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EGYPTIAN ACADEMIC JOURNAL OF BIOLOGICAL SCIENCES BOTANY

ISSN 2090-3812

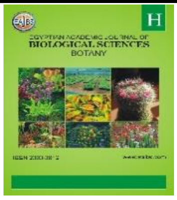
www.eajbs.com

Vol. 15 No.2 (2024)

Citation: Egypt. *Acad. J. Biolog. Sci.* (H. Botany) *Vol.15 (2) pp 15-28 (2024)*
DOI: 10.21608/EAJBSH.2024.383361

Egypt. Acad. Journal Biology. Sci., 15 (2):15-28 (2024)

Egyptian Academic Journal of Biological Sciences
H. Botany
ISSN 2090-3812
www.eajbsh.journals.ekb.eg.



Impact of Wheat Seeding Rates with Sugar Beet, Humic Acid and N Fertilizer Rates on Yield and Chemical In Both Crops

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ARTICLE INFO
Article History
Received:28/8/2024
Accepted:2/10/2024
Available:6/10/2024

Keywords:
Intercropping, sugar beet, wheat, N fertilizer, humic acid, Land equivalent ratio (LER).

ABSTRACT

A field Experiment was conducted during 2022/2023 and 2023/2024 in Etay El-Baroud, Research Station, El Beheira Governorate,(ARC), Giza, Egypt to study the effect of four fertilizer treatments (80% N of recommended + 10L. Humic acid fed^{-1}, 60% N of recommended + 10L. Humic acid fed^{-1}, 40% N of recommended + 10L. Humic acid fed^{-1} and 100% N which is recommended fed^{-1}) under three intercropping rates of wheat with sugar beet (100% sugar beet + 12.50% wheat, 100% sugar beet + 25% wheat and 100% sugar beet + 37.50% wheat). Split plot design with three replications. Results indicated that all studied traits of sugar beet achieved the highest values with 100% N fed^{-1} or 80% N + 10L. Humic acid fed^{-1}. Sowing sugar beet under an intercropping rate of 100% sugar beet + 12.50% wheat recorded the highest values of yield and quality of sugar beet in both seasons. Interaction between intercropping of 100% sugar beet + 12.50% wheat and application of 100% N fed^{-1} recorded the highest values on most sugar beet traits in the first and second seasons. Application of 100% N fed^{-1} or 80% N + 10L. Humic acid fed^{-1} recorded the highest values of wheat in both seasons. intercropping rate of 100% sugar beet + 37.50% wheat recorded the highest grain yield of wheat in both seasons. Sowing wheat of 100% sugar beet + 37.50% wheat and application of 100% N fed^{-1} achieved the highest yields of wheat. Using 80% N of recommended + 10L. Humic acid fed^{-1} fertilizer treatment and the intercropping rate of 100% sugar beet + 12.50% wheat recorded the highest LER, MAI and income.

INTRODUCTION

The sugar beet crop is the second sugar crop after sugar cane in Egypt. Egypt imports 300 thousand tons of sugar every year narrowing the shortage gap. 121 countries around the world are cultivated sugar beet; their total sugar beet production amounts to 270 million tons from an area of 7.9 million hectares (FAO, 2023). Sugar beet aria in Egypt is 682. 770 fed and the yield is 14.195.170 tons (Agricultural Economics, 2023).

Wheat is the first cereal crop in Egypt and the main ingredient for bread flour in Egypt. Egypt imports from 5 to 5.5 million tons annually, the area of wheat in the world was 219 million hectares, producing 761 million tons. Egypt was estimated at about 3.06 million fed, which produced 9.042 million tons (FAO, 2023).

Intercropping is one of the solutions and a major pillar to reduce imports of wheat. The Minister confirmed that the 2022-2023 agricultural season witnessed a cultivated area of 9.8 million fed, with a crop area of 17 million fed. As a result of the agricultural intensification rate, which represented 180 percent. Hence, there is a need to maximize production per unit area to accelerate production increases, which will encourage a reduction in the expected food security gap. Intercropping is a component of sustainable agriculture; it is a system that produces more unit area than single crops (Kumar et al., 2014). Intercropping wheat with sugar beet by reducing the density of wheat reduced competition between plants and increased production per unit area (Gomaa *et al.*, 2019).

Organic manures (such as humic and fulvic acids) make up 65-70% of organic matter present in soil, and the term humus is widely used as a synonym for soil organic matter. Specifically, humic acid compounds may have various biochemical effects either at the cell wall, membrane level or in the cytoplasm, including increased photosynthesis and respiration rates in plants, enhanced protein synthesis and phytohormone-like activity (Chen and Aviad, 1990). The addition of humic acid substances increased the surface per unit area for photosynthetic, which increased growth and nutrient absorption by plants. This led to the permeability of the membrane (Enan *et al.*, 2016). Also, Mollasadeghi (2010) revealed that humic acid reduces the level of use of chemical fertilizers, attributes plant tolerance against adverse conditions such as water, heat, and cold stresses, and makes it more resistant to diseases, insects, and other adverse environmental conditions. Furthermore, increasing the overall plant production, i.e. the production and stimulating the roots. In the same way, Samavat and Malakoti (2010) found that the application of humic acid in the plant nutrient solution leads to increased shoot and root growth, thus enhancing the N content in the shoots. Sharaf (2012) reported that the maximum values for all growth characters resulted from the yeast treatment, then the macro- and micronutrient treatment, and then the amino acid treatment and the humic acid treatment compared to the without humic acid. The maximum refined sugar yield as the most important economic parameter of the yield was achieved by 3 times the application of 5 L ha^{-1} humic acid (Rassam *et al.*, 2015). Humic acid plays an important role in improving plant growth, as it can be used to combat the deficiency of micronutrients in alkaline soil. It can strengthen the effect on plant growth, as a result of improving the physical properties of the soil (Ghada *et al.*, 2018). Humic acid as a modern fertilization strategy has been used as foliar spraying of plants, as the organic materials of humic acid have not had any harmful effects on the environment (Rosa et al., 2018). The highest values of sugar beet character from adding humic acid to the soil compared to not adding humic acid (Abd El-Lattief, *et al.*, 2020).

