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Research Article

Effect of Wheat Plant Distribution, Nitrogen and Potassium Fertilizer Levels on Wheat-sugar Beet Association

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Abstract

A two-season field experiment was conducted at Gemmeiza Research Station, Egypt, during 2017/2018 and 2018/2019 to study the effect of some wheat plant distribution systems (2, 3 and 4 rows), three N fertilizer levels (80, 100, 120 kg N fed^{-1}) and three K fertilizer levels (24, 48, 72 kg K fed^{-1}) on the productivity of both crops and farmers benefit. Sugar beet was planted on both sides of the bed (120 cm width), wheat was planted in all intercropping treatments at 25% of sole culture seed rate. A split-split plot design with three replications was used. Wheat plant distribution allocated to the main plots, N fertilizer arranged in the sub-plots and K fertilizer is presented in the sub-sub plots. Wheat plant height and spike length recorded the highest values by wheat planting in 2 rows followed by in 3 and 4 rows was showed the lost values in both seasons. Simultaneously; the other characters of wheat i.e. spike grains wt., 1000-grain wt., no. of grains $spike^{-1}$, no. of spikes m^{-2}, grain yield fed^{-1} and straw yield ton fed^{-1} recorded the highest values with 4 wheat rows in both seasons. All studied characters of wheat were increased by increasing N fertilizer levels from 80 to 100 up to 120 kg N fed^{-1} in both seasons. Most wheat characters were decreased by increasing K fertilizer levels from 24 to 48 up to 72 kg K fed^{-1} in both seasons. Most of the wheat characters were significantly influenced by the different interaction under study in both seasons. Sugar beet yield and its components as well as sugar% recorded the highest values when wheat was planted in 2 rows. Increasing N fertilizer levels increased all studied characters in both seasons. All sugar beet characters were recorded the highest values by using 48 kg K fed^{-1} followed by 72 and 24 kg K fed^{-1} in both seasons. Most sugar beet characters were significantly affected by the different interactions between factors under study in both seasons. The best land equivalent ratio (LER) and Land Equivalent Coefficient (LEC) achieved the highest values with treatment included 2 wheat rows with 120 kg N and 24 or 48 kg K fed^{-1}. Simultaneously, Aggressivity (A), wheat was the dominant crop and sugar beet was dominated in both seasons. The treatment of wheat planting in 4 rows with 120 kg N fed^{-1} and 24 kg K fed^{-1} recorded the highest values for both total income and net return in both seasons.

Keywords: Intercropping; Competitive Relationships; Total Income

Introduction

Intercropping is the growing of two (or more) crops together on the same area and often produces an advantage in terms of more yield and less variation in yield than comparable areas of solid crops [1]. In view of lessening resources like irrigation water, arable land and energy, there is a dire requirement to devise and practiced new strategies and techniques of crop production to meet the expanding needs for food, feed and forage through sustainable utilization of available inputs [2]. Nowadays, in Egypt, the irrigation water and cultivated area are limited and high prices fertilization; so Intercropping wheat with sugar beet is one of the most important practices and means of maximizing productivity

and allow full utilization of the environmental resources with minimum competition, especially for light, water and nitrogen fertilization levels [3-7].

Ibrahim and Abdel-Aal [8], Toaima [9], Mohammady [10] and Shanware [11] mentioned that the yield and yield components of wheat were significantly increased by increasing NPK fertilizer levels. Wheat plants fertilized with the highest levels of NPK (120, 50 and 72 Kg fed^{-1}) (One hectare = 2.38 feddan) had the highest values of plant height, spike length, spike weight, 1000-grain weight $spike^{-1}$ and number of spikes m^{-2}. Beshay., *et al*. [12] indicated that the intercropping beet-wheat in 3 rows gave the highest reduction in root, sugar % and top yields as compared to sole crop. Abd El-Gwad., *et al*. [13] revealed the significant differences between nitrogen levels and 130 kg N fed^{-1} had exhibited in intercropping 4 rows of wheat with fodder beet. Abd El-Zaher., *et al.* [14] reported that the highest values of root diameter and root yield fed^{-1} of sugar beet were achieved at intercropping 2 rows of barley with 110 kg N fed^{-1}. Whereas, the lowest values of these characters were recorded when intercropped with 4 rows of barley and fertilized by 90 kg N fed^{-1}. The highest values of barley grain yield fed^{-1} obtained at 4 rows of barley intercropped with sugar beet at 90 kg N fed^{-1} and the lowest ones were obtained at 2 rows of barley with 90 Kg N fed^{-1}. The increase in nitrogen levels from 80 up to 140 Kg N fed^{-1} caused significantly increased in more characters of wheat [15].

Ibrahim., *et al*. [4] revealed that the interaction effect when intercropped 2 rows of wheat on the back of sugar beet beds and fertilized with 90 kg N fed^{-1} achieved the highest values of sugar beet root length, root and top fresh weight $plant^{-1}$. Wheat grain weight $spike^{-1}$ had the highest values when used 2 rows of wheat with 90 Kg N fed^{-1}., while, the lowest values were achieved when sown 3 rows of wheat with sugar beet and fertilized by 50 kg N fed^{-1} in the first season. Singh., *et al*. [16] revealed that intercropping 3 rows of wheat fertilized with 120 kg N ha^{-1} recorded the highest net return compared with intercropping 1 and 2 rows of wheat with sugar beet as compared with sugar beet and wheat in pure stand. Badr [17] found that the severe inter competition between wheat and sugar beet plants under wheat high density, grain weight the highest values obtained at 100% sugar beet + 25% wheat. Abou-Elela [18] found that the increasing wheat density 2, 3 up to 4 rows of wheat on beds (120 cm) width of sugar beet caused a reduction in root length $plant^{-1}$.

Objective of the Study

The objective of this research was to study the response of wheat plant distribution and different nitrogen and potassium fertilizer levels on yield and its components of wheat and sugar beet as well as competitive relationships and net return.

Materials and Methods

A two-season field experiment was conducted at Gemmeiza Agric. Res. St., ARC, Egypt, during the growing seasons of 2017/2018 and 2018/2019 to study the effect of wheat plant distribution (two, three and four rows), three nitrogen fertilizer levels (80,100, 120 kg N fed^{-1}) and three potassium fertilizer levels (24, 48, 72 kg K fed^{-1}) on the productivity of both crops and farmers benefit.

Wheat was planted in all intercropping treatments at 25% of sole culture seed rate on the top of all beds distributed in 2, 3 or 4 rows. The sole culture of wheat 100% was planted on broadcasting at seed rate of 60 kg fed^{-1}. Sugar beet was planted on both sides of the bed (120 cm width); 20 cm apart between hills and thinned one plant $hill^{-1}$ in all intercropping treatments and in addition to 100% sugar beet pure stand, which was planted one side of the ridges (60 cm width) spaced at 20 cm apart between hills to give 35000 plants fed^{-1}.

Nitrogen fertilizer levels (80 "equal the recommended dose of sugar beet", 100 and 120 kg N fed^{-1})were applied in the form of ammonium nitrate (33.5% N) at the three equal doses distributed before first, second and third irrigations, respectively.

Potassium fertilizer levels (24, 48 and 72 kg K fed^{-1}) were applied in two equal doses before the first irrigation and before third irrigation. The treatments were arranged in a split-split plot design with three replications. Wheat plant distribution allocated to the main plots, nitrogen fertilizer arranged in the sub-plots and potassium fertilizer levels are presented in the sub-sub plots. The sub-sub plot area was 4.8 m width × 3 m length= 14.4 m^2 (291.7 fed^{-1}). The preceding summer crop was maize in both seasons. Phosphorus fertilizer was added during land preparation in the form of calcium superphosphate (15.5% P_2O_5) at the rate of 200 kg fed^{-1}. Thinning sugar beet took place after 45 days after sowing to one plant $hill^{-1}$ at 20 cm a part. The other agricultural practices of growing wheat with sugar beet were applied as recommended. Sowing sugar beet (cv. Diamond) was in 30/10/2017 and 28/10/2018 in the first and second seasons, respectively; and wheat (cv. Gemmei-

za) was planted after 21 days from sugar beet planted (just before the first irrigation of sugar beet).

A representative soil sample of the field was taken from 0 - 30 cm layer and used for determining some physical and chemical properties of the studied soil according to Klute [19]. The mechanical and chemical analyses of the experimental sites are recorded in table 1.

Particle size distribution		Total macronutrients (%)	
Coarse sand (%)	5.23	N	0.144
Fine sand (%)	18.46	P	0.032
Silt (%)	37.24	K	0.356
Clay (%)	39.07	Available N, mg kg^{-1}	33.42
Texture class	Clay loam	Available P, mg kg^{-1}	10.63
pH, 1:2.5 (susp.)	7.77	Available K, mg kg^{-1}	315.72
EC, dSm^{-1}	1.67	Organic matter (O.M, %)	2.50
Soluble ions, meq l^{-1}		Organic carbon (O.C, %)	1.45
Mg^{2+}	5.32	C / N ratio	10.07
Ca^{2+}	6.13	DTPA - extractable micronutrients (ppm)	
Na^{+}	7.46	Fe	3.83
K^{+}	0.23	Br	0.26
CO_3^{2-}	0.00	Mn	3.15
HCO_3^{-}	3.62	Zn	4.46
Cl^{-}	8.13	Cu	1.53
SO_4^{2-}	7.39		

Table 1: Physical and chemical properties of the experimental soil.

