented in Table 5. The interaction effects were highly significant for P.H and M.P.L in both seasons and for N.P/P and S.I in the 1st season as well as for B.Y , Fol. Y. and H.I in the 2nd season. However, variances due to interaction (AxB) for S.Y/P and S.Y are lacked significance in both seasons. The tallest plants of 40.80 and 149.04 cm. in the first and second seasons, respectively, achieved by $a_2 \times b_1$ without significant with $a_1 \times b_4$, $a_3 \times b_1$, $a_4 \times b_1$, $a_4 \times b_2$ and $a_4 \times b_4$ in the first season and by $a_1 \times b_3$ without significant with $a_1 \times b_2$, $a_1 \times b_4$, $a_2 \times b_2$, $a_2 \times b_4$, $a_3 \times b_1$, $a_3 \times b_2$ and $a_4 \times b_4$ in the second season. On the contrary, the shortest plants of 28.90 and 127.70 cm. detected by $a_1 \times b_1$ and $a_4 \times b_1$ in the first and second seasons, respectively. While, the tallest main panicle of 14.20 and 30.80 cm. cleared by $a_3 \times b_1$ followed without significant difference by $a_1\times b_3$ of 13.90cm. and $a_1 \times b_4$ of 13.10cm. in the first season and by $a_3\times b_2$ followed without significant different by $a_3\times b_3$ of 30.15cm. and $a_3 \times b_1$ of 29.35cm. in the second season, respectively. on the other hand, the shortest main panicle of 9.70 and 22.30 cm. detected by $a_2\times b_3$ followed without significant difference by $a_3\times b_3$ of 9.75cm. in the first season and by $a_1 \times b_1$ followed without significant difference by $a_1\times b_2$ of 22.80cm.in the second season. The highest number of panicles / plants of 8.30 in the first season was obtained by $a_2 \times b_4$ followed without significant differences by $a_3 \times b_1$, $a_1 \times b_3$, $a_3\times b_3$ and $a_3 \times b_2$. Meanwhile, $a_1 \times b_2$ equally with $a_2 \times b_1$ recorded the lowest number of panicles / plant of 6.00 without significant differences with $a_1 \times b_1$, $a_1 \times b_4$, $a_2 \times b_2$, $a_2 \times b_3$, $a_3 \times b_4$, $a_4 \times b_1$, $a_4 \times b_2$, $a_4 \times b_3$ and $a_4 \times b_4$. As well as $a_3 \times b_2$ without significant differences with $a_3 \times b_1$, $a_3 \times b_3$ in the first season and $a_1 \times b_2$ without significant differences with $a_2 \times b_2$, $a_2 \times b_1$, $a_2 \times b_4$, $a_1 \times b_3$, $a_1 \times b_4$, $a_3 \times b_2$, $a_3 \times b_1$, and $a_2 \times b_3$ in the second season gave the highest seed index of 2.60 and 2.64g. in the first and second seasons, respectively, on contrary the lightest 1000-seed weight of 1.23 and 1.75 g. was achieved by $a_1 \times b_2$ and $a_4 \times b_3$ in the first and second seasons, respectively.

With regard to the interaction effect on biological yield/fed., foliage yield/fed. (ton) and harvest index, it could be concluded that $a_4 \times b_1$ improved biological yield/fed. of 6.27(ton) and foliage yield/fed. of 4.01(ton), while $a_1 \times b_1$ increased the harvest index of 48.22% and decreased biological yield/fed. of 4.31(ton) and foliage yield/fed. of 2.24(ton), while the lightest harvest index of35.71% achieved by $a_2 \times b_2$ in the second season.

III-2- Seed quality parameters

The effects of interaction between planting date and plant distribution treatments on quality parameters of quinoa were highly significant for all studied traits in both seasons except saponin % . The highest percentage of protein of quinoa seeds (18.07 and 18.62 %) obtained by $a_2 \times b_1$ in the first and second seasons, respectively, while $a_3 \times b_3$ recorded the lowest percentage of protein in quinoa seeds of15.69 and 16.24%, in the first and second seasons, respectively. Despite the interaction effect was not significant for saponin % in both seasons, $a_1 \times b_1$ recorded the highest percentage of saponin in quinoa seeds of 2.02 and 2.24 % and highest percentage of moisture in quinoa seeds at harvest of 7.42 and 7.85 % in the first and second seasons, respectively. Meanwhile, $a_4 \times b_3$ gave the lowest saponin percentage of 0.93 and 1.15 % in the first and second seasons, respectively, as well as $a_1 \times b_4$ equally with $a_3 \times b_4$ decreased moisture percentage in quinoa seeds of 6.20 and 6.63%. in the first and second seasons, respectively.

