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Research Article
Effect of Foliar Application of Yeast and Algae on Yield and Quality of Soybean in Newly Soils

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Abstract

Background and Objective: Using the foliar application in development agriculture became a new strategy in the production system to decrease the cost of nutrition. This study amid to investigate the effect of yeast and algae on yield and quality of soybean under fertigation in newly soils at Wadi El-Natroun, El-Behaira Governorate, Egypt, during the two seasons 2018 and 2019. **Materials and Methods:** The experimental design was a split-plot design in a randomized complete block arrangement with three replications. Yeast and algae were allocated to the main plots, while rates treatments were distributed at random in the sub-plots and control treatment foliar water. **Results:** The results showed that either the foliar application with algae and yeast stimulates many growth aspects individually, such as plant length, number of seeds/plant and seed weight/plant compared to the control treatment. In addition, foliar spraying with algae at 8 g L^{-1} increased NPK content, crude protein content and total carbohydrate in seed. **Conclusion:** This study concluded that the foliar application influences at algae have provided high yields and chemical constituents under fertigation in sandy soil.

Key words: Soybean, yeast, algae, spray, fertigation

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Soybean (*Glycine max* (L.) Merrill) is one of the most important proteins and oilseed crops in the world. Its oil is the world's largest edible oil component. It has emerged as one of the most important commercial crops in many countries. Soybean contributes more than 41% of the world's total oilseed production. Its oil is also used as a raw material in the manufacture of antibiotics, paints, varnishes, adhesives and lubricants (etc.).

Any improvement in the agricultural system that results in higher production levels should reduce the negative environmental impact of agriculture and enhance the sustainability of the system[1]. World production of soya beans is projected to increase by 2.2% annually to 371.3 million metric tons by 2030 using an exponential smoothing model with a dampened trend[2].

Soybean cultivation began in Egypt in 1976. The production of soybean in Egypt has increased to about 966 ha. Yield levels have stabilized at approximately 2895 metric tons per hectare[3]. Yeasts are unicellular fungi that proliferate primarily through asexual means and grow rapidly on simple carbohydrates. A wide range of yeasts exhibits pro-growth characteristics, including pathogen inhibition; phytohormone production and phosphate solubilization[4].

The use of extracts of algae to improve crop yield and productivity could be recommended in the current work. Foliar sprays with extract of algae have increased yield, index of seeds and quality of faba bean. Some biochemical metabolites (total carbohydrate, total protein and also N, P and K) of seeds increased by the application of the seaweed extract[5]. Nikhil[6] has shown that algae are vast and diverse gatherings of basic, autotrophic living beings, ranging from unicellular to multi-cellular. Most of them can coordinate photosynthesis and energy is transformed into sugar and then into biomass. It contains all of the nutrients and plant development hormones that are essential for plant yield improvement[7].

The ability of different forms of blue-green algae completes both photosynthesis and nitrogen fixation, which give them biological and agricultural inclinations another sort of bio-fertilizer, which can improve soil structure, particularly saline-alkaline soil and increase the yielding and quality of crops. To some extent, they are valuable in the refining of water[8]. Khattab *et al.*[9] have suggested a rise in plant growth from treated plants with algae extract. The plant height, weight, 100 seed weight, grain yield/ton, straw yield and proteins, nitrogen, phosphorus and potassium are significantly increased with these treatments.

This study's primary objective is to assess the application of different concentrations of yeast and algae to enhance the growth, yield and quality of soybean grown in fields, fertigation in sandy soil.

MATERIALS AND METHODS

Two field studies were thus performed on a private farm in the Egyptian. Wadi El-Natroun, El-Behaira Governorate, during two consecutive summer seasons of 2018 and 2019. Study the yield efficiency of yeast and algae, yield components and quality of soybean under fertigation in newly soil conditions. A representative soil sample (0-30) was taken from the experimental field before sowing for each season to determine the physical and chemical properties of the soil and also chemical analysis of irrigation water used and Physico-chemical analysis of the yeast and algae used are shown in Table 1 and 2 by using the method described by Cottenie *et al.*[10].