The objectives of this investigation are reducing chemical nitrogen fertilizer, reducing pollution, and increasing soil properties by using humic acid. Increasing the area of wheat and increasing productivity, quality and return of unit area by intercropping wheat with sugar beet.

MATERIALS AND METHODS

A field experiment was carried out at the Agriculture Research Station, Agriculture Research Center (ARC) Etay El-Baroud, El-Beheira Governorate, Egypt to study four nitrogen and humic acid fertilizer treatments and three seeding rates of wheat (*Triticum aestivum L.)* cv. Sahka 94 with sugar beet *(Beta vulgaris L.)* cv. Halawa kws, during 2022/2023 and 2023/2024 seasons. The experimental design was a randomized complete block in a split-plot system in three replications. Fertilizer treatments were distributed in the main plots as follows:

T1: 80% N of recommended + 10 liters humic acid fed^{-1}.
T2: 60% N of recommended + 10 liters humic acid fed^{-1}.
T3: 40% N of recommended + 10 liters humic acid fed^{-1}, and
T4: 100% N, which is recommended. Whereas the three intercropping seeding rates of wheat with sugar beet were randomly implemented in the sub-plots as follows:

P1: 100% sugar beet + 12.50% wheat (7.50 kg of wheat grain in rows on the width of sugar beet ridge).

P2: 100% sugar beet + 25% wheat (15 kg of wheat grain in rows on the width of sugar beet ridge).

P3: 100% sugar beet + 37.50% wheat (22.50 kg of wheat grain in rows on the width of sugar beet ridge). Besides of monoculture of both crops as recommended.

The previous crop was maize in the first and second seasons. The chemical and physical properties of the experimental soil are shown in **(**Table 1**)**.

Table 1: Physical and chemical analysis of experimental soil during the 2022/2023 and 2023/2024 seasons.

Soil properties	Soil texture	Sand%	Silt%	Clay%	P^H	Organic matter%	Available N (ppm)	Available P (ppm)	Available K (ppm)	EC (m mhos) cm^{-1} (1:5)
2022/23	Clay	7.10	32.50	60.40	7.72	2.00	1.51	0.40	279.87	1.94
2023/24	Clay	7.60	31.79	60.61	7.78	2.06	1.53	0.39	287.78	1.60

Humic acid: was added to soil at a rate of 10 liters per $feddan^{-1}$ in two equal doses before the first and second irrigations. Humic Type Commercial Product: Hemogreen Humic Acid 10% Liquid Produced by Technogreen Company, Nubaria, Egypt. Analysis of the humic acid produced is shown in Table 2.

Table 2: Properties of the humic acid substance used in the experiment**.**

Macronutrients (%)			Micronutrients (meq/l)			OM (%)	Ec (dSm^{-1})	P^H
N	P	K	Zn	Mn	Fe	72.01	2.99	7.65
2.03	0.35	3.39	0.61	11.55	18.65			

The number of ridges in each sub-plot was 3 ridges (120 cm width), and the length of the ridge was 3 m (plot area was 10.80 m^2 = 1/388.89 of fed). Calcium superphosphate (15.5% P_2O_5) at 100 kg fed^{-1} was added during soil preparation in the first and second seasons. Nitrogen fertilizer was added in the form of urea (46% N). 100% N= 173.91 kg urea which is the recommended dose, 80% N= 139.13 kg urea of the recommended dose, 60% N = 104.35 kg urea of the recommended dose and 40% N = 69.57 kg urea of the recommended dose in two equal doses, the first dose after the plants thinned out and the second dose was added before the second irrigation. According to the recommendation of the Ministry of Agriculture and Land Reclamation, the other cultural Practices were done. Sugar beet was planted on the 10^{th} and 13^{th} of October, whereas wheat was planted on the 13th and 15^{th} of November in the 2022/2023 and 2023/2024 seasons, respectively. Sugar beet was harvested on the 5^{th} and 7^{th} of May, while wheat was harvested on the 2^{nd} and 4^{th} of May in both seasons, respectively.

A- Sugar beet:

Yield Characters: At harvest, ten plants were randomly taken from each sub-plot to determine the following measurements, root length (cm), root diameter (cm), top weight $plant^{-1}$ (g) and root weight (g). Root yield (ton fed^{-1}) and top yield (ton fed^{-1}) were taken from the whole plot. Sugar yield (tons fed^{-1}) was calculated from root yield (tons fed^{-1}) x sucrose%.

Quality Characters: 1-Total soluble solids percentage (TSS %) was using a hand refractometer according to (A.O.A.C., 1990), and estimated in juice of fresh root.

2- According to Le-Docte (1972) was measured sucrose % by hand saccharemeter.

3- According to Carruthers and Oldfield (1961) estimated juice purity %, by the equation of the following: $\text{Juice purity\%} = \frac{\text{Sucrose\%}}{\text{TSS\%}} \times 100$

B- Wheat:

Yield and Yield Components: At harvest take ten plants from each sub-plot to measure the following, plant height (cm), spike length (cm), number of grains $spike^{-1}$, grains weight spike^{-1} (g), number of spikes m^{-2} and 1000-grain weight (g). Grain weight m^{-2} (g) was taken at the one-meter area from the plot. Grain yield (ardab fed^{-1}) and straw yield in tons fed^{-1} were taken from the whole plot.

