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Improving yield and its component traits through mixed intercropping and sowing methods in wheat (*Triticum aestivum* L.) with Egyptian clover (*Trifolium alexandrinum* L.)

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ENHANCING land productivity through efficient resource utilization is a core objective in sustainable agriculture. Intercropping and improved sowing techniques are widely recognized for their potential to optimize crop performance and maximize yields. Integrating winter wheat with Egyptian clover has demonstrated positive effects on photosynthetic activity and yield stability. Intercropping legumes with cereals offers a promising solution, as legumes can fix atmospheric nitrogen biologically, enriching the soil for current or subsequent crops. This study evaluated the impact of different sowing methods and intercropping ratios on the performance of wheat and Egyptian clover under field conditions across two consecutive seasons (2021/2022 and 2022/2023). A total of eight treatment combinations were assessed in a strip-plot layout within a randomized complete block design (RCBD) with three replications. Two sowing techniques—broadcasting and row planting were tested alongside four intercropping arrangements involving wheat (cv. Gemmeizah 11) and Egyptian clover (var. Fahl): sole cropping of either species, and mixed cropping at 75:25, 50:50, and 25:75 ratios. Findings indicated that intercropping had no adverse effect on wheat grain yield. Row planting, particularly at a 50:50 ratio, significantly improved yield components and economic returns. These results support the adoption of intercropping systems, especially with row sowing, as a viable strategy for enhancing productivity and sustainability in wheat-based cropping systems. Plant height, thousand grain weight, biological yield, grain yield and protein % were strongly correlated and positive with PC1 but spike length, and no. of spikes/m^2 were negative strong correlation in PC2.

Keywords: Intercropping, Wheat, Egyptian clover, Correlation, PCA.

Introduction

Wheat (***Triticum aestivum* L.**) The most important winter crops in Egypt. Its area cultivation reached approximately 1430252 ha-1 in **2022**, producing approximately 9.7 million tons of seed (**FAOSTAT, 2022**). One of the various reasons caused by the low self-sufficiency of wheat of roughly 47% is that most farmers keep animals on farms. Many farmers prefer growing Egyptian clover instead of wheat for livestock feed.

Egyptian clover is ranking as the most annual forage crop in the world, especially in Mediterranean Sea zones. Its cultivated area was recorded of 1.403 million feddans in the **2022/2023** season in Egypt, **Agriculture Statistics (2023).** Egyptian clover possessed high-rate growth, great quality forage and very low bloating potential, in winter. It is considered as the most important crop for feeding livestock during winter season (about 6 months) in Egypt. **El-Nahrawy** (**2005**) noted that Egyptian clover has high nutritional value due to of its high protein content. Moreover, it enhances the physical and chemical of properties soil, via the high nitrogen fixation potential. Both broadcasting rows and seeding rates affect legumes and non-legume crops production (**Anees. et al., 2020**).

Intercropping method is an arranged practice where two or more crop species are sown together in the same area of field. This method can enhance biodiversity, improve resource-use efficiency, and increase overall productivity compared to monoculture systems. This practice can lead to several benefits of increased yield: In addition, the intercropping can boost the total yield from unit area through making better utilization of available resources i.e. light water, and nutrients (**Yin et al., 2018**). Growing multiple crops together can disrupt pest and disease cycles, reducing the need for chemical pesticides (**Mamine, and Farès, 2020**). Economic benefits of intercropping can provide farmers with a more stable income by diversifying their crop production and reducing the risk associated with market fluctuations for a single crop (**Gou et al., 2018**).

Intercropping systems during the winter cultivation have been tested by various researchers. The advantages coming from the intercropping cereal and legumes crops are the N fixation of the latter one (**Lithourgidis et al., 2007**), high forage quality (**Ross et al., 2004; Vasilakoglou and Dhima, 2008; El-Karamany et al., 2012**), and high biomass productivity (**Ghaffarzadeh,**

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2013). Most of the previous studies during winter intercropping focused on the forage production. They were intercropped the wheat, barley, Egyptian oat with berseem clover (**ElKaramany et al., 2012; Ross et al., 2004; Vasilakoglou and Dhima, 2008**). Intercropping clover with wheat enhances nitrogen fixation, clover adds nitrogen to the soil, benefiting the subsequent crops, soil health, improves soil structure and organic matter, weed suppression, which helps in suppressing weeds by providing ground cover and forage, provides additional forage for livestock.

Different sowing methods were used such as flat, terraces, and rows, can significantly affect the growth and yield of both wheat and Egyptian clover. For instance, wheat sowing in terraces and intercropping with 10% Egyptian clover resulted the highest performance for growth, yield, and crude protein content compared to other sowing methods (**El-Shamy et al., 2017**).
The sowing methods (broadcasting in rows, and ridges) revealed that the sowing wheat in ridges surpassed significantly the other methods for growth rate, such as chlorophyll content, leaf area index, spike length, number of spike lets and spike-1, number of grain spike-1, 1000 kernel weight (g), biological, grain, and straw, yields as ton ha-1, followed by wheat sowing in rows and broadcasting method through two seasons (**El-Metwally et al., 2018**). Whereas drill-planting with row spacing was inferior to the broadcast method. This may be concluded that the paired row and drill planting methods are suitable for wheat sowing into sandy loam soils (**Naresh et al., 2014**). In addition, there is inconsistency and application use of fertilizers, lacked information on variants, edaphic countenance, mismanagement of farmers' field operations, and technology (**Ali et al., 2018; Kumar et al., 2005; & Meena et al., 2013**). A cultivar which performs better in adapted types of soil can be weak in the other type of soil, and vice versa (**Adhikari et al., 2019**).

