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Effect of plant biostimulants, harvesting dates and storage periods on Sesame (*Sesamum indicum* L.) growth, yield and seed quality in newly reclaimed soils.

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THE study aimed to determine the efficacy of harvest dates and storage periods under various plant biostimulants on growth, yield and seed quality of Sesame (Shandawil 3). Reaching the best storage period as a way for expanding sesame cultivation in newly reclaimed lands. Results revealed that spirulina mixed with chlorella achieved a significant increase in most of the studied traits such as the plant height, number of branches/plant, number of leaves/plant, first capsule height, number of capsules/plant, biological yield, seed yield, standard germination, seedling length, electrical conductivity, thousand seed weight, protein content, seed oil of sesame seeds, peroxidase value and acidity number followed by chlorella, spirulina and vinasse individually. For the harvest date, the optimum date (120 days) achieved significant values for most of the studied traits compared with harvest date (105 days). Storage periods of 0, 6, and 18 months, respectively recorded the highest values for germination and seed quality. In comparison to other periods, 18 months of storage produced the lowest values for germination percentage, seedling length, seedling dry weight and vigour index. Respecting the interaction effects between biostimulants and harvest dates, spirulina+ chlorella achieved the highest plant, highest No. branches/p, while, chlorella 2% alone recorded the highest number of leaves/plant. Spirulina 2% recorded the highest values of highest of first capsules. Using Spirulina with chlorella at the optimum harvesting date gave the highest values of a number of capsules/p, seed yield, and biological yield compared with other treats. Seedling parameters are no appreciable variations among stimulants, harvesting dates, and storage periods.

Keywords: *Sesame, plant biostimulants vinasse; spirulina, chlorella, harvest dates, storage, seed quality*

Introduction

In Egypt, Sesame (*Sesamum indicum*, L.) is considered the most important oil crop. Further study is required to boost sesame production by utilizing plant biostimulants to enhance seed germination and seedling characteristics because of Egypt's severe edible oil shortage. Sesame is grown for its seeds, which contain 50% oil, 8% protein, 18% carbs, 3% fibre, and 6% ash, according to (**Atia et al., 2014**). (**Sharaby & Butovchenko, 2019**), elucidate sesame seeds are more important as a source of protein, calcium, and phosphorus. Additionally, it is anticipated that future changes in land use, management, and climate will lead to an even greater increase in abiotic stress (**Chaudhry& Sidhu 2022**). One of the primary goals of agronomists is to mitigate the effects of environmental stress on seed germination and early seedling growth. Similarly, developing abiotic stress-tolerant seeds through conventional breeding programmes requires a significant amount of time and resources, and the use of genetically modified seeds for agricultural purposes is restricted in many countries. As an alternative, seeds can be treated with biostimulants to improve germination and seedling vigour in both ideal and stressful conditions (**Gupta et**

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al., 2022). Biostimulants can help improve plant growth and sesame crop quality (**Applications, 2021**). Several factors can influence sesame seed production, including the use of plant biostimulants on the foliar application. Also, improve crop health, yield, and quality **Sonia (2024).** Using biostimulants is acknowledged as a state-of eco-friendly farming method that supports crop sustainability (**Sun 2023**). Environmental stress conditions have a negative impact on seed germination and seedling establishment, which are the most critical and vulnerable stages of a plant's life cycle. Vinasse is a suspension of organic matter and solid minerals that is produced when alcohol is distilled; it contains some non-volatile compounds, alcohol, and leftover sugars and has a favourable impact (**Karthiga Devi et al., 2019**). Furthermore, the physical, chemical, and biological properties of the soil have improved as a result of the use of vinasse for irrigation, particularly in sugarcane farming (**Moran 2016**). (**Sow & Ranjan, 2021**) demonstrated that applications of spirulina are one of the beneficial, potent supplements provided by nature with hardly perceptible side effects. A practical and affordable method of increasing crop productivity and food security. Spirulina can be used as a stimulant in organic farming systems, but more research is needed and farmers should be aware of Spirulina's success as a plant biostimulants for the growth and yield of various crops rather than chemical biostimulants. Chlorella vulgaris is green algae that is commonly found in freshwater, oceanic, and geostationary environments (**Ru 2020**). It has a high photosynthetic ability and the potential to grow rapidly in autotrophic, mixotrophic, and heterotrophic environments (**Richmond 2013**). Furthermore, chlorella vulgaris contains a variety of beneficial components such as essential amino acids, dietary fibres, minerals, proteins, bioactive compounds, chlorophylls, and antioxidants (**De Morais 2015**). Chlorella vulgaris has enormous potential due to its high nutritional value, as demonstrated by numerous studies. Seed quality and quantity must be maintained through appropriate storage. The conditions during harvesting and the type of storage structures used determine how long the seed can be safely stored, and the loss of 25-33% of the annual global grain crop, including seeds, during storage has a significant impact on food security around the world. (**FAO, 2018**). (**Alemayehu et al., 2020**) demonstrated that while post-harvest loss-mitigation techniques have been proven successful, their implementation has been slow in most developing countries. To preserve the quantity and quality of sesame seeds for consumption, seeds for the next season, and to boost competitiveness in the export market a crucial issue for Egypt better storage technologies are needed. The purpose of study was to investigate the effect of various plant biostimulants, harvest dates, and their interactions on growth, yield, and yield components to assess the effects of storage periods on seed germination, seedling establishment, and oil seed quality of sesame cv. Shandweel-3 cultivar in newly reclaimed soils.