Table 1: Physico-chemical properties of the experimental sites during the two seasons

	Particle size distribution (%)									
Growing season	Sand	Silt	Clay	Texture	OM (%)	$CaCO_3^-$ (%)	pH	EC (dSm^{-1})		
1st	85.15	9.07	5.78	Sandy	0.23	1.39	8.84	1.35		
2nd	83.76	10.02	6.22	Sandy	0.35	1.33	7.78	1.20		
	Cations (1:2) (meq L^{-1})				Anions (1:2) (meq L^{-1})				NPK available (mg kg^{-1})		
Growing season	Ca^{++}	Mg^{++}	Na^+	K^+	$CO_3^=$	HCO_3^-	Cl^-	$SO_4^=$	N	P	K
1st	2.12	1.55	5.60	1.57	0.00	2.15	7.35	1.34	33.22	72.34	115.42
2nd	2.15	1.64	5.63	1.60	0.00	2.30	7.42	1.30	23.28	79.34	98.22
		Soluble cations (mg L^{-1})					Soluble anions (mg L^{-1})			
pH	EC dSm^{-1}	K^+	Na^+	Mg^{++}	Ca^{++}		$CO_3^=$	HCO_3^-	Cl^-	$SO_4^=$
Chemical analysis of irrigation water										
7.70	0.80	3.18	3.12	6.22	7.02		0.00	3.87	0.57	15.10

OM: Organic matter, EC: Electrocoagulation

Table 2: Physico-chemical analysis of the yeast and algae

	Characteristics				Macronutrients (%)			Micronutrients (%)			
Type	pH	C/N ratio	O.M. (%)	O.C. (%)	N	P	K	Fe	Zn	Mn	Cu
Yeast	7.70	22.20	52.60	27.30	2.60	1.40	0.60	0.06	0.02	0.01	0.003
Algae	7.50	18.30	57.30	25.00	3.30	2.50	0.63	0.15	0.05	0.02	0.005

OM: Organic matter, OC: Organic carbon

Data recorded

Cultural practices: Soybean was sown in May 5th in the 1st and 2nd seasons. Soybean (Giza 22) seeds were inoculated prior to sowing with the specific strain of *Rhizobium leguminosarum*. Soybean in the rate of 30 kg fed^{-1} (fed = 4200 m^2) was sown one side of the ridge in the hills 15 cm apart and two plant/hill was left at thinning (21 days after sowing). Phosphorus and potassium were added at a rate of 60 kg P_2O_5/fed and 50 kg K_2O/fed, respectively. Phosphorus was applied as a single super phosphate (15.5% P_2O_5) pre-sowing. Potassium was applied as potassium sulfate (48% K_2O) at 45 days after sowing in one dose.

Experimental design: The field experiments in both seasons were conducted under a drip irrigation system with 30 cm distance between drippers (2 L/hour) and 60 cm between rows. The plot size was 15 m^2 (1/280 fed). Each plot consisted of five ridges 5 m long and 0.6 m wide. The irrigation system was irrigated at 4-5 day intervals. The experimental design was a split-plot design in a randomized complete block arrangement with three replicates. Yeast and Algae were allocated to the main plots, while rates treatments were distributed at random in the sub-plots.

Treatments: Field soybean plants at 30 days from sowing were sprayed with the following treatments:

- Water (control)
- Yeast and Algae (2, 4 and 8 g L^{-1})

Yeast and algae were applied as foliar sprays on foliage at two times, the first after one month from sowing, the other two months later.

At harvest (120 days after sowing) ten plants were taken randomly from the two central rows guarded (from all plots) to determine the following traits:

- Plant height (cm)
- No. of seeds/plant
- Seed weight/plant (g)

All plants of each plot were harvested then seed and straw yields (ton/fed) were determined by multiplying seed and straw yields/plot*280.