C- Competitive Relationships and Yield Advantages:

1. Land Equivalent Ratio (LER): LER is the sum of fractions of the intercropped yield related to their monoculture crop yields. It is usually assumed that the same level of management must be the same for intercropping as for mono-cropping. It was determined according to Willey and Soiree (1972).

$$LER = \frac{Yab}{Yaa} + \frac{Yba}{Ybb}$$

Where: Y_{ab} = yield of the crop (a) intercropped with crop (b), Y_{ba} = yield of the crop (b) intercropped with crop (a), Y_{aa} = yield of the crop (a) as a single crop and Y_{bb} = yield of the crop (b) as a single crop.

2. Relative Crowding Coefficient (K): From Dewit (1960).

$$K = (K_{ab} \times K_{ba}).\ K_{ab} = \frac{Yab \text{ x } Zba}{(Yaa - Yab) \text{x } Zab},\ \text{and } K_{ba} = \frac{Yba \text{ x } Zab}{(Ybb - Yba) \text{x } Zba}$$

Where Z_{ab} and Z_{ba} were proportions of Sugar beet (a) and wheat (b) in the intercropping, respectively.

3. Aggressivity (A): This is often used to determine the competitive relationship between two crops used in mixed cropping **(**Mc-Gilchrist, 1965).

$$Aa = \frac{Yab}{Yaa \text{ x } Zab} - \frac{Yba}{Ybb \text{ x } Zba},\ \text{and } A_b = \frac{Yba}{Ybb \text{ x } Zba} - \frac{Yab}{Yaa \text{ x } Zab}$$

If A = 0, both crops are equally competitive, if Aa is positive, then the a is dominant, if Aa is negative, then the a is dominated.

D. Economic Evaluation:

1. Total Return (L.E.): Total income was calculated by the price from sugar beet yield plus wheat yield. The difference between the gross production from intercropping and monoculture crops was used to compute the farmer's benefit (L.E.). For sugar beet root, the cost per ton of roots as reported by the local market was 1300 and 1900 E.L. ton^{-1} in both seasons, while the yield of the tops was 200 and 300 E.L. ton^{-1} in the two seasons. Wheat grains prices were 1500 and 2000 E.L. ardab^{-1} (150 kg), while the straw yield of wheat was 1400 and 1800 E.L. ton^{-1} in the first and second seasons, respectively.

2. Monetary Advantage Index: MAI was calculated for economic evaluation of intercropping systems as compared with monoculture crops. According to the equation, of $MAI = \frac{Value\ of\ combined\ intercrops\ X\ LER - 1}{LER}$, As suggested by Willey (1979**).** To calculate the monetary advantage index (MAI) (L.E.) were used: prices of sugar beet and wheat were presented by the local market, in both seasons.

Statistical Analysis:

Data were statistically analyzed according to Snedecor and Cochran (1967). The least significant difference (LSD) at 5% probability was applied to compare the averages of the study treatments, which were calculated using the CoStat V 6.4 program (2005).

RESULTS AND DISCUSSION

A: Sugar Beet:

1. Fertilizer Effects:

Results in Table (3) showed that fertilizers application had a significant effect on sugar beet yield and its components in the two growing seasons. Root and sugar yields fed^{-1} recorded the same trend of yield components in the first and second seasons. The highest values were given when sugar beet was fertilized at 100% N and 80% N + 10L. Humic acid, these fertilizer treatments were not up to a 5% level of significance in the two growing seasons. The higher sugar yield fed^{-1} was recorded when sugar beet was fertilized with 80% N + of humic acid in the first and second seasons. These results may be due to that humic substances can reduce mineral fertilizer, and make nutrients available and humic contains nutrients available to the plant during the growing season. These findings were obtained by Rassam *et al*. (2015). The results proved the existence of a significant humic acid and the number of applications with nitrogen on all parameters under study. Similar results were obtained by Mollasadeghi (2010). Humic-fertilizers widely used as an alternative to chemical fertilizers, gave better results by reducing the usage of mineral fertilizer and producers have introduced new types that are environmentally friendly, and improve soil fertility and crop productivity (Russo and Berlyn 1990). Also, Sharaf (2012) reported that the highest mean values of all growth and yield components were resulted by the yeast treatment then macro and micronutrients treatment, and then amino acids treatment as well as humic acid application compared with control. Whereas the lowest values of root traits and sugar yield fed^{-1} resulted when sugar beet plants were fertilized with 40% N + 10L humic acid in the growing seasons. Badawi *et al.* (2013) obtained that the loss values resulted from 0 tons compost fed^{-1} + 0 kg humic acid fed^{-1} + 40 kg N fed^{-1} at 120 and 150 days after sowing in the first and second seasons, respectively.

Fertilizer treatments had a significant effect on total soluble solids %, sucrose % and purity % in the first and second seasons as shown in Table (3). The higher results of these characters were resulted by 40% N + 10 L. humic acid. Whereas the lowest values were obtained by 100% N in the two growing seasons. These findings due to nitrogen fertilization increase the impurities in quality traits. Humic acid increased refined sugar yield, the highest refined sugar yield was highest values by 3 times addition of 5 L ha^{-1} humic acid, also recorded a 27% increase of refined sugar yield in the plots containing humic acid (Sadeghi-Shoae *et al.,* 2013). The addition of humic acid caused a significant increase of quality characters in the first and second seasons. The highest rates were shown when sugar beet by 40% N + 10L. Humic acid fed^{-1} in both seasons. Refined sugar, root yield and refined sugar yield and a reduction in molasses forming substances content, compared to the 100% mineral fertilizer (Shaban *et al.,* 2014; Rassam *et al.*, 2015 Enan *et al.,* 2016).

Table 3: Sugar beet characters as affected by fertilizer treatments during the 2022/2023 and 2023/2024 seasons.