Economic benefits for line sowing often results in a higher benefit-cost ratio due to increased yields and better resource utilization1. Broadcast showing proved to be the lowest initial costs but may result in lowest economic returns due to reduced yields (Palit, et al., 1988).
Thus, the objective of our investigation was to test the intercropping effect of wheat with Egyptian clover var. Fahl at different plant spaces. Also, design of different intercropping patterns that could maximize resource efficiency provide farmers opportunities to increase the final net incomes and maximize the use of their inputs.

Materials and Methods

Experimental site and design

The current experiment was conducted during two consecutive seasons i.e. 2021–2022 and 2022–2023, at the experimental farm of the Agronomy Department, Faculty of Agricultural, Assiut University, Egypt (27° 18' N, 31° 16' and 53 a.s.l.). The experiment used a randomized complete block design (RCBD) in three replicates which arrangement strip block to evaluate grain yield and its components of wheat and seed yield of Egyptian clover var. Fahl under mixed intercropping systems compared to pure stand of each. The physical and chemical features of the experimental site are shown in **Table 1.**

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

Season	2021-2022	2022-2023
		Mechanical analysis
Sand	26.4	26.4
Silt	25.1	25.2
Clay	48.5	48.4
Soil type	Clay	Clay
		Chemical analysis
PH	7.77	7.77
Organic matter %	1.72	1.70
Total N%	0.09	0.08
Total CaCO3%	1.17	1.22

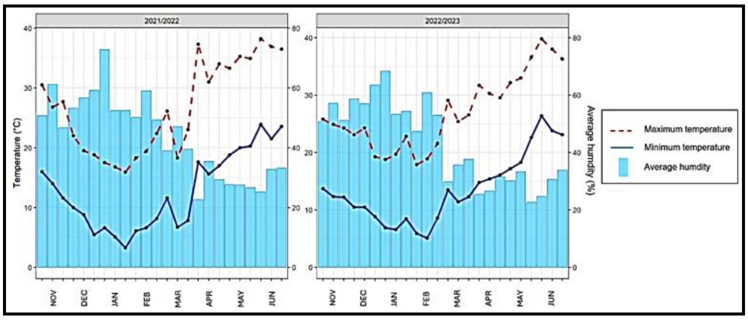

Fig. 1. Means of air temperature and relative humidity obtained from etiological station at Assiut, Egypt, during the two growing seasons.

The field experiment comprised eight treatments combinations. Two sowing methods, i.e Broadcasting and Rows were allocated vertically for four different systems of intercropping wheat cultivar Gemmeizah 11with Egyptian clover var. Fahl such as:

1- 100% solid wheat or Egyptian clover.
2- 75% wheat + 25% Egyptian clover.
3- 50% wheat + 50% Egyptian clover.
4- 25% wheat + 75% Egyptian clover.

For each showing methods were distributed horizontally. There was a randomly distributed horizontal plot. The plot size was 3×4 m. The sowing dates for the seeds were 18th and 19th November in the 2021/2022 and 2022/2023 seasons respectively. The recommended agricultural practices for wheat and clover plants, including seeding rate, tillage, irrigation, weed and disease control, harvesting, etc., were carried out as recommended. The crop was harvested at the respective harvest stage in different treatments for recording date as are shown in plot diagram

Solid for each wheat or Egyptian clover	75% Wheat	50% Wheat	25% Wheat
	25% Egyptian clover	50% Egyptian clover	75% Egyptian clover

Measured Traits

Five Representative plants were randomly sampled from each plot's middle ridges to measure growth characteristics for wheat.

1- Plant height (PH), (cm).
2- Spike length (SL), (cm) of wheat.

Another wheat traits:

3- No. of Spikes (NS), (m2).
4- Biological yield (BY), (ton ha-1).
5- Grain yield (GY), (ton ha-1).
6- Thousand grain weight (TGW), (g).
7- Protein % (PP).

Egyptian clover var. Fahl traits:

1- Biological yield (BY) (ton ha-1).
2- Seed yield, (SY),(ton ha-1).
3- Thousand seeds weight (TSW), (g).

Total nitrogen (N) was determined using the micro Kjeldahl method according to **A.O.A.C** (**2005**).

Statistical analysis

Data analysis

Analysis of variance for data obtained in the two seasons was carried out according to **Gomez and Gomez (1984)**. Different between means were compared using the least significant differences (L.S.D) value at 5% level according to **Waller and Duncan (1969**).

Correlation coefficient analysis

The correlation coefficients among studied traits for both growing seasons were computed using R Studio **(R Studio, 2020**). In addition, the phenotypic correlation coefficients were calculated between each pair of the traits studied as outlined by **Walker** (**1969**).

Principal Component Analysis (PCA)

PCA is a widely used statistical tool to analyze the genetic variation among plant genotypes and determine the most important variables which contribute to variation (**Price et al., 2006**). In the present study the correlation matrix method was performed using (**R studio,2020**) and the PC1 and PC2 with the highest eigenvalues were selected, as proposed by **Jeffers** (**1967**). A biplot of the first two components was used for grouping treatment combinations and illustrating the relationship between the studied traits and treatment combinations.

Land Equivalent Ratio (LER)

The ratio of area needed under sole cropping to that of intercropping at the same management level to produce an equivalent yield LER was calculated according to **Mead and Willey** (**1980**) as follows:

LER=(Yab/Yaa)+(Yba/Ybb), where, Yaa and Ybb are the sole crop yields of crops a (wheat) and b (Egyptian clover var. Fahl), respectively. Yab and Yba are the intercrop yield for crop a and crop b, respectively.

Economic returns:

The farmer's benefit was calculated for each treatment in Egyptian pounds (L.E) using the market prices for both seasons. The average market prices were 5900 L.E ton-1 for wheat grain and 6000 L.E ton-1 for seed of Egyptian clover at 2022 season, 10660 and 80000 L.E ton-1 for wheat grain, and seed of Egyptian clover, respectively in 2023 seasons. **Agriculture Statistics (2023).**

Results and Discussion

Analysis of variance

The mean square of the sowing methods was significant or highly significant for most studied traits in both seasons. As well as the mean squares of intercropping system showed that all studied traits were highly significant for both seasons. Also, the interaction between sowing methods and intercropping system was significant or highly significant for all studied characters, except biological yield in first season only (**Table 2**).