Methods of analysis: For each plot the following traits were done:

- Total nitrogen was determined by the Kjeldahl method using the method described by Cottenie *et al.*[10]
- Phosphorus was determined spectrophotometrically using the method described by Cottenie *et al.*[10]
- Potassium was determined using a flame photometer as described by Cottenie *et al.*[10]
- Method of soil analysis, physical and mineralogical properties according to Black[11]
- Crude Protein was calculated as N%×6.25 according to the Association of Official Agricultural Chemists[12]
- Seed oil percentage: the soxhlet continuous extraction apparatus with petroleum ether (40-60°C) as an organic solvent was used to determine the oilseed percentage according to the Association of Official Agricultural Chemists[12]
- Total Carbohydrates were determined according to Dubois *et al.*[13]
- Total carbon, organic carbon and organic matter were done according to Nelson and Sommers[14]

Statistical analysis: The responses of the treatments were compared by Analysis of Variance (ANOVA)[15]. Significant differences between the means of parameters were determined using Duncan's multiple range tests ($p \leq 0.05$).

RESULTS AND DISCUSSION

Yield and its components

Plant height: The effects of yeast, algae on growth and yield of soybean plants are shown in Table 3. The results showed that all treatments significantly increased growth as indicated by plant height. These effects were more obvious especially at higher concentrations of these treatments. As shown in

Tables 3 application of algae and yeast at 8 g L^{-1} increased plant height. The interaction between algae and yeast was significant except the first season. Previous stduies[15-17] indicated that the application of algae and yeast increased plant height.

No. of seeds/plant: It is evident from Table 3 that the significant differences were noticed both in algae and yeast treatments with respect to the number of seeds per plant. Among the algae recorded a significantly higher number of seeds per plant over yeast. Among the treatments, algae (8 g L^{-1}) recorded a significantly higher number of seeds per plant (148.86 and 156.81) which was significantly higher over rest of the treatments.

All other treatments also recorded a significantly higher number of seeds per plant as compared to control. The interaction between algae and yeast were significant. Amer[17] indicated that the application of yeast increased common bean growth, yield and its component.

Seed weight/plant (g): It is evident from Table 3 that foliar had a significant influence on seed weight per plant. Among the algae recorded significantly higher seed weight per plant over yeast whereas, among the treatments, algae (8 g L^{-1}) exhibited significantly higher seed weight per plant. Significantly higher seed weight/plant was observed in control which was significantly lower than all the treatments. However, the interaction between algae and yeast was significant.

On the other hand, the application of algae promoted bean growth and productivity and these effects agreed with the findings of Khattab *et al.*[9] who found that foliar application of algae significantly increased plant height and number of pods of faba bean.

100-seed weight (g): The data on 100-seed weight revealed significant differences due to foliar application treatments (Table 4). The treatment algae (8 g L^{-1}) recorded significantly higher 100-seed weight which was significantly higher over control. The interaction of algae and yeast was significant. On the other hand, the application of algae promoted bean growth and productivity and these effects agreed with the findings of Khattab *et al.*[9] who found that foliar application of algae significantly increased plant of 100 seed weight, seed yield/ton and straw yield of faba bean.

Yield (ton/fed): The effects of algae and yeast on the yield of soybean plants are shown in Table 4. The results showed that all treatments significantly increased yield as indicated by the plant of weight, the weight of 100 seed weight, seed yield/ton and straw yield. These effects were more obvious especially at higher concentrations of these treatments.

Also, foliar application with algae and yeast treatments improved seed yield of soybean plants due to increasing flower formation and the reduction of flowers and pod shedding as well as increasing their ability to accumulate more bio constituents. Significantly higher seed yield with algae (8 g L^{-1}) was compared with control in the two seasons, respectively.