Traits	Root length (cm)	Root diameter (cm)	Top weight plant^{-1}	Root weight (g)	Top yield (ton fed^{-1})	Root yield (ton fed^{-1})	Sugar yield (ton fed^{-1})	TSS (%)	Sucrose (%)	Purity (%)
Fertilizer treatments (T)	**2022/23**									
80%N+10L. H. Acid fed^{-1}	26.26	7.03	222.87	500.12	7.80	16.86	2.63	21.22	15.51	0.73
60%N+10L. H. Acid fed^{-1}	25.35	6.38	180.67	411.75	6.33	14.86	2.37	21.55	15.83	0.73
40%N+10L. H. acid fed^{-1}	23.22	5.83	122.12	347.15	4.28	12.54	2.12	22.06	16.78	0.76
100% N fed^{-1}	26.38	7.05	230.04	502.38	8.05	16.90	2.50	20.91	14.77	0.71
L.S.D. 0.05	0.30	0.30	11.98	13.67	0.42	0.12	0.03	0.49	0.17	0.01
Fertilizer treatments (T)	**2023/24**									
80%N+10L. H. Acid fed^{-1}	25.92	7.10	216.38	490.22	7.58	16.70	2.54	20.83	15.39	0.73
60%N+10L. H. Acid fed^{-1}	24.95	6.39	175.82	403.39	6.16	14.53	2.29	21.22	15.67	0.74
40%N+10L. H. acid fed^{-1}	22.90	5.87	118.53	336.11	4.26	12.46	2.06	21.65	16.42	0.76
100% N fed^{-1}	25.96	7.12	224.47	494.54	7.85	16.73	2.52	20.78	14.99	0.72
L.S.D. 0.05	0.13	0.22	10.74	12.58	0.38	0.20	0.03	0.63	0.18	0.01

2. Intercropping Effect:

Data presented in Table (4) revealed that yield and yield components characters of sugar beet were significantly affected by intercropping wheat with sugar beet in both seasons. The higher results of these characteristics resulted when growing sugar beet under intercropping seeding rate of 100% sugar beet + 12.50% wheat in the first and second seasons. Then 100% sugar beet + 25% wheat. Whereas, the lowest rates were recorded when growing sugar beet with an intercropping seeding rate of 100% sugar beet + 37.50% wheat in both seasons. These results back to that increasing the seeding rate of wheat from 12.50% up to 37.50% led to a decrease in sugar beet traits. So, these traits of sugar beet were affected by the difference of plant species in competition on light, which led to increased shading, especially at higher wheat plant density. Similar results were reported by Attia *et al.* (2007); Aboukhadra *et al.* (2013b); Salama *et al.* (2016) and Gomaa *et al.* (2019).

Results in Table (4) obtained that the quality of sugar beet characters was significantly affected by intercropping seeding rates in both seasons. Also, chemical characteristics were increased by decreasing the seeding rate of wheat compared with sugar beet in pure stand in both seasons. These results are due to intra and inter-competitive. Saban *et al.* (2008) found that intercropping improves the economic status of growers and the sugar industry. On the other hand, Aboukhadra *et al.* (2013b) recorded an increase in sugar yield and sucrose % of sugar beet intercropped with low densities of wheat and faba bean. They confirmed such an increase, to the considerable increase in root yield and, thus the amount of sugar extracted from the roots. These findings were reported by Salama *et al.* (2016) and Gomaa *et al.* (2019).

Table 4: Sugar beet characters as affected by intercropping rates of wheat during the 2022/2023 and 2023/2024 seasons.

Characters	Root length (cm)	Root diameter (cm)	Top weight plant^{-1}	Root weight (g)	Top yield (ton fed^{-1})	Root yield (ton fed^{-1})	Sugar yield (ton fed^{-1})	TSS (%)	Sucrose (%)	Purity (%)
Intercropping rates	**2022.23**									
100% S. b +12.50% W	27.02	7.47	229.22	526.46	8.02	18.14	2.96	22.11	16.42	0.74
100% S. b +25% W	25.42	6.69	191.97	437.88	6.72	15.18	2.38	21.20	15.74	0.74
100% S. b +37.50% W	23.47	5.55	145.58	356.70	5.10	12.54	1.88	20.99	15.01	0.72
L.S.D. 0.05	0.16	0.15	7.53	8.64	0.27	0.12	0.04	0.32	0.21	0.01
Sugar beet alone	29.29	9.01	294.10	596.57	10.30	20.85	3.34	20.75	16.01	0.77
Intercropping rates	**2023/24**									
100% S. b +12.50% W	26.91	7.53	224.39	519.65	7.86	17.94	2.86	21.38	16.16	0.76
100% S. b +25% W	24.92	6.71	183.18	430.98	6.49	14.90	2.33	21.10	15.73	0.75
100% S. b +37.50% W	22.96	5.62	143.83	342.57	5.04	12.47	1.86	20.87	14.96	0.72
L.S.D. 0.05	0.13	0.11	9.47	6.44	0.36	0.13	0.01	0.31	0.13	0.02
Sugar beet alone	28.78	8.87	288.11	589.94	10.09	20.11	3.25	20.46	16.15	0.79

3. Interaction Effect:

Yield and its components of sugar beet were significantly affected by the interaction, except root length in the second season and root diameter in the first and second seasons, as shown in Table (5). Sugar beet was fertilized at 100% N or 80% N + 10L. Humic acid recorded the highest values under an intercropping seeding rate of 100% sugar beet + 12.50% wheat for yields of root and sugar fed^{-1} in the first and second seasons. Whereas, the lower values were obtained when sugar beet was fertilized with 40% N + 10 L. humic acid fed^{-1} under the intercropping seeding rate of 100% sugar beet + 37.50% wheat in the two growing seasons. These findings were back to inter and intera-specific competition. These observations were approved by Aboukhadra *et al.* (2013b); Salama *et al.* (2016) and Gomaa *et al.* (2019).