Table 5: Effect of interaction between planting date and plant distribution treatments on yield, yield components and quality of quinoa in 2019/2020 and 2020/2021 seasons.

interaction of A x B	P.H	M.P.L	N.P/P	S.Y/P	S.I	S.Y	B.Y	Fol. Y	H.I	P%	S%	S.M%
2019 /2020 season												
$a_1 \times b_1$	28.90	10.50	6.50	31.58	2.02	1.58	3.35	1.77	47.38	16.34	2.02	7.42
$a_1 \times b_2$	34.15	11.35	6.00	27.28	1.23	1.36	2.95	1.59	46.84	16.81	1.70	6.66
$a_1 \times b_3$	31.40	13.90	7.90	22.53	2.06	1.13	2.78	1.65	41.41	16.85	1.66	6.35
$a_1 \times b_4$	36.07	13.10	6.70	30.19	1.65	1.51	3.06	1.55	49.41	16.96	1.42	6.20
$a_2 \times b_1$	40.80	10.75	6.00	38.61	2.00	1.69	3.77	2.08	44.74	18.07	1.63	6.78
$a_2 \times b_2$	29.80	11.10	6.25	36.36	1.96	1.82	3.86	2.04	47.13	16.56	1.27	6.80
$a_2 \times b_3$	30.25	11.00	6.45	34.94	1.80	1.75	3.63	1.88	48.11	16.28	1.11	6.60
$a_2 \times b_4$	35.35	9.70	8.30	34.14	1.92	1.71	3.88	2.18	44.00	16.81	1.56	7.02
$a_3 \times b_1$	38.80	14.20	8.17	34.81	2.41	1.74	3.80	2.06	45.82	16.28	1.26	6.43
$a_3 \times b_2$	34.25	11.35	7.35	37.36	2.60	1.71	3.81	2.11	44.84	15.70	1.41	6.92
$a_3 \times b_3$	31.55	9.75	7.70	37.14	2.28	1.74	3.99	2.25	43.68	15.69	1.33	6.30
$a_3 \times b_4$	31.75	10.10	6.35	35.81	1.96	1.79	3.91	2.12	45.80	17.99	1.02	6.20
$a_4 \times b_1$	35.65	10.25	6.85	33.89	1.80	1.69	3.66	1.96	46.31	17.73	1.52	6.68
$a_4 \times b_2$	40.60	12.45	6.35	36.03	1.84	1.80	3.83	2.02	47.07	17.65	1.08	6.70
$a_4 \times b_3$	33.80	10.70	6.45	46.86	2.00	1.88	3.94	2.06	47.76	15.82	0.93	6.21
$a_4 \times b_4$	36.30	12.45	6.90	41.17	1.84	1.91	4.00	2.10	47.62	17.18	1.09	6.61
F-test	**	**	**	NS	**	NS	NS	NS	NS	**	NS	**
$LSD_{0.05}$	5.71	2.13	0.95	-	0.37	-	-	-	-	0.82	-	0.29
2020/ /2021season												
$a_1 \times b_1$	134.80	22.30	23.39	45.98	2.32	2.07	4.31	2.24	48.22	16.89	2.24	7.85
$a_1 \times b_2$	147.60	22.80	21.09	45.40	2.64	2.04	4.78	2.74	42.83	17.36	1.92	7.09
$a_1 \times b_3$	149.04	23.50	22.95	44.70	2.55	2.01	4.91	2.89	41.36	17.40	1.88	6.78
$a_1 \times b_4$	146.30	22.85	20.90	46.53	2.51	2.09	5.68	3.59	36.87	17.51	1.64	6.63
$a_2 \times b_1$	137.30	24.30	21.25	46.07	2.58	2.07	5.77	3.69	35.93	18.62	1.85	7.21
$a_2 \times b_2$	143.05	27.10	22.95	46.30	2.62	2.08	5.84	3.75	35.71	17.11	1.49	7.23
$a_2 \times b_3$	141.20	27.10	24.30	48.22	2.35	2.17	5.89	3.72	36.90	16.83	1.33	7.03
$a_2 \times b_4$	147.21	27.05	23.45	47.30	2.58	2.13	5.72	3.59	37.20	17.36	1.78	7.45
$a_3 \times b_1$	143.60	29.35	30.50	47.70	2.41	2.15	5.89	3.74	36.46	16.83	1.48	6.86
$a_3 \times b_2$	148.20	30.80	28.90	53.83	2.46	2.42	5.99	3.56	40.49	16.25	1.63	7.35
$a_3 \times b_3$	138.15	30.15	28.45	53.65	2.45	2.41	6.07	3.65	39.79	16.24	1.55	6.73
$a_3 \times b_4$	138.20	27.00	28.05	53.47	2.17	2.41	5.92	3.51	40.59	18.54	1.24	6.63
$a_4 \times b_1$	127.70	28.70	19.15	50.07	2.21	2.25	6.27	4.01	35.96	18.28	1.74	7.11
$a_4 \times b_2$	138.90	29.10	19.20	61.00	2.01	2.75	5.85	3.10	46.91	18.20	1.30	7.13
$a_4 \times b_3$	136.10	28.10	19.15	60.43	1.75	2.72	5.96	3.24	45.64	16.37	1.15	6.64
$a_4 \times b_4$	147.60	27.25	19.80	57.68	2.25	2.60	5.87	3.27	44.21	17.73	1.31	7.04
F-test	**	**	NS	NS	*	NS	**	**	**	**	NS	**
$LSD_{0.05}$	6.04	1.72	-	-	0.29	-	0.46	0.40	3.92	0.82	-	0.29