Table 3: Impact of yeast and algae foliar application on some growth of soybean under fertigation in sandy soil

	Plant height (m)				No. of seeds/plant				Seed weight/plant (g)			
Sources	2	4	8	Mean	2	4	8	Mean	2	4	8	Mean
2018												
Control	1.14	1.12	1.13	1.13	94.00	92.33	93.67	93.33	12.33	13.00	13.00	12.78
Yeast	1.21	1.32	1.42	1.32	100.41	118.31	138.68	119.13	16.56	19.43	23.14	19.71
Algae	1.39	1.46	1.52	1.46	120.07	136.22	148.86	135.05	19.62	23.55	26.06	23.08
Mean	1.25	1.30	1.36	1.30	104.83	115.62	127.07	115.84	16.17	18.66	20.73	18.52
$LSD_{0.05}$												
Sources				0.03				4.39				0.75
Rates				0.05				2.36				0.86
S×R				ns				4.81				0.90
2019												
Control	1.18	1.18	1.17	1.18	99.02	97.26	98.67	98.32	15.33	16.00	16.00	15.78
Yeast	1.27	1.40	1.50	1.39	105.77	124.63	146.08	125.49	20.00	24.33	27.33	23.89
Algae	1.47	1.54	1.60	1.54	126.48	143.49	156.81	142.26	22.33	28.67	29.67	26.89
Mean	1.31	1.37	1.42	1.37	110.42	121.79	133.85	122.02	19.22	23.00	24.33	22.18
$LSD_{0.05}$												
Sources				0.03				4.62				1.05
Rates				0.06				2.49				1.03
S×R				0.08				5.06				1.66

S×R: Sources×Rates

Table 4: Impact of yeast and algae foliar application on yield of soybean under fertigation in sandy soil

	100 seed weight (g)				Seed yield (ton/fed)				Straw yield (ton/fed)			
Sources	2	4	8	Mean	2	4	8	Mean	2	4	8	Mean
2018												
Control	13.00	13.00	13.00	13.00	1.24	1.24	1.25	1.24	2.14	2.15	2.10	2.13
Yeast	15.86	16.28	17.34	16.49	1.26	1.34	1.49	1.36	2.31	2.40	2.51	2.41
Algae	15.71	17.34	17.93	16.99	1.32	1.38	1.56	1.42	2.40	2.49	2.55	2.48
Mean	14.86	15.54	16.09	15.50	1.27	1.32	1.43	1.34	2.28	2.35	2.39	2.34
$LSD_{0.05}$												
Sources				1.60				0.04				0.07
Rates				0.71				0.03				0.06
S×R				ns				0.06				0.13
2019												
Control	13.42	13.45	13.40	13.42	1.28	1.26	1.28	1.27	2.23	2.21	2.21	2.22
Yeast	15.73	16.81	17.90	16.81	1.41	1.53	1.58	1.51	2.38	2.50	2.60	2.49
Algae	16.22	17.80	18.51	17.51	1.50	1.57	1.64	1.57	2.49	2.55	2.70	2.58
Mean	15.12	16.02	16.60	15.92	1.40	1.45	1.50	1.45	2.37	2.42	2.50	2.43
$LSD_{0.05}$												
Sources				1.81				0.05				0.06
Rates				0.70				0.03				0.07
S×R				ns				0.06				0.08

However, the interaction between algae and yeast was significant. Algae and yeast are considered as a natural source of cytokines that stimulates cell division and enlargement as well as the synthesis of protein, nucleic acid and chlorophyll[17] as well as the presence of organic acids such as hymic, fulvic and amino acids, in addition to the macro and micronutrients. On the other hand, the application of algae promoted bean growth and productivity and these effects agreed with the findings of Khattab *et al.*[9] who found that foliar application of algae significantly increased plant of grain yield/ton of faba bean.

Straw (ton/fed): In the present study, it was revealed that the application of algae and yeast significantly increased then umber of seeds, number of pods, pod weight per plant, 100-seed weight and finally straw yield which are the most important yield determining components in soybean. Data in Table 4 showed that the algae significantly surpassed either yeast in increasing soybean straw yield. As for foliar rates, it is clear from data in Table 4 that there is a gradual significant increase in straw yield as the foliar rate increased up to 8 g L^{-1}. The data clearly showed that soybean plants responded to all of the applied foliar rates under any fertilizer types.

The highest macronutrient content was obtained when soybean was fertilized with 8 g L^{-1}. With respect to the interaction effects, it is apparent from Table 4 that all interactions between types of fertilizers and rates had a significant effect in both seasons. Foliar application of algae increased the straw yield as compared to control in soybean and effects agreed with the findings of Khattab *et al.*[9] who found that foliar application of algae significantly increased plant of straw yield of faba bean.