Effect of sowing methods and intercropping patterns on growth, yield and its components of wheat.

The findings in both seasons (**Tables. 3 and 4**) were demonstrated the greatest significant values for all traits under this study when wheat was sown in rows with all intercropping systems of 75, 50, and 25% Egyptian clover var. Fahl. Planting methods were significantly affected by most of the traits studied. These results are in line with those obtained by **El-Temsah (2017**) and **Morsy et al (2021).** Furthermore **Salem et al., (2013)** reported that sowing of Egyptian clover var. Fahl in newly reclaimed soils improved several chemical, physical and biological traits of soil such as pH, organic matter, nitrogen, phosphorus, potassium as well as, it improved available water. Consequently, sowing

Egyptian clover var. Fahl could improve the growth of wheat and its productivity. In this respect, **Abou-Keriasha et al., (2013)** found that the intercropping wheat with faba bean or Egyptian clover var. Fahl resulted in increased yield of wheat.

The data in Table 3 show that the plant height (cm) decreased when planted in solid and individually compared to planting in rows and intercropping with clover by 25%. There is a clear significant difference between the averages in (2021/2022) and (2022/2023) respectively.

Spike length (cm) had a differing significantly in sowing method and intercropping systems where gave the highest values in sowing intercropping of clover var. Fahl 25% with method rows in two seasons respectively., show in **Table 3**.

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Also, significant differences in spikes per m2 were recorded as the highest values in sowing rows compared to broadcasting with intercropping clover var. Fahl in 25% in two seasons sewing experiments respectively. The characteristic biological yield (ton ha$^{-1)}$ recorded the highest values when sowing rows with intercropping clover var. Fahl 25% and lowest in broadcasting of solid this reason the clover nutrients in wheat through bacterial nodes, in two seasons sewing experiments respectively explained in **Table 3**., while the biological yield had increased significantly when sowing at different intercropping system where give the highest values when sowing in rows and intercropping with clover var Fahl, 25% in both season respectively., show in **Table 3**, this is due to the ability of plants tillers more nutrients and the clover nutation it.

According to the data in Table 4, the grain yield (ton ha^{-1}) was revealed to be significant when it was shown with intercropping clover var. Fahl 25% in both seasons, while the lowest values were obtained when it was shown by broadcasting in solid during the two seasons, respectively. On other hand, the intercropping clover var-Fahl 25% and sown in rows produced high value for thousand grain weights. in both seasons.

The results showed that the grain yield productivity increased with decreasing the intercropping clover var. Fahl %, which the grain yield increased by decreasing intercropping clover var. Fahl % with broadcasting sowing method more than rows sowing method in both seasons (**Table 4**).

The protein % recorded different values under intercropping system where give highly values when sowing in rows and intercropping with clover var Fahl, 25% in both seasons respectively, show in **Table 4**.

Thise results contrast with those reported by EL-**Shamy *et al*., 2017**. They reported that pure stand of wheat gave highest values of most measured traits in comparison to intercropping systems. In comparison to other intercropping systems, the significant highest values for plant height, spike length, number of spikes/m^2, thousand grain weight, biological yield, and grain yield (ton ha^{-1}) were obtained during both seasons when wheat was sown in rows and intercropping with 25% Egyptian clover var. Fahl (**Table 3 and 4**). The Egyptian clover var. Fahl and wheat can complement each other for using the nitrogen sources in soil, but the nitrogen fixing by legume can also capture atmospheric nitrogen. **Clark** (**2007**) reported that Berseem Clover can fix 45.4 to 90.7 kg N per acre. Grain legume density is an important factor in intercrops for inorganic nitrogen utilization by cereals and for increasing the nitrogen content of cereal grains. Thus, the role of legumes as a nitrogen supplier in the intercropping system and as a builder of soil organic matter is important the future studies for the environment and agricultural lands.

Table 2. Analysis of variance for the studied traits under intercropping system of wheat on Egyptian clover and sowing methods in the two seasons.

	S.O.V	Sowing Method		Error a		Intercropping		Error b		S*I		Error c	
		2021-2022	2022-2023	2021-2022	2022-2023	2021-2022	2022-2023	2021-2022	2022-2023	2021-2022	2022-2023	2021-2022	2022-2023
	D.F	1		2		3		6		3		6	
Wheat traits	Plant height (cm)	35.31*	40.060*	1.550	2.730	122.36**	114.69**	0.330	1.280	12.18**	3.81*	0.53	0.860
	Spike length (cm)	60.17**	42.93**	0.150	0.031	1.75**	2.5**	0.150	0.110	0.59*	0.16*	0.09	0.031
	No. of Spikes/ m^2	138928**	140301**	100.040	51.290	21671**	22452**	31.400	73.56**	2030.5**	2047.48**	5.87	5.24
	Thousand grain weight (g)	12.76**	70.72**	0.140	0.310	19.32**	10.52**	0.110	0.720	2.13**	1.65*	0.14	0.280
	Biological yield (ton ha^{-1}).	15.2**	12.43*	0.210	0.280	5.68**	4.24**	0.039	0.300	1.139**	0.670	0.06	0.260
	Grain yield (ton ha^{-1}).	1.80**	2.190*	0.020	0.070	3.66**	2.59**	0.260	0.230	1.76**	1.720**	0.04	0.110
	Protin %	0.13*	0.25**	0.003	0.00035	1.66**	1.72**	0.017	0.0358	0.024*	0.094**	0.004	0.01
Egyptian clover traits ver	Thousand seed weight (g).	1.58**	0.57**	0.001	0.001	0.18**	0.15**	0.001	0.003	0.093**	0.02**	0.003	0.001
	Biological yield (ton ha^{-1}).	11.07**	18.37**	0.002	0.004	19.95**	3.82**	0.001	0.020	4.28**	0.14**	0.001	0.002
	Seed yield (ton ha^{-1}).	0.11**	0.43**	0.001	0.0002	0.11**	0.16**	0.004	0.001	0.03**	0.013**	0.003	0.001

***a**nd **significant at the 5% and 1% probability levels respectively.

Table.3. Effect of the interaction between sowing method and intercropping on growth, yield and its components of wheat during both of growing seasons.