Data recoded

Wheat characters

Growth yield and yield components

Ten guarded plants were taken randomly from each sub-sub-plot to estimate the following characters. Plant height (cm), spike length (cm), weight of grains $spike^{-1}$ (g), number of grain $spike^{-1}$, 1000-grain weight (g) number of spikes m^{-2}. Four ridges and two beds were harvested and threshed to estimate the following data: Grain yield (ard fed^{-1}) and straw yield (ton fed^{-1}) of wheat for pure stand and intercropped, respectively (ardab weight of wheat crop = 150 Kg).

Sugar beet characters

Yield and yield components

At harvest time, five plants were taken randomly from each sub-sub plot to estimate the data of yield components. Whereas the top and root yields were calculated from the inner four ridges and two beds in the sub-sub plots of sugar beet for pure stand and intercropped, respectively, as follows: Plant weight (kg), root weight $plant^{-1}$ (g), no. of Leaves fresh $plant^{-1}$, root length (cm), root diameter (mm), top yield fed^{-1} (ton), root yield fed^{-1} (ton) and sugar yield fed^{-1} (ton).

Chemical quality of sugar in sugar beetroot

Samples of 26 g fresh root weight were taken from each sub-sub plot to determine: Sucrose percentage was determined according to methods described by Le-Docte [20].

Competitive relationships and yield advantages

The following competitive relationships and yield advantages were calculated.

Land equivalent ratio (LER)

It was determined according to the following formula described by Willey and Rao [21]: LER = , Where, Y_{aa} and Y_{bb} were pure stand of crop a (sugar beet) and b (wheat), respectively. Y_{ab} is intercrop yield of crop (a) and Y_{ba} is intercrop yield of crop (b).

Land equivalent coefficient (LEC)

It is a measure of interaction concerned with the strength of the relationship and was calculated according to Adetiloye., *et al.* [22] as follows: LEC = $L_a \times L_b$, Where, L_a = relative yield of crop a (sugar beet) and L_b = relative yield of crop b (wheat).

Aggressively (A)

It was calculated according to Mc-Gilchrist [23] as the following formula: Aab = ; Aba = , Where, A_{ab} = Aggressivity value for the component a (sugar beet); A_{ba} = Aggressivity value for the component b (wheat); Y_{ab} is intercrop yield of sugar beet, Z_{ab} is the percentage of the area occupied by sugar beet.

Economic evaluations

Total income and net return were calculated for each treatment in Egyptian pounds (LE) using market prices of sugar beet and wheat according to Agricultural Statistics, Economic Affairs Sector, Ministry of Agriculture and Land Reclamation (MALR) and Agricultural Economics Research Institute (AERI), Agricultural Research Center (ARC) Wishahy., *et al*. [24]. The sugar beet prices were LE 378.5,400 ton^{-1} of roots and LE 54,63 ton^{-1} of top-fresh, meanwhile wheat prices were LE 575,680 ardab^{-1} of grains and LE 1000,1100 ton^{-1} of straw in 2017/2018 and 2018/2019, respectively. Solid costs were LE 11292 and 12670 fed^{-1} for sugar beet and LE 10057 and 11850 fed^{-1} for wheat in 2017/2018 and 2018/2019, respectively.

Statistical analysis

Mean data collected were statistically analyzed in the combined analysis according to Gomez and Gomez [25]. Treatment means were compared using the least significant difference (L.S.D at 0.05%) test as outlined by Waller [26]. All statistical analysis performed using analysis of variance technique by MSTAT-C [27]. Sole cultures of sugar beet and wheat presented in this study for calculating competitive relationships and economic evaluation only and not included in the statistical analysis.

Results and Discussion

Wheat

Effect of wheat plant distribution on some wheat characters

Data presented in table 2 indicated that all wheat characters under study were significantly affected by plant wheat distribution systems in both seasons. Data revealed that plant height and spike length recorded the highest values when wheat plants were grown in two rows followed by in three rows whereas, in four rows were showed the lowest value in both seasons. These results may be due to plant wheat distribution system of two rows increase intra-specific competition among wheat plants than other patterns for light, water, hence an increase in cell division and elongation. Similar results were obtained by Aboukhadra., *et al*. [6], Toaima [9], Abou-Elela [18] and Badr [15]. The characters as spike wt, 1000-grain wt, no. of grains spike^{-1} and no. of grains m^{-2} behaved opposite trend of the plant height and spike length in both seasons as shown in table 2. Therefore, when wheat plants were sown in four rows recorded the highest value followed by in the three rows and in two rows occupied the latest ranked in both seasons. These results may be due to the increase in the number of rows from two to three up to four rows and equal seed rates in all distributions were reduced number of grains per hill in four rows and sequently increased number of tillers m^{-2} than other treatments. This result coincided with those obtained by Toaima [9], Shehata [28] and Badr [17].

Data presented in table 2 revealed that the grain yield fed^{-1} was exhibited the same line of the previous characters in both seasons. Wheat plants in four rows recorded the highest value of grain yield fed^{-1} and straw yield fed^{-1} followed by three and two rows. The increase in grain yield are fed^{-1} due to increase in yield component i.e. spike wt, 1000-grain wt, no. of grains spike^{-1}, no. of spikes m^{-2}. Whereas, the increase in straw yield ton fed^{-1} under four rows due to increase in tillers, which consequently increase no. of spikes m^{-2} compared with three rows and two rows in both seasons as shown in table 2. Wheat plants in four rows were the most effective intercropping system than those of fewer numbers in rows. This is may be due to the specified quantity of seeds was distributed over the largest area of land and a greater number of rows, this led to a clear decrease in the intra-specific competition among wheat plants and the optimal use of environmental resources and land. These results are in agreement with Abd El-Gwad., *et al.* [13], Abd El-Zaher., *et al.* [14] and Abou-Elela [18].

Effect of N fertilizer levels on some wheat characters

Data in table 2 revealed that intercropped wheat plants with sugar beet and fertilized by 120 Kg fed^{-1} gave the highest values followed by those fertilized by 100 simultaneously 80 kg fed^{-1} gave the lowest values for wheat plants in both seasons. This was completely true for each of all studied characters of wheat in both seasons. The increase in plant height due to the increase in nitrogen application may be attributed to the increase in meristematic activity, stimulation of cell elongation and auxin production in wheat plants and reflected that on yield components of wheat. This result is in agreement with those obtained by Abou - Elela [18], Badr [15], Aboukhadra., *et al.* [6] and Shehata [28].

Character Factor		Plant height(cm)		Spike length (cm)		Spike weight (g)		1000-grain weight (g)	
		S1	S2	S1	S2	S1	S2	S1	S2
Wheat plant distribution	2 rows	117.4	108.2	15.2	15.7	2.1	2.3	46.1	49.2
	3 rows	111.4	104.0	14.0	14.6	2.2	2.9	48.4	52.0
	4 rows	108.9	99.1	14.3	13.5	3.6	3.7	61.2	60.1
LSD at 0.05		2.0	2.6	0.2	0.3	0.2	0.2	1.5	3.5
N- Levels	80 Kg	110.3	101.8	13.9	13.8	2.1	2.7	49.2	51.9
	100 Kg	112.5	102.3	14.1	14.4	2.3	2.8	51.2	52.5
	120 Kg	114.9	107.2	15.5	15.6	3.4	3.5	55.4	57.0
LSD at 0.05		2.6	1.4	0.1	0.4	0.3	0.2	2.1	2.0
K- Levels	24 Kg	116.4	108.8	15.8	15.7	3.3	3.5	58.1	58.5
	48 Kg	110.4	101.8	13.9	14.1	2.3	2.8	59.7	52.5
	72 Kg	110.9	100.7	13.9	14.0	2.2	2.6	48.0	50.4
LSD at 0.05		2.6	1.3	0.1	0.3	0.3	0.3	1.9	2.3
Character Factor		No. of grains spike-1		No. of spikes m-2		Grain yield (ard fed-1)		Straw yield (ton fed-1)	
		S1	S2	S1	S2	S1	S2	S1	S2
Wheat plant distribution	2 rows	52.9	47.4	266.3	217.0	7.49	6.94	0.87	0.62
	3 rows	54.4	57.7	301.0	244.5	8.10	7.06	1.04	0.91
	4 rows	72.1	64.0	397.7	351.9	9.03	8.54	1.45	0.91
LSD at 0.05		4.1	3.2	22.1	13.1	0.51	0.20	0.07	0.10
N- Levels	80 Kg	56.0	52.6	297.1	245.4	7.69	5.04	0.8	0.66
	100 Kg	56.5	56.6	320.4	268.1	8.25	7.43	1.23	0.81
	120 Kg	66.9	60.0	348.1	300.0	8.68	7.96	1.33	0.7
LSD at 0.05		1.5	2.4	13.1	11.2	0.3	0.15	0.1	0.10
K- Levels	24 Kg	66.7	60.3	382.0	321.4	8.77	8.16	1.38	0.85
	48 Kg	57.3	55.2	320.0	269.5	7.98	7.33	1.0	0.61
	72 Kg	55.5	53.7	263.6	222.7	7.88	7.05	0.98	0.71
LSD at 0.05		2.22	1.9	12.8	11.3	0.31	0.13	0.08	0.08

Table 2: Effect of wheat plant distributions, N and K fertilization levels on wheat growth and yield characters during 2017/2018 and 2018/2019 seasons.

Also, the increase in grain yield of wheat fed^{-1} due to the increase in N levels is a result of the effect of nitrogen fertilizer increasing all yield components from 80 to 100 up to120 kg N fed^{-1} such as spike length, spike wt, no. of grains spike^{-1} and 1000-grain wt. and no of spikes m^{-2}. These results are in agreement with those reported by Badr [15], Aboukhadra., *et al.* [6] and Shehata [28].