P.H =Plant height at harvest (cm.) ; M.P.L = Main panicles length at harvest (cm.); N.P/P = Number of panicles /plant at harvest ; S.Y/P = Seed yield/plant at harvest (g.); S.I =1000 seed weight at harvest (g.) ; S.Y = Seed yield /fed.(ton); B.Y = Biological yield /fed.(ton); Fol. Y= Foliage yield /fed.(ton); H.I= Harvest index; P%= Protein percentage; S%=Saponin percentage and S.M%= Seed moisture %.

Ns, *and ** indicate insignificant, significant at 0.05 and significant at 0.01 level, respectively.

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الملخص العربي:

تأثير ميعاد الزراعة وتوزيع النباتات على صفات النمو والمحصول ومكوناته وجودة الكينوا

سامى رمسيس نجيب ،أبو بكر عبد الوهاب طنطاوى ، إنجيل ثروت إبراهيم ومحمود منصور عبدالمجيد

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أقيمت تجربتان حقليتان بالمزرعة البحثيه –كلية الزراعة – جامعة المنيا خلال موسمى الزراعة 2019 / 2020 و 2020/ 2021 بهدف دراسة تأثيرأربعة مواعيد زراعة (الزراعة فى 15 أكتوبر ، أول نوفمبر ، 15 نوفمبر و أول ديسمبر) وأربعة معاملات توزيع نباتات (زراعة نباتين فى جور بمسافة 20 سم على جانب واحد من الخط بعرض 60 سم ، زراعة نبات واحد فى جور بمسافة 10 سم على جانب واحد من الخط بعرض 60 سم ، زراعة نبات واحد فى جور بمسافة 20 سم على جانبى الخط بعرض 60 سم و زراعة نباتين فى جور بمسافة 40 سم على جانبى الخط بعرض 60 سم) والتداخل بينهما على صفات النمو ، المحصول ومكوناته والجودة لمحصول الكينوا ، نفذت التجربتان في تصميم القطاعات كاملة العشوائية في ترتيب القطع المنشقة مرة واحدة في ثلاث مكررات ، حيث خصصت القطع الرئيسية لمواعيد الزراعة ، بينما وزعت معاملات توزيع النباتات عشوائيا" في القطع الشقية وأكدت النتائج ما يلى :

أظهرت تأثيرا" معنوي وعالي المعنوية لجميع الصفات المدروسة فى كلا الموسمين فيما عدا طول النبات (سم) و دليل الحصاد فى الموسم الأول. أعطى ميعاد الزراعة الرابع أعلى محصول بذور /نبات (39.49 ، 57.30جم) ، محصول بذور/فدان (1.82 ، 2.58 طن) فى كلا الموسمين وأعلى محصول بيولوجى / فدان (5.99 طن) ودليل حصاد (43.18%) فى الموسم الثانى ، وكذلك أدى إلى تحسين جميع صفات الجودة المدروسة فى كلا الموسمين فيما عدا النسبة المئوية للرطوبة فى البذور فى الموسم الثانى.

أظهرت معاملات توزيع النباتات تأثيرا" عالى المعنوية على طول النبات وطول القنديل الرئيسى بالسم ، ومحصول البذور / نبات بالجم و محصول البذور /فدان بالطن فى الموسم الثانى ، وجميع صفات الجودة فى كلا الموسمين وتأثير معنوى فقط على طول النبات فى الموسم الأول. المعاملة الثالثة لتوزيع النباتات أدت إلى تحسين محصول البذور /نبات (51.75جم) ومحصول البذور /فدان (2.33 طن) فى الموسم الثانى .