The interaction had a significant effect on the quality characters of sugar beet, except TSS% in the two growing seasons as resulted in Table (5). The higher values were obtained when sugar beet was fertilized by 40% N + 10L. humic acid fed^{-1} with intercropping seeding rate of 100% sugar beet + 12.50% wheat in both seasons. The lowest values for these characters were recorded when sugar beet plants were fertilized by 100% N with an intercropping seeding rate of 100% sugar beet + 37.50% wheat in the first and second seasons. Rassam *et al.*, (2015) found that sucrose% and refined sugar% in one application of humic acid were reduced from 16.86% and 15.13% to 15.87% and 14.06% than in three applications of humic acid, respectively. These findings were obtained by Shaban *et al.* (2014) & Enan *et al.* (2016).

Table 5: Sugar beet characters as affected by interaction between intercropping rates and fertilizer treatments during the 2022/2023 and 2023/2024 seasons.

Characters		Root length (cm)	Top weight plant^{-1}(g)		Root weight (g)		Top yield ton fed^{-1})		Root yield (ton fed^{-1})		Sugar yield (ton fed^{-1})		Sucrose (%)		Purity (%)	
F. treatments	Intercropping rates	1st	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
80%N+10L. H. acid fed^{-1}	100% S. b +12.50% W	28.05	272.17	265.69	595.51	589.15	9.50	9.30	19.77	19.60	3.23	3.00	16.33	15.99	0.74	0.73
	100% S. b +25% W	26.33	228.08	215.46	489.15	476.57	7.99	7.56	16.59	16.40	2.54	2.51	15.30	15.30	0.73	0.74
	100% S. b +37.50% W	24.40	168.37	167.98	415.70	404.95	5.90	5.89	14.21	14.11	2.12	2.10	14.90	14.87	0.72	0.72
60%N+10L. H. Acid fed^{-1}	100% S. b +12.50% W	27.01	216.98	211.44	481.71	475.35	7.60	7.41	17.72	17.50	2.95	2.83	16.67	16.17	0.75	0.76
	100% S. b +25% W	25.47	188.15	179.83	422.31	419.35	6.59	6.30	14.90	14.19	2.36	2.25	15.83	15.84	0.74	0.75
	100% S. b +37.50% W	23.57	136.88	136.20	331.23	315.46	4.80	4.78	11.95	11.89	1.79	1.78	15.01	15.00	0.71	0.72
40%N+10L. H. acid fed^{-1}	100% S. b +12.50% W	25.03	143.89	141.21	427.75	419.68	5.04	4.95	15.25	14.96	2.69	2.55	17.67	17.01	0.78	0.78
	100% S. b +25% W	23.01	117.26	114.19	355.48	348.67	4.11	4.00	12.58	12.48	2.12	2.09	16.83	16.74	0.77	0.78
	100% S. b +37.50% W	21.61	105.21	100.19	258.46	239.98	3.70	.51	9.80	9.93	1.55	1.54	15.84	15.52	0.73	0.73
100% N fed^{-1}	100% S. b +12.50% W	27.97	283.08	279.21	601.14	594.41	9.94	9.77	19.84	19.70	2.98	3.05	15.01	15.47	0.70	0.73
	100% S. b +25% W	26.87	234.38	223.25	484.58	479.34	8.20	7.80	16.64	16.54	2.50	2.49	15.00	15.04	0.72	0.72
	100% S. b +37.50% W	24.30	171.88	170.95	421.41	409.87	6.01	5.98	14.22	13.96	2.04	2.02	14.30	14.47	0.70	0.71
L.S.D. 0.05		0.27	12.41	15.59	14.23	10.61	0.44	0.60	0.19	0.21	0.07	0.02	0.34	0.22	0.01	0.02

B- Wheat:

1- Fertilizer Effect:

Results in Table (6) revealed that wheat yield and its components were significantly affected by fertilizer treatments. 100 kg N fed^{-1} (mineral fertilizer) resulted in higher values of wheat measures in the first and second seasons. Appling wheat of 80% N + 10L. Humic acid or 100% N, did not reach a 5% level of significance in most characters. Whereas, the lowest values were recorded when applying wheat by 40% N + 10L. Humic acid in the two growing seasons. This result may be back to Humic acid contains more than 75% humic substances, these substances may contain hormonal molecules in their structure, or these substances stimulate the plant to produce internal hormones that affect the physiological processes of the plant, growth & yield. Humic acid-fertilizer could reduce the mineral fertilizer, and make nutrients available to the plant during the two growing seasons. Similar harmony was shown by Jindo *et al.* (2012) & Alhosein & Hamd-Alla (2019). Humic acid may affect photosynthesis and respiration, the formation of complex pheromones with mineral ions, and also works to stimulate enzymes, and stimulate DNA recruitment and physical properties (Sherif *et al.,* 2002 Ghada *et al.*, 2018).

Table 6: Wheat characters as affected by fertilizer treatments during 2022/2023 and 2023/2024 seasons.

Traits	Plant height (cm)	Spike length (cm)	Number of grains spike^{-1}	Grain weight (g spike^{-1})	Number of spikes m$^{2-1}$	Grain weight (g m$^{2-1}$)	1000-grain weight (g)	Grain yield (ardab fed^{-1}	Straw yield (ton fed^{-1})
Fertilizer treatments (T)	**2022/23**								
80%N+10L. H. Acid fed^{-1}	99.55	17.28	59.18	3.12	51.71	161.85	52.62	4.54	1.21
60%N+10L. H. Acid fed^{-1}	97.66	16.99	57.51	3.02	47.35	145.06	52.67	4.05	1.11
40%N+10L. H. acid fed^{-1}	94.45	15.82	56.88	2.95	38.55	115.19	51.48	3.21	0.71
100% N fed^{-1}	102.29	17.36	59.95	3.13	52.52	164.21	52.46	4.58	1.23
L.S.D. 0.05	3.41	0.19	0.81	0.04	2.16	3.46	0.41	0.15	0.11
Fertilizer treatments (T)	**2023/24**								
80%N+10L. H. Acid fed^{-1}	97.52	17.01	59.41	3.23	49.24	159.04	54.78	4.48	1.14
60%N+10L. H. Acid fed^{-1}	95.28	16.77	57.88	3.14	45.69	141.95	53.71	3.99	0.96
40%N+10L. H. acid fed^{-1}	92.43	15.55	57.39	3.07	36.25	112.62	52.41	3.15	0.67
100% N fed^{-1}	100.57	17.18	59.09	3.25	49.78	161.28	54.92	4.51	1.19
L.S.D. 0.05	1.70	0.12	0.63	0.03	1.95	2.77	0.60	0.09	0.06