At the same time, straw yield fed^{-1} behaved the same trend of grain yield fed^{-1} in both seasons as shown in table 2. The increase in straw yield fed^{-1} might be due to increase of plant height and no. of spikes m^{-2} as a result of the increase in no. of tillers m^{-2}. Similar results were obtained by Abd El-Gwad., *et al.* [13], Badr [15] and Aboukhadra., *et al.* [6].

Effect of K fertilizer levels on some wheat characters

Data presented in table 2 revealed that increasing potassium fertilizer levels from 24 to 48 up to 72 kg K fed^{-1} were negative significantly affected on all characters of wheat i.e. growth, yield attri-

butes and yields in both seasons. Therefore, wheat plants fertilized by 24 kg K fed^{-1} gave the highest values in all characters followed by those fertilized by 48 and 72 kg K fed^{-1} in both seasons. Therefore, 24 kg K fed^{-1} enough to play important roles in photosynthesis, protein synthesis, and translocation of assimilate as well as increasing plant growth and yield, yield components of wheat. Similar results were obtained by Ibrahim and abdel-Aal [8], Toaima [9] and Shanware [11].

Interaction effects

The interaction effect between wheat plant distribution and N fertilizer levels

Data presented in table 3 indicated that spike length, no. of grains spike^{-1}, 1000-grain wt, no. of spikes m^{-2}, grain yield fed^{-1} and straw yield fed^{-1} were significantly in both seasons affected by the interaction between wheat plant distribution and nitrogen fertilizer.

Wheat plant distribution	N-Levels	Spike length (cm)		No. of grain spike^{-1}		1000-grain weight (g)	
		S1	S2	S1	S2	S1	S2
2 rows	80 Kg	15.0	14.6	48.1	49.1	52.2	43.9
	100 Kg	14.9	14.8	45.0	49.7	47.7	47.2
	120 Kg	15.7	17.6	45.1	48.8	58.7	51.4
3 rows	80 Kg	13.5	13.5	45.4	50.8	51.3	53.0
	100 Kg	13.5	15.1	46.6	48.7	48.0	58.2
	120 Kg	15.2	15.2	53.3	56.6	64.0	61.8
4 rows	80 Kg	13.4	13.3	54.1	55.8	64.4	43.9
	100 Kg	14.0	13.1	61.9	59.1	73.9	47.2
	120 Kg	15.5	14.2	67.7	65.4	78.0	51.4
LSD at 0.05		0.14	0.63	3.61	3.5	2.58	4.1
Wheat plant distribution	**N-Levels**	**No. of spikes m^{-2}**		**Grain yield (ard fed^{-1})**		**Straw yield (ton fed^{-1})**	
		S1	S2	S1	S2	S1	S2
2 rows	80 Kg	235.3	184.7	6.98	6.46	0.38	0.56
	100 Kg	253.2	213.4	6.94	6.95	1.07	0.85
	120 Kg	310.3	253.4	8.55	7.42	1.15	0.45
3 rows	80 Kg	268.7	212.9	7.65	6.73	0.86	0.60
	100 Kg	314.6	262.6	8.60	6.89	1.22	0.63
	120 Kg	321.3	258.1	8.06	7.55	1.05	0.70
4 rows	80 Kg	387.3	338.6	8.44	8.24	1.18	0.83
	100 Kg	393.3	328.4	9.21	8.46	1.40	0.94
	120 Kg	412.6	388.6	9.44	8.93	1.79	0.95
LSD at 0.05		22.6	19.4	0.56	0.25	0.17	0.18

Table 3: Interaction effect between wheat plant distributions and N fertilization levels on wheat characters during 2017/2018 and 2018/2019 seasons.

Data revealed that spike length recorded the highest value (15.7 and 17.6 cm) by planting wheat in 2 rows and fertilized by 120 Kg N fed^{-1} in the first and second seasons respectively; and the lowest value (13.4 and 13.1 cm) was obtained where wheat plants were distributed in 4 rows and fertilized by 80 and 100 Kg N fed^{-1} as shown in table 3 in the first and second seasons respectively. With respect no. of grains spike^{-1}, data indicated that treatment of wheat planted in 4 rows and fertilized by 120 Kg N fed^{-1} in both seasons

recorded the highest values, on the other hands, the lowest values were obtained in 2 rows ×100 Kg N fed^{-1} in the first seasons and in 3 rows × 100 Kg N fed^{-1} in the second seasons. Concern to 1000-grain weight, the highest values were obtained when wheat was plant in 4 rows in both seasons and fertilized by 120 Kg N fed^{-1} in the first season and 3 rows in the second seasons and opposite the lowest values (47.7 and 43.9) in 2 rows and fertilized by 100 kg N fed^{-1} in the first season and by 80 kg N fed^{-1} in the second seasons.

Data in table 3 indicated that no. of spikes m^{-2} recorded the highest values (412.6 and 388.6) by sowing wheat plants in 4 rows and fertilized by 120 kg N fed^{-1} in the first second and seasons respectively, and the lowest values (235.3 and 184.7) in 2 rows and fertilized by 80 Kg N fed^{-1} in the first and second seasons respectively.

Grain yield fed^{-1} of wheat gave the highest value by growing wheat plants at 4 row and fertilized by 120 Kg N fed^{-1} (9.44 and 8.93 ardab fed^{-1}) in the first and second seasons respectively, whereas the lowest value were obtained when wheat was grown in 2 rows and fertilized by 100 kg N fed^{-1} (6.94) in the first season and fertilized by 80 kg N fed^{-1} (6.46) in the second seasons. Straw yield fed^{-1} of wheat recorded the highest values by wheat planting in 4 rows and fertilized by 120 Kg N fed^{-1} (1.79 and 0.95) ton fed^{-1} in both season and the lowest value was obtained when wheat was planted in 2 rows and fertilized by 80 and 120 Kg N fed^{-1} (0.38 and 0.45 ton). These results indicate that the increase in yield and most of its components in wheat in both seasons may be due to the distribution of the specified amount of seeds in four rows with the use of 120 kg N fed^{-1}, which has given freedom and homogeneity to wheat plants, decreased the intra-specific competition among them under the ground in the use of soil moisture and nutrients and above the ground in light and shading, which It leads to the production of more active and productive plants. The results are similar to that obtained by Ibrahim., *et al*. [4], Abd El-Gwad., *et al*. [13], Badr [15], Aboukhadra., *et al.* [6] and Badr [17].

The interaction effect between wheat plant distribution and K fertilizer levels

Data presented in table 4 indicated that plant height, spike length, 1000-grain wt, no. of spike m^{-2}, grains yield fed^{-1} and straw yield fed^{-1} of wheat in both seasons and no. of grains spike^{-1} in the second seasons were significantly affected by plant distribution and potassium fertilizer. The results indicated that plant height and spike length recorded the highest values(123.5 and 112.4 cm) and (16.4 and 17.5 cm) by sowing wheat plants in 2 rows and fertilized by 24 Kg K fed^{-1} in the first and second seasons, respectively, whereas the lowest values for these plant height were showed where wheat was planted in 4 rows and fertilized by (48 and 72 Kg K fed^{-1}) in the first and second seasons, respectively, while spike length of wheat recorded the lowest values by growing wheat plants in 3 and 4 rows in both seasons and fertilized by 48 and 72 kg K fed^{-1} in the first and second season, respectively. The results indicated that 1000-grain wt recorded the highest values (78 and 67.1g), by sowing wheat plants in 4 rows and fertilized by (24 and 72 kg K fed^{-1}) kg K fed^{-1} in the first and second seasons, respectively and the lowest value were obtained in 2 rows and (72 and 24 kg K fed^{-1}) in the first and second seasons.

Wheat plant distribution	K-Levels	Plant height (cm)		Spike length (cm)		1000-grain weight (g)	
		S1	S2	S1	S2	S1	S2
2 rows	24 Kg	123.5	112.4	16.4	17.5	63.2	44.2
	48 Kg	115.3	105.2	14.5	14.8	49.8	52.6
	72 Kg	113.3	106.9	14.6	14.7	45.7	45.8
3 rows	24 Kg	114.2	110.0	15.4	15.7	58.9	61.3
	48 Kg	111.0	102.0	13.3	14.1	51.8	56.2
	72 Kg	109.1	100.1	13.4	14.0	52.6	55.4
4 rows	24 Kg	111.4	103.9	15.4	13.9	78.0	61.3
	48 Kg	104.8	98.2	13.9	13.5	70.2	63.4
	72 Kg	110.3	95.1	13.7	13.1	68.1	67.1
LSD at 0.05		4.6	2.2	0.2	0.6	3.8	3.3

Wheat plant distribution	K-Levels	No. of spikes m^{-2}		Grain yield (ard fed^{-1})		Straw yield (ton fed^{-1})	
		S1	S2	S1	S2	S1	S2
2 rows	24 Kg	314.1	264.4	7.77	7.57	1.13	0.77
	48 Kg	252.9	202.9	7.70	6.49	0.74	0.77
	72 Kg	231.9	184.2	7.00	6.76	0.72	0.32
3 rows	24 Kg	367.0	306.8	8.63	7.53	1.31	.63
	48 Kg	301.6	251.7	7.73	7.15	0.87	0.56
	72 Kg	236.0	175.1	7.95	6.48	0.94	0.73
4 rows	24 Kg	464.9	392.9	9.91	9.37	1.67	1.13
	48 Kg	405.4	251.7	8.5	8.35	1.42	0.8
	72 Kg	322.9	308.7	8.68	7.90	1.28	0.78
LSD at 0.05		22.2	19.5	0.55	0.2	0.13	0.14

Table 4: Interaction effect between wheat plant distribution and K fertilization levels on some wheat characters during 2017/2018 and 2018/2019 seasons.