N, P and K (%): Results in Table 5 indicated that all adopted treatments of algae and yeast showed positive statistical effects on soybean seeds macronutrients N, P and K content (%) in two seasons. The data clearly showed that all foliar types significantly exceeded the control of this regard in both seasons. Data in Table 5 showed that algae significantly exceeded soybean seeds N, P and K contents over that of either yeast in both seasons.

The highest values were attained by the application of algae with a higher rate (8 g L^{-1}) followed by application yeast the same rate compared to the control. Regarding the effect of interactions between algae and yeast and rates of application on N, P and K contents in soybean seeds the results in Table 5 indicated that all interactions caused a non-significant effect on soybean seeds N, P and K contents except N in the first season and K second season. The growth of plants was increased of the algae treated plants. On the other hand, these treatments significantly increased protein, nitrogen, phosphorus and potassium[16].

Quality

Protein (%): It is realized from Table 6 that all foliar significantly increased crude protein percentage of soybean seeds under fertigation in both seasons. Results also indicated that seeds of soybean plants fertilized with algae significantly

Table 5: Impact of yeast and algae foliar application on some macronutrients of soybean seeds under fertigation in sandy soil

	Nitrogen (%)				Phosphorus (%)				Potassium (%)			
Sources	2	4	8	Mean	2	4	8	Mean	2	4	8	Mean
2018												
Control	2.92	2.92	2.93	2.92	0.36	0.35	0.35	0.35	1.85	1.84	1.85	1.85
Yeast	3.37	3.45	3.53	3.45	0.48	0.50	0.51	0.50	2.00	2.18	2.36	2.18
Algae	3.49	3.53	3.58	3.53	0.49	0.51	0.53	0.51	2.18	2.29	2.44	2.30
Mean	3.26	3.30	3.35	3.30	0.44	0.45	0.46	0.45	2.01	2.10	2.22	2.11
$LSD_{0.05}$												
Sources				0.04				0.03				0.17
Rates				0.03				0.02				0.06
S×R				0.05				ns				ns
2019												
Control	3.01	3.01	3.02	3.01	0.42	0.40	0.41	0.41	1.91	1.90	1.91	1.91
Yeast	3.55	3.66	3.71	3.64	0.50	0.53	0.58	0.54	2.07	2.25	2.41	2.24
Algae	3,65	3.66	3.75	3.71	0.51	0.55	0.60	0.55	2.26	2.33	2.49	2.36
Mean	3.28	3.44	3.49	3.41	0.48	0.49	0.53	0.50	2.08	2.16	2.27	2.17
$LSD_{0.05}$												
Sources				0.05				0.07				0.11
Rates				0.04				0.05				0.04
S×R				ns				ns				0.11

Table 6: Impact of yeast and algae foliar application on the quality of soybean under fertigation in sandy soil

	Protein (%)				Carbohydrates (%)				Oil (%)			
Sources	2	4	8	Mean	2	4	8	Mean	2	4	8	Mean
2018												
Control	18.25	18.25	18.31	18.27	27.00	26.67	27.00	26.89	16.30	16.32	16.35	16.32
Yeast	21.06	21.56	22.06	21.56	30.63	32.20	34.98	32.60	21.57	23.46	23.72	22.92
Algae	21.81	22.06	22.38	22.08	31.35	33.45	35.76	33.52	22.91	23.77	25.21	23.96
Mean	20.37	20.62	20.92	20.64	29.66	30.77	32.58	31.00	20.26	21.18	21.76	21.07
$LSD_{0.05}$												
Sources				0.77				1.67				1.12
Rates				0.45				0.92				0.82
S×R				0.92				1.82				ns
2019												
Control	18.81	18.81	18.88	18.83	27.00	36.50	26.60	30.03	16.43	16.40	16.42	16.42
Yeast	22.19	22.88	23.19	22.75	31.27	32.66	35.12	33.02	21.70	23.60	25.04	23.45
Algae	22.81	22.88	23.44	23.04	31.96	34.06	36.00	34.01	23.05	24.15	25.94	24.38
Mean	21.27	21.52	21.84	21.54	30.08	34.41	32.57	32.35	20.39	21.38	22.47	21.41
$LSD_{0.05}$												
Sources				0.25				1.56				0.61
Rates				0.24				0.99				0.79
S×R				0.41				1.64				1.38

exceeded yeast in this respect in both seasons. The highest percentage of seeds crude protein was recorded with algae compared to the control, in the first and second seasons respectively.