2. Intercropping Effects.

Results in Table (7) showed that intercropping seeding rates had a significant effect on all wheat traits in the first and second seasons. Wheat plant height was increased due to an increase in wheat seed rate from 12.50 to 25 up to 37.50%, this result may be due to inter and intra-specific competition. Similar harmony was reported by Aboukhadra *et al.* (2013b) and Gomaa *et al.* (2019). The number of grain spike^{-1}, the number of spike m$^{2-1}$, grain weight m$^{2-1}$, and grain and straw yield fed^{-1} behaved the same trend of plant height in both seasons as shown in (Table, 7). This behavior may be due to an increase in wheat seed rate from 12.50 to 25 up to 37.50% of its pure stand. It is worth mentioning here that similar results by Abou-Elela (2012); Aboukhadra *et al.* (2013b) and Salama *et al.* (2016). On the other hand spike length, the number of grain spike^{-1}, grains weight spike^{-1} and 1000-grain weight as yield components characters were decreased when increased of wheat seed percent in the first and second seasons as shown in Table (7). These findings may be back to inter and intra-species competition between wheat and sugar beet plants for nutrients, water and light. These results were reported by Baumann *et al.* (2001); Aboukhadra *et al.* (2013a) and Roghieh *et al.* (2018) coincided with the present results.

Table 7: Wheat characters as affected by intercropping rates during 2022/2023 and 2023/2024 seasons.

Traits	Plant height (cm)	Spike length (cm)	Number of grains spike^{-1}	Grain weight (g spike^{-1})	Number of spikes m$^{2-1}$	Grain weight (g m$^{2-1}$)	1000-grain weight (g)	Grain yield (ardab fed^{-1})	Straw yield (ton fed^{-1})
Intercropping rates (P)	**2022/23**								
100% S. b +12.50% W	96.67	17.09	59.13	3.14	35.54	112.19	54.03	3.11	0.93
100% S. b +25% W	98.70	16.96	58.12	3.05	47.53	148.22	52.69	4.16	1.08
100% S. b +37.50% W	100.09	16.53	57.89	2.97	59.53	179.33	50.21	5.02	1.18
L.S.D. 0.05	1.49	0.23	0.91	0.04	1.45	2.63	0.45	0.09	0.06
Wheat alone	101.03	13.53	53.70	2.81	235.01	658.80	52.33	18.45	3.503
Intercropping rates (P)	**2023/24**								
100% S. b +12.50% W	94.66	16.91	58.85	3.28	33.11	109.31	55.50	3.04	0.85
100% S. b +25% W	96.50	16.63	58.60	3.23	44.64	145.53	54.10	4.10	1.00
100% S. b +37.50% W	98.20	16.34	57.87	3.01	57.98	176.33	52.27	4.95	1.11
L.S.D. 0.05	1.38	0.13	ns	0.04	1.36	2.59	0.27	0.06	0.04
Wheat alone	99.32	13.20	52.32	2.79	231.12	648.17	53.33	18.12	3.43

3. Interaction Effect:

Results in Table (8) show that interaction had a significant effect on yield and components of yield wheat in the first and second seasons. Wheat was fertilized by 100% N and an intercropping rate of 100% sugar beet + 37.50% wheat attained the highest values, followed by 80% N + 10L. Humic acid and grown wheat in the same intercropping pattern. Similar results were obtained by Gomaa *et al.* (2019). The lowest values resulted when wheat in the intercropping rate of 100% sugar beet + 12.50% wheat and 40% N + 10L.humic acid in both seasons. Grain yields of wheat and barley and seed yield of faba bean reached the maximum in the pure stand and were reduced by reducing the intercropping percentage of the three companion crops (Salama *et al.,* 2016). Yield and its components were significantly affected by nitrogen fertilizer with humic acid. 120 Kg N fed^{-1} only and 60 Kg N fed^{-1} + soil and foliar application of humic acid gave higher rates, whereas foliar and soil application of humic acid resulted in the lowest values of maize in the two growing seasons (El-Shafey and Zen El-Dein, 2016).

Table 8: Wheat characters as affected by the interaction between intercropping rates and fertilizer treatments during the 2022/2023 and 2023/2024 seasons.