Concern to no. of spike m^{-2}, grains yield fed^{-1} and straw yield fed^{-1} the highest values were showed with distributing wheat plants in 4 rows × 24 kg K fed^{-1} (464.9 and 392.9 spike m^{-2}), (9.91 and 9.37 ard fed^{-1}) and (1.67 and 1.13 ton fed^{-1}) for these characters in the first and second seasons respectively. On the other hand, the lowest values were showed when wheat planted in 2 row and fertilized by 72 kg K fed^{-1} for No. of spike m^{-2} (231.9 and 184.2) in the first and second seasons, respectively, for grain yield (7.0 ard fed^{-1}) in the first season only and straw yield (0.72 and 0.32 ton) in the first and second season, respectively. Whereas, the lowest value of grain yield ard fed^{-1} in the second season was showed by distributing wheat plants in 3 rows and fertilized by 72 kg K fed^{-1} (6.48 ard fed^{-1}). The highest values in yield of wheat planting in 4 rows and fertilized by 24 kg K fed^{-1} were recorded. Potassium with wheat plant distribution 4 rows is the most important element in the tonic for the transfer of carbohydrates from the leaves to grain and for crops production. Similar results were obtained by Aboukhadra., *et al.* [6], Abou-Elela [18], Shanware [11], Shehata [28], Badr [17].

The interaction effect between N and K fertilizer levels

Data presented in table 5 illustrated that all characters recorded the highest values by the combination of 120 kg N fed^{-1} and 24 kg K fed^{-1} in both seasons. On the other hand, the lowest values were achieved when wheat was fertilized by 80 kg N fed^{-1} with 48 and 72 kg K fed^{-1} for all characters in both seasons.

Abdel-Mawly and Zanouny [29] stated that potassium plays an important role in activation of enzymes, enhancing photosynthesis, helps in the transport of starch as well as nitrogen. Also, it play important role in the growth and development of plants, where it improves crop quality and plant metabolism, maintains cell turgor and reduces respiration.

Interaction effects among wheat plant distribution with N and K fertilizers levels

Data presented in table 6 revealed that spike length, 1000-grain wt, no. of grains $spike^{-1}$, no. of spike m^{-2}, grains yield fed^{-1} and straw yield fed^{-1}, in both seasons were significantly affected by the interaction between wheat plant distributions with N and K fertilizers.

The spike length gave the highest values (16.8 cm) by planting wheat plants in 4 rows × 120 kg N fed^{-1} with 24 Kg K fed^{-1} in the first season and 2 rows × 100 kg N fed^{-1} with 24 kg K fed^{-1} (18.9 cm) in the second seasons. Moreover, results indicated that the highest values of 1000-grain wt were achieved when wheat plant were planted in 4 rows with 120 kg N fed^{-1}× 24 kg K fed^{-1} in the first season (83.7g) and 4 rows with 100 kg N fed^{-1} and 24 kg K fed^{-1} in second season(74.0g). With respect no. of grains $spike^{-1}$, no. of spike m^{-2}, grains yield ard fed^{-1} and straw yield fed^{-1}, all these characters recorded the highest values when wheat plant distribution in 4 rows and fertilized by 120 kg N fed^{-1} and 24 kg K fed^{-1} in both seasons. Similar results were obtained by Toaima [9], Abd El-Gwad., *et al.* [13], Abd El-Zaher., *et al.* [14], Shanware [11] and Badr [17].

N-Levels	K-Levels	Spike length (cm)		No. of grain spike^{-1}		1000-grain weight (g)	
		S1	S2	S1	S2	S1	S2
80 Kg	24 Kg	15.3	14.8	63.3	66.5	64.8	56.9
	48 Kg	13.1	13.7	57.7	62.9	46.8	50.2
	72 Kg	13.4	12.9	56.8	56.3	56.3	50.6
100 Kg	24 Kg	15.3	15.3	66.8	67.7	58.8	60.3
	48 Kg	13.6	14.0	60.0	60.3	58.1	54.7
	72 Kg	13.4	13.8	56.8	59.4	52.6	54.9
120 Kg	24 Kg	16.7	16.9	74.1	71.4	76.5	63.8
	48 Kg	14.9	14.7	59.3	64.1	66.8	60.6
	72 Kg	15.0	15.2	62.7	65.4	57.4	55.6
LSD at 0.05		0.15	0.6	3.2	3.9	3.8	3.3
N-Levels	K-Levels	No. of spikes m^{-2}		Grain yield (ard fed^{-1})		Straw yield (ton fed^{-1})	
		S1	S2	S1	S2	S1	S2
80Kg	24Kg	344.7	295.6	8.14	7.67	1.04	0.76
	48Kg	298.0	249.1	7.3	7.29	0.64	0.68
	72Kg	248.7	191.4	7.63	6.46	0.73	0.56
100Kg	24Kg	371.8	307.4	8.70	8.12	1.47	0.86
	48Kg	325.9	272.9	8.41	7.00	1.11	0.90
	72Kg	263.4	224.1	7.65	7.17	1.1	0.34
120Kg	24Kg	429.6	361.1	9.48	8.69	1.6	0.92
	48Kg	336.0	286.6	8.22	7.70	1.27	0.55
	72Kg	278.7	252.4	8.35	7.52	1.11	0.62
LSD at 0.05%		22.2	19.5	0.55	0.22	0.12	0.14

Table 5: Interaction effect between N and K fertilization levels on wheat growth and yield characters 2017/2018 and 2018/2019 seasons.

Wheat plant distribution	N-Levels	K-Levels	Spike length (cm)		1000-grain weight (g)		No. of grains spike^{-1}	
			S1	S2	S1	S2	S1	S2
2 rows	80 Kg	24 Kg	16.4	16.6	64.4	50.0	48.3	49.7
		48 Kg	14.1	14.5	40.2	41.3	47.0	55.9
		72 Kg	14.4	13.8	52.1	40.3	49.0	41.8
	100 Kg	24 Kg	16.3	18.9	53.2	50.3	52.7	52.7
		48 Kg	14.2	16.9	47.7	47.0	40.3	48.0
		72 Kg	14.1	16.9	42.1	44.3	42.3	48.3
	120 Kg	24 Kg	16.6	16.9	71.9	57.3	52.7	53.8
		48 Kg	15.2	13.0	61.4	49.0	41.7	46.7
		72 Kg	15.3	14.5	42.8	48.0	41.0	46.0
3 rows	80 Kg	24 Kg	14.9	13.9	57.6	60.0	49.3	54.7
		48 Kg	12.6	13.8	42.2	57.3	45.3	47.6
		72 Kg	12.9	12.9	54.1	57.3	41.7	49.9
	100 Kg	24 Kg	14.8	17.4	45.2	56.7	53.0	53.7
		48 Kg	12.7	13.5	49.7	52.0	44.3	47.3
		72 Kg	12.6	14.6	49.0	50.3	42.3	45.0
	120 Kg	24 Kg	16.6	15.8	73.9	67.3	44.3	60.6
		48 Kg	14.6	15.0	63.4	59.3	45.0	54.3
		72 Kg	14.7	14.6	54.6	58.7	50.7	54.9

4 rows	80 Kg	24 Kg	14.6	14.0	72.3	60.7	62.3	65.0
		48 Kg	12.7	12.8	58.1	52.0	50.3	55.3
		72 Kg	12.8	13.0	62.7	54.0	49.7	67.0
	100 Kg	24 Kg	14.7	14.6	78.0	74.0	64.7	66.7
		48 Kg	13.8	13.7	77.0	65.0	65.3	55.7
		72 Kg	13.6	14.2	66.8	70.0	55.7	55.0
	120 Kg	24 Kg	16.8	13.0	83.7	66.7	75.3	69.7
		48 Kg	14.8	14.0	75.5	73.3	61.3	61.3
		72 Kg	15.0	12.2	74.8	60.0	66.3	65.3
LSD at 0.05			0.26	0.99	6.7	5.7	5.6	6.8
Sole culture of wheat			15.3	15.8	75	68.5	63.5	61.5
Wheat plant distribution	**N-Levels**	**K-Levels**	**No. of spikes m^{-2}**		**Grain yield (ard fed^{-1})**		**Straw yield (ton fed^{-1})**	
			S1	**S2**	**S1**	**S2**	**S1**	**S2**
2 rows	80 Kg	24 Kg	256.0	206.7	6.70	6.72	0.73	0.77
		48 Kg	248.0	196.7	6.82	6.62	0.11	0.70
		72 Kg	202.0	150.7	7.42	6.02	0.28	0.20
	100 Kg	24 Kg	281.7	250.0	7.54	7.71	0.24	0.70
		48 Kg	258.0	208.7	7.57	5.97	0.94	1.36
		72 Kg	220.0	181.7	5.72	7.05	1.03	0.50
	120 Kg	24 Kg	404.7	336.7	9.07	8.28	1.41	0.85
		48 Kg	252.7	203.3	8.70	6.86	1.15	0.25
		72 Kg	273.7	220.3	7.88	7.12	0.68	0.25
3 rows	80 Kg	24 Kg	331.7	285.0	8.16	7.01	1.07	0.50
		48 Kg	254.0	218.3	7.68	7.09	0.67	0.63
		72 Kg	220.3	135.3	7.11	6.09	0.82	0.67
	100 Kg	24 Kg	365.7	318.7	8.91	7.46	1.50	0.85
		48 Kg	327.3	266.7	8.38	6.60	1.07	0.37
		72 Kg	250.7	202.3	8.52	4.12	1.08	0.67
	120 Kg	24 Kg	403.7	316.7	8.82	8.12	1.35	0.55
		48 Kg	323.3	270.0	7.12	7.78	0.88	0.67
		72 Kg	237.0	187.7	8.22	4.24	0.92	0.87
4 rows	80 Kg	24 Kg	446.3	395.0	9.55	9.28	1.30	1.00
		48 Kg	392.0	332.3	7.40	8.17	1.13	0.70
		72 Kg	323.7	288.3	8.36	7.27	1.12	0.80
	100 Kg	24 Kg	468.0	353.7	9.64	9.18	1.67	1.04
		48 Kg	392.3	343.3	9.27	8.43	1.33	0.97
		72 Kg	319.7	288.3	8.72	7.75	1.20	0.80
	120 Kg	24 Kg	480.3	430.0	10.54	9.64	2.03	1.32
		48 Kg	432.0	386.3	8.84	8.45	1.79	0.73
		72 Kg	325.3	349.3	8.94	8.69	1.53	0.75
LSD at 0.05			38.5	33.9	0.95	0.38	0.21	0.23
Sole culture of wheat			399	367.2	20.53	20.11	3.00	3.10

Table 6: Interaction effect among wheat plant distribution, N and K fertilization levels on wheat characters during 2017/2018 and 2018/2019 seasons.