Characters Intercropping of Wheat	Treatment	2021 / 2022					
		Plant height cm		Spike length (SL) cm		No. Spike (NS) m2	
		Broadcast	Row	Broadcast	Row	Broadcast	Row
	Solid	86.1	90.8	12.8	15.2	316.7	502.3
	75%	95.8	94.3	13.0	16.3	383.7	521.3
	50%	96.0	98.8	13.3	16.3	447.0	590.7
	25%	96.7	100.4	13.4	17.3	474.3	616.0
	Mean	93.6	96.1	13.1	16.3	405.4	557.6
	L.S.D0.05(I)	0.81		0.55		7.92	
	L.S.D0.05(S)	2.19		0.67		17.56	
	L.S.D0.05(I*S)	1.46		0.6		4.85	
	2022 / 2023						
	Solid	88.1	89.7	10.5	13.5	318.0	502.7
	75%	92.5	93.3	11.7	14.0	383.7	522.7
	50%	94.0	98.0	11.8	14.3	452.7	589.3
	25%	97.2	101.1	12.1	15.0	472.7	624.0
	Mean	93.0	95.5	11.5	14.2	406.8	559.7
	L.S.D0.05(I)	1.6		0.48		12.11	
	L.S.D0.05(S)	2.9		0.31		12.58	
	L.S.D0.05(I*S)	1.86		0.35		4.58	

Effect of sowing methods and intercropping systems on yield of Egyptian clover var. Fahl.

The results showed that there was significant effect of different wheat sowing methods on biological and seed yields (ton/ha^{-1}), and 1000 seed weight (g) of Egyptian clover var. Fahl Fig.9~11. The rows sowing method results in significant increase for all studied traits in comparison to the broadcast method. The intercropping wheat with 75% Egyptian clover var. Fahl resulted the highest biological and seed yield, (ton ha^{-1}), as well as 1000 seed weight in both seasons (Fig. 9 ~ 11). Otherwise, these were significant effects of the interaction between sowing methods and intercropping patterns for all studied traits in both seasons, except biological yield the first seasons. (**Table 2**).

Table 4. Effect of the interaction between sowing method and intercropping on growth, yield and its components of wheat during both of growing seasons.

Characters Intercropping of Wheat

Treatment	**2021 / 2022**										
	Thousand grain weight (TGW) g		Biological yield (BY) (ton ha-1).		Grain yield (GY) (ton ha-1).		P%		Increased % of Grain yield		L.E. R
	Broadcast	Row	Broadcast	Row	Broadcast	Row	Broadcast	Row	Broadcast	Row	Row
Solid	49.73	49.70	14.03	16.17	6.36	7.65	11.59	11.63	-	-	
75%	50.10	52.43	14.70	16.50	7.21	8.19	12.13	12.43	13.37	7.10	0.20
50%	51.40	53.90	16.06	17.08	7.49	8.36	12.50	12.70	17.88	9.28	0.27
25%	53.37	54.40	16.73	18.14	8.47	9.42	12.80	12.83	33.18	23.14	0.56
Mean	51.15	52.61	15.38	16.97	7.38	8.41	12.26	12.40	21.48	13.17	0.35
L.S.D0.05(I)	0.46		0.28		0.72		0.15				
L.S.D0.05(S)	0.65		0.81		0.25		0.11				
L.S.D0.05(I*S)	0.75		0.49		1.27		0.13				
	2022 / 2023										
Solid	49.03	53.30	14.66	16.23	6.24	7.53	11.51	11.47	-	-	-
75%	50.77	54.10	15.23	17.00	6.71	7.73	12.07	12.53	7.53	2.66	0.10
50%	52.17	54.27	16.33	17.20	7.19	8.27	12.53	12.57	15.22	9.83	0.25
25%	52.33	56.37	16.73	18.28	7.91	8.90	12.50	12.87	26.76	18.19	0.45
Mean	51.08	54.51	15.74	17.18	7.01	8.11	12.15	12.36	16.51	10.23	0.27
L.S.D0.05(I)	1.2		0.76		0.68		0.22				
L.S.D0.05(S)	0.98		0.94		0.45		0.04				
L.S.D0.05(I*S)	1.06		1.02		0.66		0.2				

Table 5. Effect of the interaction between sowing method and intercropping on growth, yield and its components of Egyptian clover during both of growing seasons.

Characters Intercropping of Egyptian clover	Treatments	2021 / 2022					
		Thousand seed weight (g)		Biological yield (ton ha-1)		Seed yield (ton ha-1).	
		Broadcast	Row	Broadcast	Row	Broadcast	Row
	Solid	3.07	3.40	9.03	10.30	0.92	1.04
	75%	3.08	3.48	9.50	10.80	1.02	1.23
	50%	3.17	3.70	11.47	10.87	1.20	1.32
	25%	3.25	4.05	12.03	15.50	1.26	1.36
	Mean	3.14	3.66	10.51	11.87	1.10	1.24
	L.S.D0.05(I)	0.05		0.03		0.09	
	L.S.D0.05(S)	0.06		0.07		0.06	
	L.S.D0.05(I*S)	0.11		0.063		0.06	
		2022 / 2023					
	Solid	3.04	3.52	8.77	10.50	0.76	0.95
	75%	3.23	3.54	9.30	11.43	0.86	1.26
	50%	3.43	3.64	10.27	12.00	0.99	1.26
	25%	3.52	3.76	10.70	12.10	1.13	1.35
	Mean						
	L.S.D0.05(I)	0.07		0.19		0.03	
	L.S.D0.05(S)	0.05		0.11		0.03	
	L.S.D0.05(I*S)	0.063		0.09		0.09	