Treatments \ Traits		Number of spikes m^{2-1}		Grain weight (g m^{2-1})		1000-grain weight (g)	Grain yield (ardab fed^{-1})		Straw yield (ton fed^{-1})
(P)	(T)	2022/23	2023/24	2022/23	2023/24	2023/24	2022/23	2023/24	2023/24
80% N+10L. H. Acid fed^{-1}	100% S. b +12.50% W	40.35	37.54	130.01	127.61	56.67	3.63	3.58	1.02
	100% S. b +25% W	52.05	48.30	162.40	158.61	54.67	4.56	4.49	1.17
	100% S. b +37.50% W	62.72	61.89	193.16	191.04	53.00	5.42	5.36	1.23
60% N+10L. H. Acid fed^{-1}	100% S. b +12.50% W	34.39	33.21	107.15	103.86	55.44	2.97	2.91	0.84
	100% S. b +25% W	48.02	45.63	148.29	145.94	53.34	4.16	4.12	0.96
	100% S. b +37.50% W	59.64	58.23	179.74	176.04	52.34	5.02	4.95	1.09
40% N+10L. H. acid fed^{-1}	100% S. b +12.50% W	26.12	23.88	79.17	76.20	53.56	2.17	2.07	0.47
	100% S. b +25% W	37.72	35.97	117.48	115.94	52.50	3.30	3.27	0.69
	100% S. b +37.50% W	51.81	48.89	148.91	145.72	51.17	4.17	4.11	0.83
100% N fed^{-1}	100% S. b +12.50% W	41.31	37.88	132.41	129.71	56.33	3.67	3.61	1.08
	100% S. b +25% W	52.30	48.65	164.72	161.61	55.89	4.60	4.52	1.19
	100% S. b +37.50% W	63.96	62.89	195.51	192.52	52.56	5.47	5.38	1.29
L.S.D. 0.05		2.38	2.24	4.33	4.26	0.45	0.15	0.12	0.06

C. Competitive Relationships and Yield Advantages:

1. Land Equivalent Ratio (LER):

Results in Table (9) revealed that intercroppng seeding rates of wheat with sugar beet and fertilizer sources exceeded land usage than a unit in cases fertilizer treatments of 80% N + 10L humic acid with intercropping percent of 100% sugar beet + 12.50% wheat as well as 100% N with 100% sugar beet + 12.50% wheat in the first and second seasons, which results in 1.15 and 1.17 as well as 1.15 and 1.18 in the first and second seasons, respectively. In all fertilizer treatments, sugar beet under the three intercropping seeding rates of wheat produced higher yields than 50%, except in case fertilizer treatment of 40% N + 10L humic acid under intercropping percent 100% sugar beet + 37.50% what in both seasons, these results due to inter and intra-competition on light and water and insufficient nutritional intake. This result indicated that wheat with sugar beet is a good component where its yields exceeded the expected yield. Similar results were reported by El-Shafey and Zen El-Dein (2016); Salama *et al.* (2016); Gomaa *et al.* (2019).

2. Relative Crowding Coefficient (RCC):

Results in Table (9) revealed that the relative crowding coefficient (RCC) took a similar trend as the land equivalent ratio (LER) in the two seasons. The best results were recorded by intercropping rate of 100% sugar beet + 12.50% wheat and application by 100% N or 80% N + 10L. Humic acid, which was 4.88 and 11.96 as well as 4.48 and 9.46 in both seasons, respectively. In all treatments, the K_w contributed more to K than $K_{s.b}$ in the two seasons, except in cases 80% N + 10L. Humic acid and 100% N fertilizer treatments with 100% sugar beet + 12.50% wheat intercropping pattern in both seasons. This result indicates clearly that wheat was the better contributor in all treatments. Similar harmony of results were reported by Abou-Elela (2012) and Zen El-Dein (2015).

3. Aggressivity (A):

Date in (Table, 9) revealed that wheat was the dominant intercrop component and sugar beet was the dominated in all treatments in both seasons. Data revealed that "A" values of sugar beet were increased by increasing wheat percentage with sugar beet and the maximum values for "A" of sugar beet were achieved by intercropping 37.50% of wheat with sugar beet in the two growing seasons. The results indicate that wheat was dominant because it has a higher competitive ability than sugar beet. Similar findings of results were obtained by Abou-Elela (2012). Kumar (2008) found the negative values of aggressiveness for other crops in the intercropping patterns with wheat led to wheat being dominant. Alhosein and Hamd-Alla (2019) showed that wheat was the dominant type with a positive number, while fava beans were the dominanted type with a negative number with humic acid and intercroppinging systems in the first and second seasons.

Table 9: Effect of fertilizer treatments and intercropping rates on land equivalent ratio (LER), relative crowding coefficient (K) and aggressivity (A) during 2022/2023 and 2023/2024 seasons.

Traits		Land equivalent ratio (LER)			Relative crowding coefficient(K)			Aggressivity (A)	
Fertilizer treatments	Intercropping rates	2022/23							
		$L_{s.b}$	L_w	LER	$K_{s.b}$	K_w	K	$A_{s.b}$	A_w
80%N+10L. H. Acid fed^{-1}	100% S. b +12.50% W	0.95	0.20	1.15	2.26	1.98	4.48	-0.72	+0.72
	100% S. b +25% W	0.80	0.25	1.05	0.97	1.31	1.27	-0.24	+0.24
	100% S. b +37.50% W	0.68	0.29	0.97	0.79	1.12	0.89	-0.15	+0.15
60%N+10L. H. Acid fed^{-1}	100% S. b +12.50% W	0.85	0.16	1.01	0.70	1.55	1.09	-0.51	+0.51
	100% S. b +25% W	0.71	0.23	0.94	0.63	1.16	0.73	-0.23	+0.23
	100% S. b +37.50% W	0.57	0.27	0.84	0.50	1.01	0.51	-0.22	+0.22
40%N+10L. H. acid fed^{-1}	100% S. b +12.50% W	0.73	0.12	0.85	0.34	1.08	0.37	-0.25	+0.25
	100% S. b +25% W	0.60	0.18	0.78	0.38	0.87	0.33	-0.14	+0.14
	100% S. b +37.50% W	0.47	0.23	0.70	0.33	0.79	0.26	-0.19	+0.19
100%N fed^{-1}	100% S. b +12.50% W	0.95	0.20	1.15	2.43	2.01	4.88	-0.74	+0.74
	100% S. b +25% W	0.80	0.25	1.05	0.99	1.33	1.32	-0.25	+0.25
	100% S. b +37.50% W	0.68	0.30	0.98	0.79	1.14	0.90	-0.16	+0.16
LSD at 5% of interaction		--	---	0.04	--	---	0.75	-0.04	+0.04
Sole sugar beet		--	---	1.00	--	---	1.00	1.00	--
Sole wheat		--	---	1.00	--	---	1.00	1.00	--
		2023/24							
80%N+10L. H. Acid fed^{-1}	100% S. b +12.50% W	0.97	0.20	1.17	4.75	1.99	9.46	-0.70	+0.70
	100% S. b +25% W	0.82	0.25	1.07	1.11	2.94	3.27	-0.22	+0.22
	100% S. b +37.50% W	0.70	0.30	1.00	0.87	1.14	1.01	-0.13	+0.13
60%N+10L. H. Acid fed^{-1}	100% S. b +12.50% W	0.87	0.16	1.03	0.83	1.55	1.28	-0.48	+0.48
	100% S. b +25% W	0.71	0.23	0.94	0.60	1.18	0.71	-0.25	+0.25
	100% S. b +37.50% W	0.59	0.27	0.86	0.53	1.02	0.54	-0.20	+0.20
40%N+10L. H. acid fed^{-1}	100% S. b +12.50% W	0.74	0.11	0.85	0.36	1.04	0.38	-0.20	+0.20
	100% S. b +25% W	0.62	0.18	0.80	0.41	0.88	0.36	-0.13	+0.13
	100% S. b +37.50% W	0.49	0.23	0.72	0.36	0.79	0.29	-0.16	+0.16
100%N fed^{-1}	100% S. b +12.50% W	0.98	0.20	1.18	5.94	2.01	11.96	-0.71	+0.71
	100% S. b +25% W	0.82	0.25	1.07	1.16	1.33	1.54	-0.22	+0.22
	100% S. b +37.50% W	0.69	0.30	0.99	0.84	1.14	0.96	-0.15	+0.15
LSD at 5% of interaction		---	---	0.01	---	---	0.41	-0.05	+0.05
Sole sugar beet		--	---	1.00	--	---	1.00	1.00	--
Sole wheat		--	---	1.00	--	---	1.00	1.00	--