Sugar beet

Effect of wheat plant distribution

The results in table 7 showed that plant weight (kg), root weight, no. of leaves, root length and root yield were significantly affected by wheat plant distribution with sugar beet in both seasons. The highest values of all characters of sugar beet were obtained with two rows wheat in the first and second season compared with three and four rows. On the other hand, sugar beet in pure stand gave the highest values tallest in all characters compared with sugar beet in all intercropping pattern in both season. The results are mainly due to the effect of the severe competition either intra or inter-specific competition for light, water and nutrient elements. These results were coincided with those obtained by Attia., *et al.* [5], Abd El-Zaher., *et al.* [14], Badr [15] and Shehata [28].

Character		Plant weight (kg)		Root weight (g)		No. of leaves plant^{-1}		Root length (cm)		Root diameter (cm)	
Factor		S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Wheat plant dist.	2 rows	1.77	1.33	928	926	41.4	52.9	27.1	28.6	13.2	12.2
	3 rows	1.32	1.10	901	771	39.8	40.6	24.4	23.9	10.8	9.3
	4 rows	1.20	1.01	855	718	34.1	31.6	21.7	20.1	10.0	6.6
LSD at 0.05		0.02	0.03	41	81	1.2	2.5	1.5	1.8	0.7	2.1
N-Levels	80 Kg	1.25	1.04	790	595	36.2	38.8	23.4	22.0	10.3	8.2
	100 Kg	1.51	1.19	914	844	37.4	40.3	23.5	23.8	10.9	9.1
	120 Kg	1.53	1.24	979	874	41.6	45.9	26.2	26.8	12.8	10.7
LSD at 0.05		0.03	0.03	0.03	29	0.60	0.51	0.45	0.3	0.38	0.18
K-Levels	24 Kg	1.33	1.08	836	732	36.7	40.6	23.9	23.4	10.8	8.7
	48 Kg	1.55	1.27	1060	893	41.5	44.2	26.8	25.9	12.4	10.7
	72 Kg	1.40	1.12	787	789	37.1	40.c	22.6	23.2	10.7	8.6
LSD at 0.05		0.03	0.02	20	52	0.45	0.30	0.4	0.22	0.3	0.2

Character		Root yield (ton fed^{-1})		Top yield (ton fed^{-1})		Sugar (%)		Sugar yield (ton fed^{-1})	
Factor		S1	S2	S1	S2	S1	S2	S1	S2
Wheat plant dist.	2 rows	30.42	30.99	13.32	13.64	18.99	18.41	5.79	5.71
	3 rows	30.12	28.27	11.53	11.85	17.36	16.97	5.24	4.74
	4 rows	29.09	26.60	10.35	10.68	15.78	15.03	4.71	4.01
LSD at 0.05		0.56	0.66	0.25	0.27	0.08	0.15	0.30	0.17
N-Levels	80 Kg	29.10	27.81	11.14	11.46	17.11	16.13	4.99	4.51
	100 Kg	29.67	28.64	11.57	11.91	17.15	16.92	5.23	4.81
	120 Kg	30.84	29.43	12.48	12.80	17.87	17.36	5.53	5.13
LSD at 0.05		0.35	0.19	0.08	0.09	0.10	0.08	0.21	0.12
K-Levels	24 Kg	28.89	28.43	11.77	12.10	17.41	16.80	5.16	4.80
	48 Kg	30.84	28.82	11.89	12.22	17.56	17.00	5.43	4.93
	72 Kg	29.90	28.63	11.54	11.86	17.17	16.60	5.16	4.72
LSD at 0.05		0.27	0.09	0.14	0.15	0.09	0.12	0.18	0.11

Table 7: Effect of wheat plant distribution, N and K fertilization levels on sugar beet growth and yield characters during 2017/2018 and 2018/2019 seasons.

Effect of N fertilization levels

Data in table 7 indicated that plant weight, root weight, no. of leaves, root length, root diameter, root yield, top yield, sugar% and sugar yield fed were significantly increased by increasing nitrogen levels from 80 up to 120 kg N fed^{-1} in both seasons. These findings may be due to the role of nitrogen in activating cell elongation and attributed to building up plant organs by nitrogen. Due to enhance yield attributes and reflected that on sugar beet yields. The results are similar to that obtained by Saad [30], Ibrahim., *et al.* [4], Badr [17] and El-Ghobashi and Eata [31].

Effect of K fertilization levels

Results in table 7 indicated that all characters of sugar beet were significantly affected by potassium levels. Data revealed that a rate of 48 kg K fed^{-1} recorded the highest values for sugar beet character. Meanwhile, 24 kg K fed^{-1} occupied the second ranked for root weight and number of leaves in one season, and root length, root diameter, top yield, sugar % and sugar yield fed^{-1} in both seasons. Whereas, 72 kg K fed^{-1} occupied the third ranked. These results were scribed to role of potassium in activates enzymes, maintains cell turgor, enhance photosynthesis, reduces respiration helps in transport of sugar and starches as well as nitrogen [9,32].

Interaction effects

Interaction effect between wheat plant distribution and N fertilization levels

Results in table 8 revealed that the average values of plant weight, Root weight, root diameter and root yield ton fed^{-1}, top yield ton fed sugar % and sugar yield fed^{-1} of these characters were obtained from treatment which including in were significantly affected by the interaction wheat plant distribution and nitrogen levels in both seasons.

Data in table 8 revealed that the interaction between 2 rows of wheat × 120 kg N fed^{-1} recorded the highest values for all sugar beet characters in both seasons.

On the other hand, the lowest values for these characters were obtained when wheat was sown in 4 rows× 80 kg N fed^{-1} except, root length was recorded the lowest values with treatment of 4 rows of wheat ×100 kg N fed^{-1} in both seasons. This reduction of values occurred with increasing number of rows of wheat may be due to high competition for light and shading which caused a reduction in photosynthesis and consequently yield and yield component sugar beet. These results are similar with Abd El-Zaher., *et al.* [14], Ibrahim., *et al*. [4] and Badr [17].

Interaction effect between wheat plant distribution and K fertilization levels

Data in table 9 revealed that treatment of 2 wheat rows with 48 kg K fed^{-1} recorded the highest values for plant wt, root wt, root length, root diameter, no. of leaves plant^{-1}, root yield fed^{-1} and top yield fed^{-1} in both seasons. Meanwhile, 4 wheat rows ×24 kg K fed^{-1} recorded the lowest values for these characters in both seasons except, root wt in the first seasons. These results are harmony with Abdel-Mawly and Zanouny [29], Toaima [9] and Salem [32].

Interaction between N and K fertilization levels

Data presented in table 10 indicated that the interaction between N × K levels recorded the highest values for all characters sugar beet in table 10 by using 120 kg N fed^{-1} × 48 kg K fed^{-1} in both seasons. Whereas, using 80 kg N fed^{-1} × 72 kg K fed^{-1} recorded the lowest values for these characters in both seasons, except, root wt. in both seasons, root diameter in the second season and root yield in the second season, which recorded the lowest values by using 80 kg N fed^{-1} × 24 kg K fed^{-1}. These results are agreement with Abdel-Mawly and Zanouny [29], Toaima [9] and Salem [32].

Interaction effect among wheat plant distribution with N and K fertilization levels

Data presented in table 11 indicated that most sugar beet characters were significantly affected by interaction between three factors under study. The treatment of 2 wheat rows with 120 kg N and 48 kg K fed^{-1} recorded the highest values for plant wt., root weight, no. of leaves, root length, root diameter, root yield and top yield fed^{-1} in both seasons.

Also, data revealed that the lowest values of plant wt., root wt., no. of leaves plant^{-1}, root length and root yield fed^{-1} as a result of applying 4 rows of wheat fertilization by 120 kg N fed^{-1} and 48 kg K fed^{-1} in both seasons and root diameter in the second seasons. With respect to top yield fed^{-1} the lowest value was showed with sowing wheat in 4 row × using 100 kg N fed^{-1} × 24 kg K fed^{-1}. Where, the use of decreasing wheat plant distribution in two rows with 120 kg N and 48 kg K fed^{-1}, was increased maximizing productivity in sugar beet characters and allows full utilization of the environmental resources with minimum inter and intra-specific competition, especially for light, water, nitrogen and potassium fertilizer levels, which resulted in greater exposure of the plant canopy to the solar radiation, swell the different root systems of sugar beet and wheat, which allow the crops in the intercropping system to use the soil moisture and at different depths and, thus reduce the above and underground competition between them. Similar results were obtained by Aboukhadra., *et al.* [6], Abou-Elela [18], Shanware [11], Shehata [28], Badr [17] and Salem [32].