Regarding foliar rates, it is clear from the Table 6 that gradual significant increases in crude protein resulted as the foliar rate increased up to 8 g L^{-1}. Regarding the interaction effect, data showed significant effects in both seasons. Soybean plants responded to the entire applied foliar rate under any fertilizer type. The highest crude protein content was obtained when soybean was foliar with (8 g L^{-1}). These results are in accordance with those reported by Rawheya *et al.*[5].

Carbohydrates (%): Results in Table 6 clearly showed that all treatments of algae and yeast significantly increased total carbohydrates content in soybean seeds under fertigation than the control treatment in both seasons. The highest increase in the total carbohydrates content in both seasons was recorded by algae in the first and second seasons, respectively. Regarding foliar fertilizer rates, it is clear from the Table 6 that gradual significant increases in total carbohydrates content resulted as foliar rate increased up to 8 g L^{-1}.

With regard to the interaction effect between types and rates of application, data showed significant effects, the data clearly showed that soybean plants responded to all of the

applied foliar rates under any fertilizer types. The highest total carbohydrates content was obtained when soybean was foliar fertilized with 8 g L^{-1} algae followed by the same rate of yeast in both seasons. These data agreed with the findings of by Rawheya *et al.*[5].

Oil (%): Results in Table 6 cleared that all adopted treatments of algae and yeast revealed a significant statistical effect on oil percentage in the seeds of soybean in the two growing seasons. Algae surpassed yeast in this respect with significant differences between the foliar treatments in both seasons.

As for foliar rates, it is clear from data in the same Table 6 that gradual significant increases in oil percentage in soybean seeds were obtained as the foliar rate increased up to 8 g L^{-1}. Results in Table 6 show that the interactions between types and rates of foliar application had a significant effect on the percentage of oil in soybean seeds in the second season. These results are in accordance with those reported by Fathy and Farid[18].

Soybean is an excellent source of major nutrients including vitamins A, B and D, unsaturated fatty acids and minerals Ca and P that can meet different nutritional needs. For a sustainable agriculture system, it is necessary to utilize renewable inputs that can maximize the ecological benefits and minimize environmental hazards. The present study has assessed the influence of algae and yeast on the growth and productivity of soybean plants under fertigation in sand soil. Yeast and algae area natural source of cytokines that stimulates cell proliferation and differentiation, controlling shoot and root morphogenesis and chloroplast maturation which lead to vegetative growth stimulation[19]. This can be explained on the basis that yeast and algae are capable of indirectly enhancing plant growth. The results showed an increase in seeds oil and protein contents, especially in the two seasons[20]. The foliar application fertilizers treatments showed a higher yield and chemical constituents compared with the control under fertigation. Furthermore, results suggest that foliar application at 8 g L^{-1} associated under fertigation can be good for obtaining an optimum yield of soybean. The results of the current study revealed that foliar fertilizers such as algae and yeast improved the quantity and quality of soybean.

CONCLUSION

It could be concluded that foliar spraying with algae and yeast at 8 g L^{-1} with algae can be used to increase the final seed yield and quality parameters. These beneficial events producing plant growth promotion and increases in crop yield can take place simultaneously or sequentially. This study will help the researcher to uncover the foliar algae and yeast that many researchers were not able to explore.

SIGNIFICANCE STATEMENT

This study discovered the effect of foliar application of yeast and algae on yield and quality of soybean that can be beneficial for farmers and this study will help the researchers to uncover the critical areas of using yeast and algae that many researchers were not able to explore. Thus a new theory on improving soybean productivity in new soils may be arrived at.

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