Correlation coefficient

The correlation coefficient between each pair of studied traits in wheat was calculated and presented in Fig. 2,3, and 4 (unedr intercropping systems and sowing methoed). The results revealed that the remarkable observes were recorded for the obtained positive values. The biological yield (ton ha^{-1}) was strongly positive correlated with plant height, spike length, no. Spike/m2 for most cases in both seasons. Also, the grain yield (ton ha^{-1}) recorded a very strong and positive correlation with plant height, spike length, no. spike/m2, biological yield (ton ha-1), thousand grains weights in the first and second seasons. Moreover, the protein % recorded a strong positive correlation with plant height, thousand grains weights, biological yield (ton ha^{-1}) and grain yield (ton ha^{-1}) in most cases in the both seasons, Maen while, the positive correlation recorded between thousand grains weights g with plant height, spike length and grain yield (ton ha^{-1}) had positive correlation with protein % with plant height, spike length, no. spike (m^{2}), biological yield (ton ha^{-1}) and grain yield (ton ha^{-1}) in both seasons. This is due to the fact that clover nutrition wheat and gives a high yield. Similar results were reported by A**hmed *et al.*, (2022**).

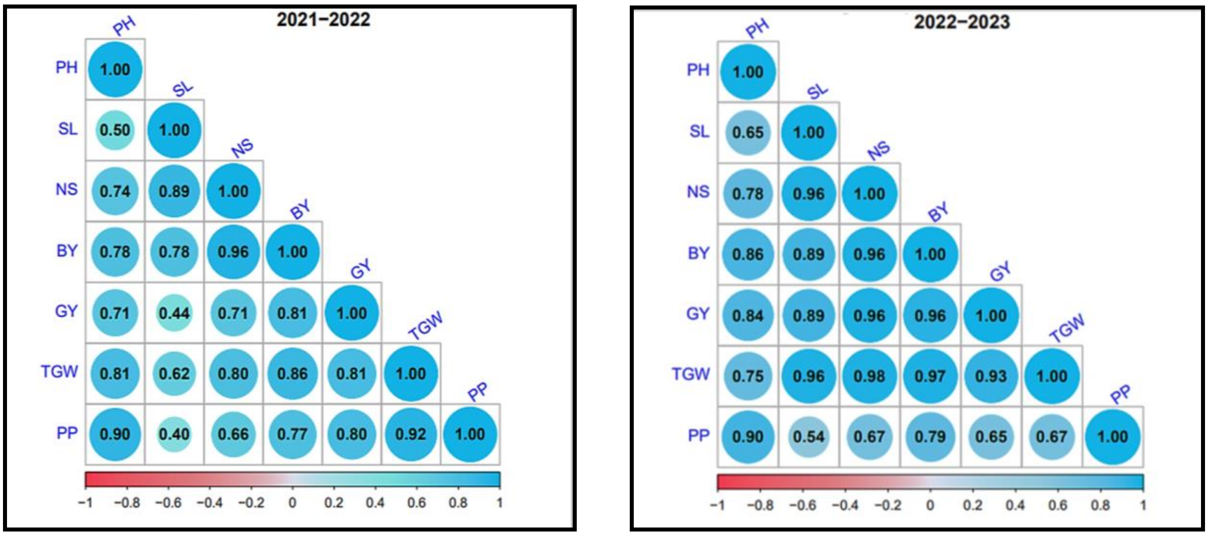

Fig. 2. Correlations coefficient, between studied traits general under all treatment factors in wheat 2021-2022 and 2022- 2023 seasons. Where are PH: Plant height cm, SL: Spike length cm, NS: No. Spike m2, BY: Biological yield (ton ha-1). GY: Grain yield (ton ha-1), TGW: Thousand grains weights g and PP: Protein %.

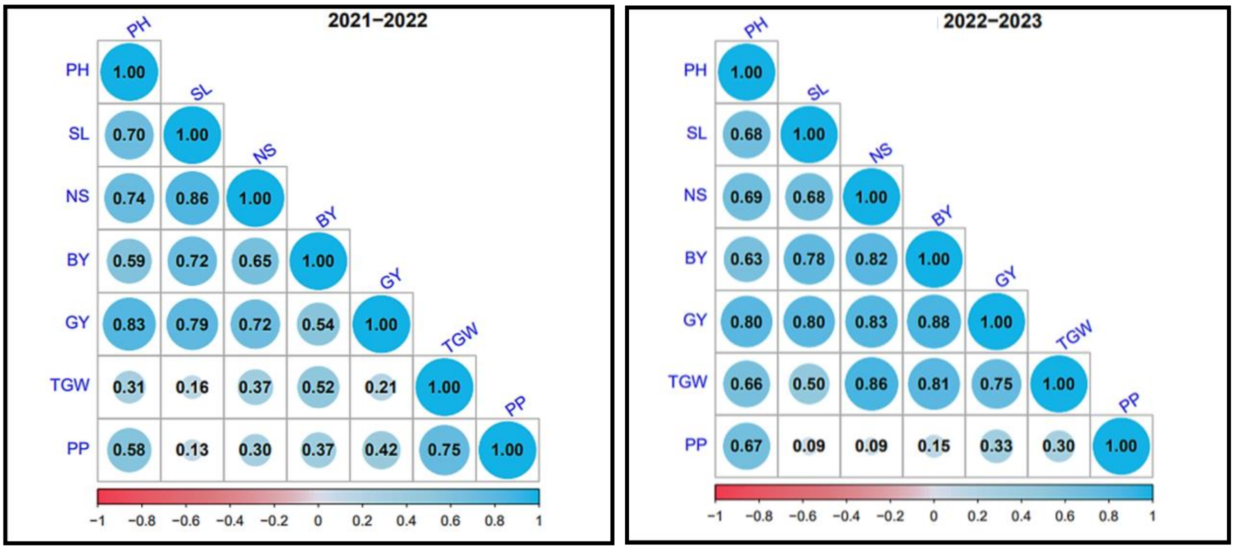

Fig. 3. Correlations coefficient, between studied traits in wheat 2021-2022 and 2022- 2023 seasons under different intercropping systems. Where are PH: Plant height cm, SL: Spike length cm, NS: No. Spike m2, BY: Biological yield (ton ha-1). GY: Grain yield (ton ha-1), TGW: Thousand grains weights g and PP: Protein %.