Wheat plant dist.	N-Levels	Plant weight (kg)		Root weight (g)		Root length (cm)		Root diameter (cm)	
		S1	S2	S1	S2	S1	S2	S1	S2
2 rows	80 Kg	1.62	1.24	865	844	26.4	25.3	12.0	12.06
	100 Kg	1.69	1.30	831	922	27.2	28.8	13.2	10.5
	120 Kg	2.00	1.45	1087	1011	27.6	31.6	14.2	13.89
3 rows	80 Kg	1.16	1.00	743	644	23.3	21.5	9.7	7.11
	100 Kg	1.45	1.18	973	844	23.4	23.94	10.2	9.83
	120 Kg	1.36	1.13	986	822	26.4	26.11	12.6	10.83
4 rows	80 Kg	0.98	0.89	761	597	20.6	19.11	9.2	5.50
	100 Kg	1.39	1.09	939	767	20.0	18.53	9.2	6.94
	120 Kg	1.22	1.13	864	789	24.6	22.77	11.5	7.33
LSD at 0.05		0.06	0.05	45	92	0.78	0.52	0.70	0.31

Wheat plant dist.	N-Levels	Root yield (ton fed^{-1})		Top yield (ton fed^{-1})		Sugar (%)		Sugar yield (ton fed^{-1})	
		S1	S2	S1	S2	S1	S2	S1	S2
2 rows	80 Kg	29.81	29.86	13.04	13.35	18.32	17.81	5.47	5.37
	100 Kg	30.27	31.13	13.30	13.45	19.04	18.41	5.77	5.70
	120 Kg	31.17	31.92	13.81	14.13	19.61	19.01	6.15	6.04
3 rows	80 Kg	28.92	27.23	10.15	10.46	17.20	16.30	4.98	4.44
	100 Kg	30.81	28.20	11.71	12.06	17.38	17.33	5.39	4.71
	120 Kg	30.63	29.24	12.71	13.03	17.51	17.30	5.36	5.07
4 rows	80 Kg	28.58	26.00	10.22	10.57	15.81	14.29	4.52	3.71
	100 Kg	27.94	26.67	9.89	10.22	15.03	15.03	4.54	4.02
	120 Kg	30.73	27.29	10.93	11.24	16.50	15.77	5.08	4.28
LSD at 0.05		0.60	0.33	0.15	0.14	3.09	0.13	0.36	0.22

Table 8: Interaction effect between wheat plant distribution and N fertilization levels on sugar beet characters during 2017/2018 and 2018/2019 seasons.

Wheat plant dist.	K-Levels	Plant weight (kg)		Root weight (g)		Root length (cm)		Root diameter (cm)	
		S1	S2	S1	S2	S1	S2	S1	S2
2 rows	24 Kg	1.66	1.27	964	878	27.0	27.7	12.6	11.3
	48 Kg	1.86	1.45	1073	989	29.4	30.3	13.8	13.7
	72 Kg	1.78	1.28	746	911	24.7	27.7	13.0	11.4
3 rows	24 Kg	1.25	1.02	790	700	23.2	23.1	10.2	8.7
	48 Kg	1.48	1.21	1043	878	27.1	25.6	12.2	10.4
	72 Kg	1.24	1.08	869	733	22.9	22.9	10.0	8.7
4 rows	24 Kg	1.09	0.96	754	619	21.3	19.5	9.7	6.1
	48 Kg	1.30	1.14	1063	811	23.8	21.9	11.1	7.9
	72 Kg	1.19	1.01	747	722	20.1	19.0	9.1	5.8
LSD at 0.05		0.06	0.03	30	91	0.64	0.38	0.59	0.26

Wheat plant dist.	K-Levels	No. of leaves plant^{-1}		Root yield (ton fed^{-1})		Top yield (ton fed^{-1})	
		S1	S2	S1	S2	S1	S2
2 rows	24 Kg	39.4	51.8	29.30	31.16	13.37	13.70
	48 Kg	45.2	55.6	31.59	30.84	13.37	13.68
	72 Kg	39.6	51.2	30.36	30.92	13.22	13.56
3 rows	24 Kg	37.9	39.2	29.22	28.23	11.67	11.96
	48 Kg	43.0	42.7	31.03	28.44	11.83	12.19
	72 Kg	38.4	39.9	30.11	28.00	11.08	11.40
4 rows	24 Kg	32.7	30.7	28.13	26.62	10.27	10.63
	48 Kg	36.3	34.4	29.89	26.66	10.48	10.78
	72 Kg	33.2	29.6	29.23	26.68	10.31	10.62
LSD at 0.05		0.78	0.52	0.48	0.16	0.24	0.25

Table 9: Interaction effect between wheat plant distribution and K fertilization levels on sugar beet characters during 2017/2018 and 2018/2019 seasons.

N-Levels	K-Levels	Plant weight (kg)		Root weight (g)		Root length (cm)		Root diameter (cm)	
		S1	S2	S1	S2	S1	S2	S1	S2
80 Kg	24 Kg	1.22	0.99	722	641	22.2	21.1	10.0	7.4
	48 Kg	1.32	1.13	902	789	26.3	23.4	11.3	9.7
	72 Kg	1.21	1.01	744	656	21.8	21.4	9.6	7.6
100 Kg	24 Kg	1.41	1.14	886	767	22.8	22.8	10.7	8.7
	48 Kg	1.53	1.24	1068	889	25.7	25.6	11.7	10.4
	72 Kg	1.59	1.18	790	878	22.0	22.9	10.2	8.2
120 Kg	24 Kg	1.37	1.11	900	789	26.5	26.4	11.8	9.9
	48 Kg	1.80	1.43	1210	1000	28.2	28.7	14.1	11.9
	72 Kg	1.41	1.18	827	833	23.9	25.4	12.4	10.2
LSD at 0.05		0.06	0.03	30	91	0.64	0.38	0.59	0.26

N-Levels	K-Levels	No. of leaves plant^{-1}		Root yield (ton fed^{-1})		Top yield (ton fed^{-1})	
		S1	S2	S1	S2	S1	S2
80 Kg	24 Kg	34.4	37.7	28.38	27.84	11.20	11.52
	48 Kg	39.8	41.3	30.17	27.58	11.2	11.51
	72 Kg	34.3	37.4	28.77	27.67	11.02	11.34
100 Kg	24 Kg	36.6	39.2	28.41	28.69	11.66	12.02
	48 Kg	39.3	39.2	30.67	28.80	11.83	12.16
	72 Kg	36.4	39.2	29.94	28.51	11.22	11.54
120 Kg	24 Kg	39.0	44.0	29.87	29.48	12.44	12.74
	48 Kg	45.4	48.8	31 68	29.57	12.64	12.98
	72 Kg	40.4	42.6	30.99	29.41	12.37	12.69
LSD at 0.05		0.78	0.52	0.48	0.06	0.25	0.23

Table 10: Interaction effect between N and K fertilization levels on sugar beet characters during 2017/2018 and 2018/2019 seasons.

Wheat plant dist.	N-Levels	K-Levels	Plant weight (kg)		Root weight (g)		No. of leaves plant^{-1}		Root length (cm)	
			S1	S2	S1	S2	S1	S2	S1	S2
2 rows	80 Kg	24 Kg	1.58	1.21	864	833	36.7	45.3	25.1	24.3
		48 Kg	1.72	1.31	1077	967	42.3	50.7	27.7	26.5
		72 Kg	1.55	1.19	653	733	35.3	45.7	26.2	25.0
	100 Kg	24 Kg	1.63	1.27	927	800	42.7	53.3	26.0	27.9
		48 Kg	1.58	1.33	943	900	45.0	55.7	28.6	30.3
		72 Kg	1.84	1.30	623	1067	41.0	53.7	26.9	28.3
	120 Kg	24 Kg	1.78	1.33	1100	1000	39.0	56.7	29.9	31.0
		48 Kg	2.28	1.69	1200	1100	48.3	60.3	31.9	34.0
		72 Kg	1.95	1.33	960	933	42.3	54.3	21.0	29.8
3 rows	80 Kg	24 Kg	1.27	1.10	870	800	41.7	38.0	25.2	22.8
		48 Kg	1.13	1.03	750	700	41.3	39.3	27.2	23.3
		72 Kg	1.11	1.10	927	766	36.7	43.0	20.8	25.0
	100 Kg	24 Kg	1.30	1.00	810	700	36.0	42.3	21.9	25.8
		48 Kg	1.65	1.30	1160	933	42.0	41.7	26.9	26.0
		72 Kg	1.17	1.00	790	633	42.3	38.0	26.9	20.5
	120 Kg	24 Kg	1.17	0.97	690	600	36.0	37.3	22.6	20.8
		48 Kg	1.66	1.30	1220	1000	45.7	47.0	27.1	27.5
		72 Kg	1.43	1.13	890	800	36.3	38.7	20.8	23.0
4 rows	80 Kg	24 Kg	0.91	0.80	613	490	30.7	30.3	19.5	18.3
		48 Kg	1. 11	1.03	880	700	35.7	34.0	24.1	20.5
		72 Kg	0.91	0.83	790	600	31.3	28.7	18.2	18.5
	100 Kg	24 Kg	1.32	1.07	860	700	31.0	26.3	20.0	17.8
		48 Kg	1.35	1.10	1100	833	31.0	30.3	21.7	20.5
		72 Kg	1.50	1.10	857	767	31.7	25.3	18.2	17.3
	120 Kg	24 Kg	1.04	1.00	790	667	36.3	35.3	24.5	22.5
		48 Kg	1.45	1.30	1210	900	42.3	39.0	25.6	24.5
		72 Kg	1.17	1.10	593	800	36.7	34.7	23.9	31.3
LSD at 0.05			0.10	0.05	52	91	1.35	0.90	1.11	0.66
Sole culture of sugar beet			1.9	1.8	960	965	42	54.7	33.5	30.2