D: Economic Evaluation:

1. Total Return (L.E.):

Total return as affected by fertilizer treatments and intercropping wheat with sugar beet in the first and second seasons as presented in Table (10). The highest values were obtained by 100% N or 80% N + 10L. Humic acid with 100% sugar beet +12.50% wheat in both growing seasons. These treatments achieved 13 and 17% as well as 16% and 16% increases compared with sole sugar beet in both seasons, respectively. These values were reported by Attia *et al.* (2007); Aboukhadra *et al.* (2013b) and Shaalan *et al.* (2015).

2- Monetary Advantage Index (MAI):

Monetary advantage index Table (10) was significantly affected by interaction treatments in the first and second seasons. The highest MAI resulted from 100% N and intercropping rate of 100% sugar beet + 12.50% wheat in the 1st season. While it was, in the

2nd season the highest MAI resulted from 80% N + 10L. Humic acid under the same intercropping rate, where the difference between them is not up to a 5% level of significance. MAI is considered an indicator of the economic feasibility of fertilizer treatments and seeding rates of wheat. The monetary index values are expressed in the land equivalent (LER). The monetary advantage index had positive values because the LER values were greater than one. (Hamd Allah *et al.*, 2014) revealed that monetary benefit is expressed by higher monetary advantage index values in intercrops, as reported in other studies (Takim, 2012; Hamdollah, 2012; Dube *et al.*, 2014; Said and Hamd-Alla, 2018).

Table 10: Effect of fertilizer treatments and intercropping rates on total return (L.E.) and monetary advantage index (MAI) during 2022/2023 and 2023/2024 seasons.

Total return (L.E.)				**Monetary Advantage Index (MAI)**	
Fertilizer treatments	**Intercropping rates**	**2022/23**	**2023/24**	**2022/23**	**2023/24**
80%N+10L. H. Acid fed^{-1}	100% S. b +12.50% W	34586	49026	4511.22	7123.44
	100% S. b +25% W	31713	44514	1510.14	2912.13
	100% S. b +37.50% W	29613	41510	-915.87	0.00
60%N+10L. H. Acid fed^{-1}	100% S. b +12.50% W	30382	42805	300.81	1246.75
	100% S. b +25% W	28552	38829	-1822.47	-2478.45
	100% S. b +37.50% W	25705	35887	-4896.19	-5842.07
40%N+10L. H. acid fed^{-1}	100% S. b +12.50% W	24916	34895	-4396.94	-6157.94
	100% S. b +25% W	23120	32694	-6521.03	-8173.75
	100% S. b +37.50% W	20967	29632	-8985.86	-11523.56
100%N fed^{-1}	100% S. b +12.50% W	33597	49525	4382.22	7554.66
	100% S. b +25% W	31894	44948	1518.76	2940.52
	100% S. b +37.50% W	29741	41400	-606.96	-418.18
LSD5% interaction		1013.93	2042.17	367.85	573.79
Sole sugar beet		29165	41236	0.00	0.00
Sole wheat		32575	42414	0.00	0.00

CONCLUSION

Intercropping patterns harness the elements of the environment and make the best use of them, and the competition between different species is praiseworthy and is less than the competition between plants of the same species, and therefore the specific production increases. Humic acid contains humic substances that increase soil fertility and reduce the use of mineral fertilizer, thus reducing pollution. It could be concluded that to obtain the maximum value of productivity, quality and LER of intercropping wheat with sugar beet is to intercrop 100% sugar beet + 12.50% wheat after 30 days from the sowing date of sugar beet and fertilizer by 80% N + 10L. Humic acid per fed.

Declarations:

Ethical Approval: No animal model(s) or human subjects were recruited directly for the current study. Consequently, no ethical considerations are necessary.

Funding: The author(s) received no specific funding for this work.

Availability of Data and Materials: All datasets analysed and described during the present study are available from the corresponding author upon reasonable request.

Acknowledgements: Not applicable.

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