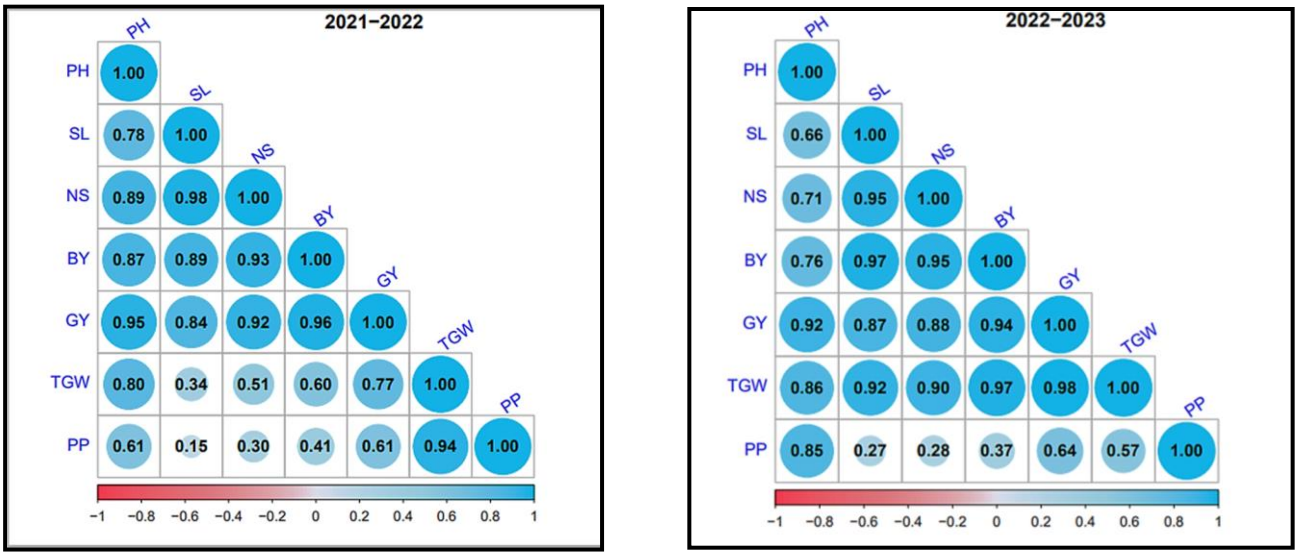

Fig. 4. Correlations coefficient, between studied traits in wheat 2021-2022 and 2022- 2023 seasons under different sowing methods on both seasons. Where are PH: Plant height cm, SL: Spike length cm, NS: No. Spike m2, BY: Biological yield (ton ha-1). GY: Grain yield (ton ha-1), TGW: Thousand grains weights g and PP: Protein %.

Principal Component Analysis

Six studied traits and eight treatments combinations were involved in the principal component analysis in a correlation matrix approach (Fig.5). The analysis exerted those two components (PC1 and PC2) recorded high Eigenvalues (5.33and 0.72) and (6.22 and 0.41) in both seasons, respectively. (**Table 7**). PC1 and PC2 explained (76.14 and 10.29%) and (88. 5.92 %) the total variation in both seasons, respectively (**Table 7; Figs.5 and 6**). In both seasons, moderate positive correlations have been observed between all studied traits PC1 and range between 0.34 Spike length (cm) and 0.41 no. of Spikes m2 and thousand grain weights (g) in the first season, and from 0.34 plant height (cm) to 0.39 grain yield (ton ha^{-1}) in the second season, the (**Table 9**). And moderate perfect positive correlations have been observed between all studied treatments factors PC1 and range between 1.0 (Broadcast 25%) and 1.0 (Rows 25%) in the first season, and from 0.15 (Broadcast 25%) to 1.0 (Rows 25%) in the second season), indicating the existence of sufficient association with the direction of the variability in the data set. In the first season (2021/2022), Parameters such as GY, PH, TGW, BY, NS and PP were positively loaded with PC1. In the second season, the parameters BY, GY, NS, WTG, SL and PP were positively loaded with PC2. This result is due to the fact that the climatic conditions in the first season are different from the second season, which led to this. Results revealed that the mixitrecropping and sowing method treatments are more diverse from each other.

Environmental fluctuations represent a major threat to yield production worldwide, and genotypes may have the option to tolerate unfavorable conditions caused by environmental change and, therefore, be valuable as potential guardians in plant breeding to improve defoliation rows in wheat with clover.