Wheat plant dist.	N-Levels	K-Levels	Root diameter (cm)		Root yield (ton fed^{-1})		Top yield (ton fed^{-1})	
			S1	S2	S1	S2	S1	S2
2 rows	80 Kg	24 Kg	11.2	11.0	29.07	30.27	13.03	13.33
		48 Kg	13.3	13.7	30.97	29.47	13.03	13.33
		72 Kg	11.5	11.5	29.40	29.85	13.07	13.40
	100 Kg	24 Kg	13.3	9.8	28.83	31.27	12.30	13.67
		48 Kg	12.8	12.5	31.57	31.17	13.07	13.41
		72 Kg	13.5	9.2	30.40	30.97	12.93	13.27
	120 Kg	24 Kg	13.3	13.2	30.00	31.93	13.77	14.10
		48 Kg	15.3	14.8	32.23	31.90	14.00	14.30
		72 Kg	14.0	13.7	31.27	31.93	13.67	14.00

3 rows	80 Kg	24 Kg	9.8	10.0	28.23	27.37	10.30	10.60
		48 Kg	10.8	8.2	29.97	27.30	10.23	10.53
		72 Kg	12.2	9.3	28.57	27.03	9.93	10.23
	100 Kg	24 Kg	11.5	6.7	29.67	28.17	11.90	12.23
		48 Kg	11.8	10.8	31.83	28.60	12.40	12.77
		72 Kg	9.0	10.3	30.93	27.83	10.83	11.17
	120 Kg	24 Kg	9.2	9.3	29.77	29.17	12.8	13.03
		48 Kg	14.0	12.2	31.30	29.43	12.87	13.27
		72 Kg	8.8	6.5	30.83	29.13	12.47	12.80
4 rows	80 Kg	24 Kg	9.7	4.7	27.83	25.90	10.27	10.63
		48 Kg	9.8	7.2	29.57	25.97	10.33	10.67
		72 Kg	8.2	4.7	28.33	26.13	10.07	10.40
	100 Kg	24 Kg	9.0	6.8	26.73	26.63	9.77	10.17
		48 Kg	10.5	7.8	28.60	26.63	10.03	10.31
		72 Kg	8.2	6.2	28.50	26.73	9.88	10.20
	120 Kg	24 Kg	10.5	6.7	29.63	27.33	10.77	11.10
		48 Kg	13.0	8.8	31.50	27.37	11.07	11.37
		72 Kg	11.0	6.5	30.87	27.17	10.97	11.27
LSD at 0.05			1.0	0.4	0.82	0.28	0.43	0.41
Sole culture of sugar beet			41.1	13.1	33.2	33.51	14.58	15.2

Table 11: Interaction effect among wheat plant distribution, N and K fertilization levels on sugar beet some characters during 2017/2018 and 2018/2019 season.

Competitive relationships

Land equivalent ration (LER)

Data presented in table 12 revealed that all treatments of LERs were increased than one in both seasons by the interaction between wheat plant distribution systems with N and K fertilizers.

The increase of LERs was ranged between 20 and 39% in the first season, and 0.03 and 36% in the second seasons, compared with sole culture. The highest values of LER were 1.39 and 1.36, which recorded in 2 rows with 120 Kg N and 48 Kg K fed^{-1} in the first and in the 2 rows of wheat ×120 Kg N fed^{-1} × 24 Kg K fed^{-1} second seasons. On the other hand, the results indicated that the lowest values of LERs were showed at 2 or 3 rows of wheat with 100 kg N and 72 kg K fed^{-1} (1.2, 1.03) in the first and second seasons, respectively. To obtain the best land equivalent ratio must be applied 2-rows wheat plant distribution systems at a rate 25 kg fed^{-1} with fertilization of 120 kg N fed^{-1} and 24 or 48 kg K fed^{-1}. Similar results were obtained with Aboukhadra., *et al.* [7], Badr [15], Shehata [28] and Badr [17].

Land equivalent coefficient (LEC)

When the values of LECs were increased than 25%, the treatments were positive; this means that all treatments had LEC values above 0.25 suggesting yield advantages and showed efficient utilization of land resource by growing both crops together and vice versa. So, all treatments as a combination between factors under study were increased than 25% in the first season, and except 3 treatments in the second season. Data revealed that the best yield advantage as the interaction between factors under study was shown with 2 or 4 rows of wheat with 120 kg N and 48 kg K fed^{-1} in the first season, and 39% with 2 or 4 rows of wheat with 120 kg N and 24 kg K fed^{-1} in the second season. Whereas, the lowest values of LECs were 26% and 17% at 2 and 3 rows of wheat with 100 kg N and 72 kg K fed^{-1} in the first and second seasons, respectively. Similar results were obtained with Sheha., *et al.* [33] and El-Ghobashi and Eata [31].

Wheat plant dist.	N-Levels	K-Levels	LER					
			S1			S2		
			RYs	RYw	LER	RYs	RYw	LER
2 rows	80 Kg	24 Kg	0.88	0.33	1.21	0.90	0.33	1.23
		48 Kg	0.93	0.33	1.26	0.88	0.33	1.22
		72 Kg	0.89	0.36	1.25	0.89	0.30	1.19
	100 Kg	24 Kg	0.87	0.37	1.24	0.93	0.38	1.31
		48 Kg	0.95	0.37	1.32	0.93	0.30	1.23
		72 Kg	0.92	0.28	1.20	0.92	0.35	1.27
	120 Kg	24 Kg	0.90	0.44	1.34	0.95	0.41	1.36
		48 Kg	0.97	0.42	1.39	0.95	0.34	1.29
		72 Kg	0.94	0.38	1.32	0.95	0.35	1.30
3 rows	80 Kg	24 Kg	0.85	0.40	1.25	0.82	0.35	1.17
		48 Kg	0.90	0.37	1.27	0.81	0.35	1.16
		72 Kg	0.86	0.35	1.21	0.81	0.30	1.11
	100 Kg	24 Kg	0.89	0.43	1.32	0.84	0.37	1.21
		48 Kg	0.96	0.41	1.37	0.85	0.33	1.18
		72 Kg	0.93	0.42	1.35	0.83	0.20	1.03
	120 Kg	24 Kg	0.90	0.43	1.33	0.87	0.40	1.27
		48 Kg	0.94	0.35	1.29	0.88	0.39	1.27
		72 Kg	0.93	0.40	1.33	0.87	0.21	1.08
4 rows	80 Kg	24 Kg	0.84	0.47	1.31	0.77	0.46	1.23
		48 Kg	0.89	0.36	1.25	0.77	0.41	1.18
		72 Kg	0.85	0.41	1.26	0.78	0.36	1.14
	100 Kg	24 Kg	0.81	0.47	1.28	0.79	0.46	1.25
		48 Kg	0.86	0.45	1.31	0.79	0.42	1.21
		72 Kg	0.86	0.42	1.28	0.80	0.39	1.19
	120 Kg	24 Kg	0.89	0.43	1.32	0.82	0.48	1.30
		48 Kg	0.95	0.43	1.38	0.82	0.42	1.24
		72 Kg	0.93	0.44	1.37	0.81	0.43	1.24

Wheat plant dist.	N-Levels	K-Levels	LEC		A			
			S1	S2	S1		S2	
					As	Aw	As	Aw
2 rows	80 Kg	24 Kg	0.29	0.30	-0.537	0.537	-0.541	0.541
		48 Kg	0.31	0.29	-0.494	0.494	-0.546	0.546
		72 Kg	0.32	0.27	-0.700	0.700	-0.383	0.383
	100 Kg	24 Kg	0.32	0.35	-0.750	0.750	-0.750	0.750
		48 Kg	0.35	0.28	-0.655	0.655	-0.320	0.320
		72 Kg	0.26	0.32	-0.248	0.248	-0.597	0.597
	120 Kg	24 Kg	0.41	0.39	-1.079	1.079	-0.867	0.867
		48 Kg	0.41	0.32	-0.905	0.905	-0.515	0.515
		72 Kg	0.36	0.33	-0.741	0.741	-0.579	0.579

3 rows	80 Kg	24 Kg	0.34	0.29	-0.924	0.924	-0.721	0.721
		48 Kg	0.33	0.28	-0.740	0.740	-0.740	0.740
		72 Kg	0.30	0.24	-0.655	0.655	-0.505	0.505
	100 Kg	24 Kg	0.38	0.31	-1.052	1.052	-0.803	0.803
		48 Kg	0.39	0.28	-0.840	0.840	-0.574	0.574
		72 Kg	0.39	0.17	-0.910	0.910	-0.013	0.013
	120 Kg	24 Kg	0.39	0.35	-1.027	1.027	-0.930	0.930
		48 Kg	0.33	0.34	-0.555	0.555	-0.837	0.837
		72 Kg	0.37	0.18	-0.841	0.841	-0.032	0.032
4 rows	80 Kg	24 Kg	0.39	0.35	-1.278	1.278	-1.190	1.190
		48 Kg	0.32	0.32	-0.688	0.688	-1.060	1.060
		72 Kg	0.34	0.28	-0.969	0.969	-0.830	0.830
	100 Kg	24 Kg	0.38	0.36	-1.341	1.341	-1.289	1.289
		48 Kg	0.39	0.33	-1.180	1.180	-1.100	1.100
		72 Kg	0.36	0.31	-1.050	1.050	-0.929	0.929
	120 Kg	24 Kg	0.38	0.39	-1.441	1.441	-1.380	1.380
		48 Kg	0.41	0.34	-0.966	0.966	-1.079	1.079
		72 Kg	0.41	0.35	-1.015	1.015	-1.147	1.147

Table 12: Interaction effect among wheat plant distribution, N and K fertilization levels on competitive relationships during 2017/2018 and 2018/2019 seasons.