In PC analysis, grain yield (ton ha^{-1}) , plant height, thousand grain weight, biological yield (ton ha^{-1}), no.of spikes and protin % were strongly correlated and positively with PC1 but spike length, no. of spikes/m2 and thousand grain weight were neigaitve strong corrleation in PC2, but plant height, biological yield, grain yield and protin % was strongly correlated and positive with PC2 in the first season. Whearas, plant height cm was strong correlated and positively with PC1 and PC2 in the second season. The same trend was observed for thousand grain weight, biological yield and proyin % was strong correlated and positive with PC1 and PC2 in the second season.There is a similarity in both seasons in the characteristics associated with spike length correlated positive in PC2 in the first season and correlated with PC2 in the second season. Similar results have been obtained by **Kintl et al., (2018)**

Economic returns

The highest total net income (i.e.63790 and 91441) L.E in first and second season, respectively, were recorded when wheat was sown on rows and intercropping with 50% Egyptian clover var Fahle. While, the lowest total net income, (i.e. 37760 and 66092) L.E in the first and second seasons respectively, were recorded when wheat was sown on broadcast and solid without intercropping with Egyptian clover. The total income of solid crops was 37760 and 45430 L.E, for wheat, while it was 55200 and 62400 L.E in broadcast and Rows methods, respectively, for Egyptian clover in first season. As well as in second season the total income of solid crops was 66092 and 81016 L.E for wheat while, it was 69600 and 7600 L.E for Egyptian clover in broadcast and Rows methods, respectively, (**Table 8**). These results are in line with those reported by **El-Shamy *et al* (2017).**

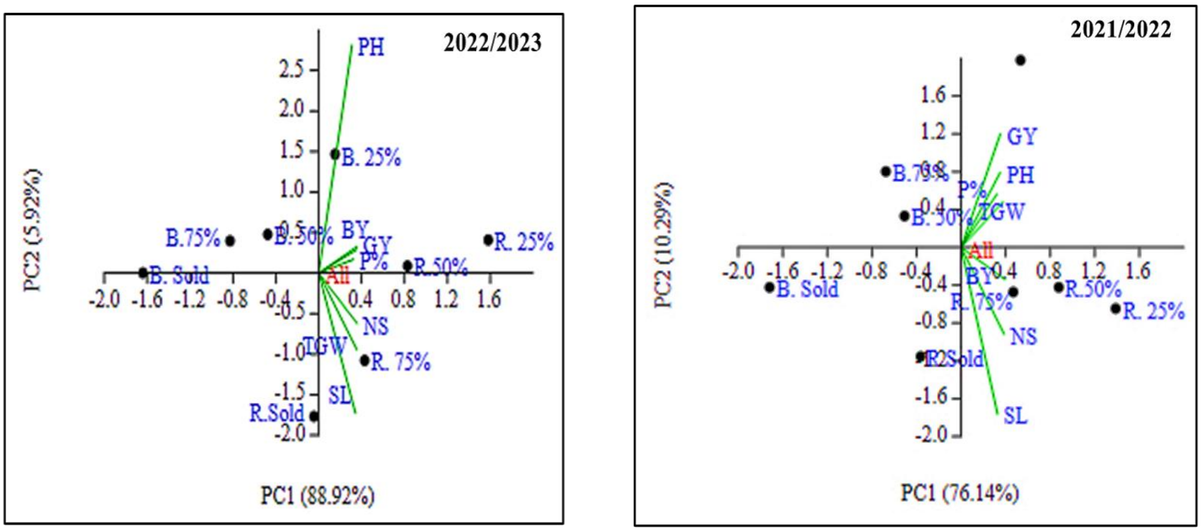

Fig. 5. Plots from the PCA demonstrate the contribution of the 6 interactions to the variation to different axes and the grouping of wheat according to PC1 and PC2. Where are PH: Plant height cm, SL: Spike length cm, NS: No. Spike m2., BY: Biological yield ton ha-1., and GY: Grain yield ton ha-1., TGW: Thousand grains weights g., P%: Protin %.

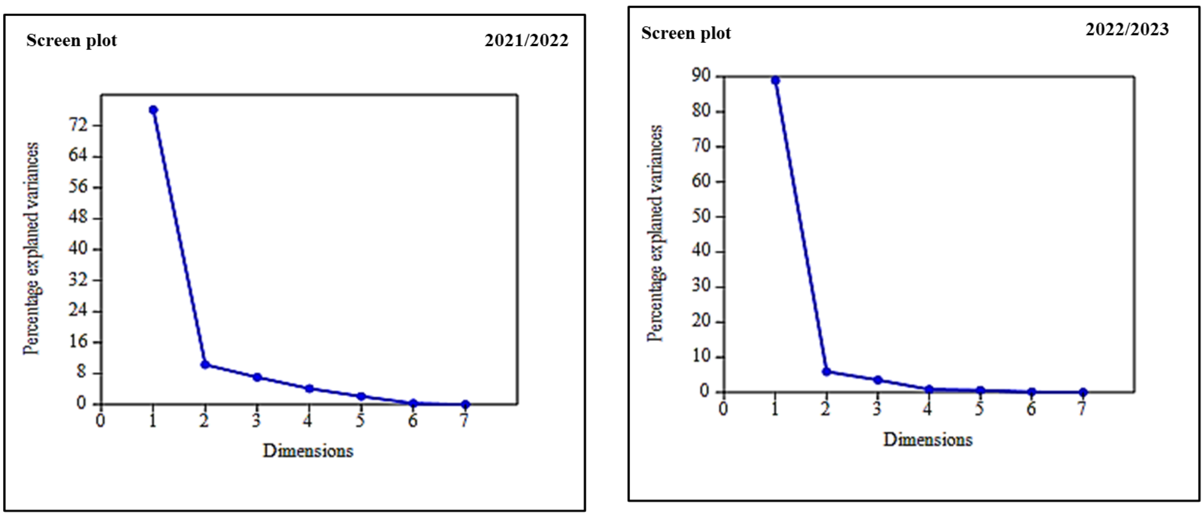

Fig. 6. Scree plot for six principal components.

Table 6. Eigenvalues and variance percentages of the six major factors were obtained from the PCA of six traits performed on wheat.

PC	2021-2022		2022-2023	
	Eigenvalue	%variance	Eigenvalue	%variance
1	5.33	76.14	6.22	88.92
2	0.72	10.29	0.41	5.92
3	0.49	7.04	0.25	3.54
4	0.29	4.12	0.06	0.84
5	0.15	2.09	0.04	0.62
6	0.02	0.31	0.01	0.14
7	0.0001	0.001	0.002	0.02

Table 7. Estimates of correlation coefficients among six traits in wheat.

	2021-2022						
	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6	PC 7
Plant height (cm)	0.37	0.31	-0.26	0.76	-0.27	0.08	0.23
Spike length (cm)	0.34	-0.68	0.24	0.06	0.14	0.13	0.56
No. of Spikes/ m2	0.41	-0.35	-0.16	-0.07	-0.28	0.45	-0.64
Thousand grain weight (g)	0.41	-0.13	-0.28	-0.23	-0.22	-0.79	-0.03
Biological yield (ton ha-1).	0.37	0.46	0.04	-0.59	-0.24	0.33	0.37
Grain yield (ton ha-1).	0.40	0.19	-0.26	-0.02	0.85	0.04	-0.12
Protein %	0.34	0.22	0.84	0.14	0.03	-0.19	-0.28
	2022-2023						
	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6	PC 7
Plant height (cm)	0.34	0.80	-0.09	0.27	0.37	0.17	0.03
Spike length (cm)	0.38	-0.49	0.05	0.18	0.51	0.10	0.56
No. of Spikes/ m2	0.39	-0.18	-0.25	-0.13	0.35	-0.52	-0.59
Thousand grain weight (g)	0.39	0.09	-0.24	0.21	-0.58	-0.50	0.39
Biological yield (ton ha-1).	0.39	0.08	-0.15	-0.83	-0.12	0.29	0.15
Grain yield (ton ha-1).	0.39	-0.27	-0.17	0.37	-0.34	0.59	-0.39
Protein %	0.36	0.05	0.91	-0.03	-0.13	-0.11	-0.13

Table 8. Economic returns (L.E) from intercropping systems of wheat with Egyptian clover during both of growing seasons.

Treatments		2021-2022							
		S1 100%		S2 75%		S3 50%		S4 25%	
		Wheat	Clover	Wheat	Clover	Wheat	Clover	Wheat	Clover
Grain and Seed yield (ton ha-1)	Broadcast	6.40	0.92	5.63	0.73	3.60	0.60	2.10	0.14
	Rows	7.70	1.04	6.38	0.77	4.10	0.66	2.35	0.34
Economic returns (L.E)	Broadcast	37760	55200	41617		57240		56190	
	Rows	45430	62400	58042		63790		60065	
2022-2023									
Grain and Seed yield (ton ha-1)	Broadcast	6.20	0.87	5.40	0.75	3.30	0.60	2.02	0.28
	Rows	7.60	0.95	6.23	0.80	3.85	0.63	2.23	0.34
Economic returns (L.E)	Broadcast	66092	69600	79964		753711		81533	
	Rows	81016	76000	93611		91441		87772	

Recommendation

Under the Assiut conditions region of Egypt Farmers are advised to plant wheat on terraces and intercropping with 50 and 25 % Egyptian clover var. Fahl. In these circumstances, it is possible to select the plant height, 1000 grain weight, protein %, and seed yield for breeding.

Conclusion

The aim of this investigation was to have new knowledge about the elimination of negative phenomena during the cultivation of winter wheat. There is a need to reduce the excessive application of nitrogen fertilizer which leaches from the soil. The agricultural technology was used to test winter wheat (Triticum aestivum), growing in the of intercropping system with Egyptian clover (Trifolium alexandrinum L.). Based on the results obtained, we can conclude that growing winter wheat in the intercropping system significantly increased the grain yield. Moreover, it was found that the cultivation of wheat in intercropping with clover makes it possible to reduce the applied nitrogen level by more than 20%, without any reduction on grain production. In addition, the planting method in rows with the intercropping of clover increased the grain yield of wheat, the economic return reached to the highest values when the wheat was intercropping with clover at 50%.

Plant height, thousand grain weight, biological yield, grian yield, and protin % were strongly correlated and positively with PC1 but spike length, and no. of spikes/m2 were neigaitve strong corrleation in PC2 under the same conditions of intercropping and sowing methods.

Consent for publication:

All authors declare their consent for publication.

Author contribution:

The manuscript was edited and revised by all authors.

Conflicts of Interest:

The author declares no conflict of interest.

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تحسين المحصول ومكوناته من خلال طرق الزراعة وتحميل القمح مع البرسيم المصري

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يُعد تحميل الحبوب والبقول (قمح + برسيم مصرى) ضروريا لتعزيز الانتاجية وكفاءة استخدام الارض . حيث يمكن للبقوليات تثبيت النيتروجين الجوى مما يثرى التربة للمحاصيل المنزرعة او اللاحقة.

هدف هذا البحث تاثير طرق الزراعة (البدار – صفوف) والتحميل للقمح مع البرسيم باستخدام الزراعة المنفردة لكل منهما والزراعة بنسبة ٧٥% قمح + ٢٥% برسيم مصرى , ٥٠% قمح +٥٠ % برسيم مصرى , ٢٥% قمح +٧٥% برسيم مصرى مع استخدام تصميم القطاعات الكاملة العشوائية بثلاث مكرارات لمدة موسمين متتاليين ٢٠٢٢/٢٠٢١، ٢٠٢٣/٢٠٢٢.

وأشارت النتائج الى ان الزراعة بطريقة الصفوف افضل من الزراعة بطريقة البدار وان تحميل القمح مع البرسيم بنسبة ٥٠% قمح + ٥٠% برسيم مصرى ادى الى تحسين المحصول ومكوناته والعائد الاقتصادى بشكل ملحوظ.

كما كان ارتفاع النبات ووزن الالف حبة والمحصول البيولوجي والغلة ونسبة البروتين ارتباطا ارتباطا ايجابيا قوى بمكون الرئيسى للتباين الأول (PC1) بينما كان طول السنبلة وعدد السنابل / م٢ مرتبطا ارتباط سالبيا وقويا مع مكون الرئيس للتباين الثاني (PC2).