* s: Sugar Beet; w: Wheat.

Aggressivity (A)

Data presented in table 12 indicated that all treatments as a result of the interaction between wheat plant distributions with N and K fertilizers recorded negative values for sugar beet and positive values for wheat in both seasons. So, wheat was a dominant crop and sugar beet was a dominated crop in all treatments under study in both seasons. This means that wheat more aggressively than sugar beet, this because of the differences in canopy texture in height of wheat and sugar beet, the two species not only competed for nutrient and water but also sunlight. Our results indicate that land use of the wheat-sugar beet intercropping pattern was more efficient than sole cropping, which may be due to more rational use of environmental resources in intercropping situations. Similar results were obtained by Toaima [9], Abou-Elela [18], Shehata [28] and Badr [17].

Economic evaluation

Total income and net return (LE fed^{-1}) of all intercropping treatments were found to be superior to solid cultures of sugar beet and wheat as shown in table 13.

The sugar beet prices were LE 378.5, 400 ton^{-1} of roots and LE 54, 63 ton^{-1} of top-fresh, meanwhile wheat prices were LE 575, 680 $ardab^{-1}$ of grains and LE 1000, 1100 ton^{-1} of straw in 2017/2018 and 2018/2019, respectively.

The maximum values of total income and net return (19872 and 20488) and (7092 and 6508) LE fed^{-1} were achieved under 4 rows which fertilized by 120 kg N fed^{-1} and 24 kg K fed^{-1}, in the first and second seasons, respectively. Whereas, the lowest values of total return and net return in the first season (16137 and 3737 LE fed^{-1}) were achieved when wheat plants were planted in 2 rows with 100 kg N fed^{-1} and 24 kg K fed^{-1}, and they were 16518 and 2788 LE fed^{-1} by planting wheat plants 3 rows with 120 kg N fed^{-1} and 24 kg K fed^{-1} in the second season. Highest total income or net return must choose to plant wheat in 4 rows with 120 kg N fed^{-1} and 24 kg K fed^{-1}. These results are in agreement with Abou - Elela [18], Shehata [28], Badr [17] and Sheha., *et al*. [33].

Wheat plant dist.	N-Levels	K-Levels	2017/2018 Season			
			Wheat		Sugar beet	
			Grain yield (LE)	Straw yield (LE)	Root yield (LE)	Top yield (LE)
2 rows	80 Kg	24 Kg	3852	730	10988	703
		48 Kg	3921	110	11706	703
		72 Kg	4266	280	11113	705
	100 Kg	24 Kg	4335	240	10897	664
		48 Kg	4353	940	11933	705
		72 Kg	3289	1030	11491	698
	120 Kg	24 Kg	5215	1410	11340	743
		48 Kg	5002	1150	12182	756
		72 Kg	4531	680	11820	738
3 rows	80 Kg	24 Kg	4692	1070	11170	556
		48 Kg	4416	670	11328	552
		72 Kg	4088	820	10799	536
	100 Kg	24 Kg	5123	1500	11215	642
		48 Kg	4818	1070	12031	669
		72 Kg	4899	1080	11691	584
	120 Kg	24 Kg	5071	1350	11253	691
		48 Kg	4094	880	11831	694
		72 Kg	4726	920	11653	673
4 rows	80 Kg	24 Kg	5491	1300	10519	554
		48 Kg	4255	1130	11177	557
		72 Kg	4807	1120	10708	543
	100 Kg	24 Kg	5543	1670	10103	527
		48 Kg	5330	1330	10810	541
		72 Kg	5014	1200	10773	533
	120 Kg	24 Kg	6060	2030	11200	581
		48 Kg	5083	1790	11907	597
		72 Kg	5140	1530	11668	592
Sole culture of Sugar beet			-	-	12566	787
Sole culture of wheat			11805	3000	-	-

Wheat plant dist.	N-Levels	K-Levels	2017/2018 Season		
			Total income fed^{-1} (LE)	Costs (LE)	Net return fed^{-1} (LE)
2 rows	80 Kg	24 Kg	16274	12100	4174
		48 Kg	16441	12300	4141
		72 Kg	16365	12392	3973
	100 Kg	24 Kg	16137	12400	3737
		48 Kg	17932	12470	5462
		72 Kg	16508	12530	3978
	120 Kg	24 Kg	18708	12780	5878
		48 Kg	19091	12832	6259
		72 Kg	17769	12980	4789
3 rows	80 Kg	24 Kg	17489	12100	5389
		48 Kg	16967	12300	4667
		72 Kg	16244	12392	3852
	100 Kg	24 Kg	18481	12400	6081
		48 Kg	18589	12470	6119
		72 Kg	18255	12530	5725
	120 Kg	24 Kg	18365	12780	5585
		48 Kg	17500	12832	4668.
		72 Kg	17973	12980	4993

4 rows	80 Kg	24 Kg	17865	12100	5765
		48 Kg	17120	12300	4820
		72 Kg	17179	12392	4787
	100 Kg	24 Kg	17844	12400	5444
		48 Kg	18011	12470	5541
		72 Kg	17520	12530	4990
	120 Kg	24 Kg	19872	12780	7092
		48 Kg	19377	12832	6545
		72 Kg	18931	12980	5951
Sole culture of Sugar beet			13353	11292	13353
Sole culture of wheat			14805	10057	14805
Wheat plant dist.			N-Levels	K-Levels	2018/2019 Season

			Wheat		Sugar beet	
			Grain yield (LE)	Straw yield (LE)	Root yield (LE)	Top yield (LE)
2 rows	80 Kg	24 Kg	4569	847	11692	839
		48 Kg	4501.	770	12410	839
		72 Kg	4093	220	11819	844
	100 Kg	24 Kg	5242	770	11561	861
		48 Kg	4059	1496	12639	844
		72 Kg	4794	550	12189	836
	120 Kg	24 Kg	5630	935	12083	888
		48 Kg	4664	275	12938	900
		72 Kg	4841	275	12558	882
3 rows	80 Kg	24 Kg	4766	550	12227	667
		48 Kg	4821	693	11881	663
		72 Kg	4141	737	11335	644
	100 Kg	24 Kg	5072	935	11857	770
		48 Kg	4488	407	12701	804
		72 Kg	2801	737	12276	703
	120 Kg	24 Kg	5521	605	11944	820
		48 Kg	5290	737	12526	836
		72 Kg	2883	957	12327	806
4 rows	80 Kg	24 Kg	6310	1100	11074	669
		48 Kg	5555	770	11735	672
		72 Kg	4943	880	11252	655
	100 Kg	24 Kg	6242	1144	10631	640
		48 Kg	5732	1067	11352	649
		72 Kg	5270	880	11306	642
	120 Kg	24 Kg	6555	1452	11782	699
		48 Kg	5746	803	12504	716
		72 Kg	5909	825	12261	710
Sole culture of Sugar beet			-	-	13404	958
Sole culture of wheat			13675	3410	-	-

Wheat plant dist.	N-Levels	K-Levels	2018/2019 Season		
			Total income fed^{-1} (LE)	Costs (LE)	Net return fed^{-1} (LE)
2 rows	80 Kg	24 Kg	17948	13320	4628
		48 Kg	18521	13370	5151
		72 Kg	16976	13420	3556
	100 Kg	24 Kg	18435	13580	4855
		48 Kg	19039	13630	5409
		72 Kg	18369	13730	4639
	120 Kg	24 Kg	19537	13980	5557
		48 Kg	18779	14030	4749
		72 Kg	18556	14130	4426
3 rows	80 Kg	24 Kg	18211	13320	4891
		48 Kg	18058	13370	4688
		72 Kg	16858	13420	3438
	100 Kg	24 Kg	18636	13580	5056
		48 Kg	18400	13630	4770
		72 Kg	16518	13730	2788
	120 Kg	24 Kg	18891	13980	4911
		48 Kg	19389	14030	5359
		72 Kg	16973	14130	2843
4 rows	80 Kg	24 Kg	19154	13320	5784
		48 Kg	18733	13370	5363
		72 Kg	17730	13420	4310
	100 Kg	24 Kg	18658	13580	5078
		48 Kg	18801	13630	5171
		72 Kg	18099	13730	4369
	120 Kg	24 Kg	20488	13980	6508
		48 Kg	19770	14030	5740
		72 Kg	19705	14130	5575
Sole culture of Sugar beet			14362	12670	1692
Sole culture of wheat			17085	11850	5235

Table 13: Interaction effect among wheat plant distribution, N and K fertilization levels on economic evaluation of intercropping wheat with sugar beet in 2017/2018 and 2018/2019 seasons.

Conclusion

Despite the biological success of the two-row wheat distribution system (25% of the wheat seed rate fed^{-1}) in the wheat-sugar beet association, which achieved a maximum land equivalent ratio, the profitability of the farmer remains the deciding factor in the choice of an effective intercropping system. The study therefore advises farmers, based on the results of the economic assessment and market price of the Gemmeza district, to use the 4-row wheat distribution method (25% of the wheat seed rate fed^{-1}) in the wheat-sugar beet association and to fertilize the combination with 120 kg N and 24 kg K fed^{-1} to achieve the best profitability for the farmer.

Conflict of Interest

No declare for financial interest or any conflict of interest exists.

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