Materials and Methods

Two field experiments were carried out at the Experimental Farm of Agriculture of the Experimental and Research Centre, Faculty of Agriculture, Samalout, El-Minia University, (latitude of 28.05º N and longitude of 30.44º E altitude of 40 m above sea level), El-Minia Governorate, Egypt, and Seed Technology Research Unit. Field Crops Research Institute (FCRI); Agricultural Research Center (ARC), Dakahlia Governorate, during two seasons of 2020 and 2021. Table (1) shows the mechanical and chemical analysis of the experimental soil conducted prior to sowing, as per (**Avery and Bascomb 1982**).

The plants were sprayed with two types of algae, namely spirulina and chlorella, in addition to vinasse. The harvest was done on two different dates 105 and 120 days after planting, and all field readings were taken. Seeds resulting from the harvest dates were stored for a period of (0-6-18) months. Laboratory measurements were taken for the storage periods, which includes: (standard germination, length of seedling, seedlings dry weight, seedlings vigor index, thousand seed weight, electrical conductivity, specific gravity, percentage of seed moisture, percentage of protein in seeds, percentage of seed oil, peroxidase number, and acid number of seed oil).

Agricultural practices:

The seeding rate was 4 kg/fed. Seeds were planting at hills 10 cm. apart; the plants were thinned after the first hoeing (21days from planting) to one plant/hill. Calcium superphosphate (15.5% P_2O_5) was applied at a rate of 200 kg/fed during soil preparation and 50 kg/fed thereafter potassium sulphate (48% K_2O) was added during the second irrigation. However, nitrogen fertiliser was applied in the form of ammonia nitrate

TABLE 1.The physical and chemical characteristics of the test soil.

Chemical characteristics	Value	Physical characteristics	Value
pH. (1: 2.5). water	8.1	F.C. %	16.4
Ca CO3 (g/kg.)	3.7	PWP %	6.6
CEC. cmolc/kg.	14.8	WHC %	30.2
Electrical Conductivity.	1.2	Av. (F.C. - PWP) %	9.8
Organic Matter. g/kg.	0.5	Av. (WHC - PWP) %	23.6
Total N. mg/kg	49.3	Sand	68.3
Total P. mg/kg	19.4	Silt	16.7
Total K. mg/kg	334.3	Clay	15.1
Soil texture	Loamy sand		

F.C: Field Capacity, PWP: Permanent Wilting Point, CEC: Cation Exchange Capacity, WHC: Water Holding Capacity, and Av.: Average.

(33.5%N) at a rate of 30 kg. N/fed. in two equal doses 21 and 45 days after sowing. All other recommended agricultural practices for sesame production were implemented in accordance with the Ministry of Agriculture's recommendations (land preparation, irrigation, fertilizer, weeding etc..). In both seasons, the preceding winter crop was wheat (*Triticum durum,* L.). A Randomized Complete Block Design (RCBD) was used in a split-plot arrangement and three replicated. Plant biostimulants assigned to the main plots. Harvesting dates were assigned to sub-plots measuring 10.5 m2 (3.5 × 3m) with 6 ridges (50 cm apart) and a ridge length of 3.5 m.

Plant biostimulants treatment:

Five biostimulants treatments consists of i.e., (a1=control, a2= Vinasse, a3= Spirulina, a4= Chlorella, a5= Spirulina + Chlorella). We added three equal doses every 15 days after thinning. Harvest dates consists of i.e., (b1= optimum date at 120 days, b2= before 15 days of optimum date at 105 days).

The sowing dates for the first and second seasons were May 1st and 11th, respectively. The ideal harvesting date (120 days) was on 1st and 10th of September in both seasons, consequently. Seeds for the sesame cultivar Shandaweel-3 were obtained from the Oil Crops Research Department, Field Crop Research Institute, ARC, Giza, Egypt. To prevent rot infection, these seeds were treated with Rizolex-T (3 g/kg seeds) prior to planting.

Storage conditions:

Sesame seeds were obtained after harvesting for each biostimulate treatment divided into two main parts according to the harvest date. Damaged and spoiled seeds were discarded, each main part was divided into three equal parts according to the storage period. All measurements and laboratory tests were performed on the first part (zero age storage) as the control treatment. Samples were stored in moisture-proof aluminium foil bags with tightly sealing after evacuating the air according to **Alaa Shahein and Amany Mohamed (2016) and Raleng et al., (2014)** under normal storage conditions in Seed Technology Research Unit until the date of preparation for laboratory measurements and tests after (6 and 18 months).

The recorded data:

At harvest, samples of ten guarded plants were randomly selected from inner ridges in each sub plot to estimate the following traits: 1. Plant height 2. Number of branches per plant 3. Number of leaves per plant 4. The first capsule's height 5. Number of capsules per plant 6. Biological yield (tonne/fed.) 7. Seed yield per plant (g) 8. Seed yield (ardab/fed) 9. Standard germination percentage: The International Seed Testing Association (**ISTA 1999**) defined germination percentage as the percentage of normal seedlings at the end of the testing period. Three replicates were used for germination at 25°C for 8 days. Normal seedlings were counted and expressed as germination percentages at the final count. Ten normal seedlings from each replicate were taken to measure seedling length and seedling dry weight in accordance with (**Krishnasamy and Seshu 1990**) 10. Seedling length 11. Electrical

Fig.1. Photos of plant biostimulants materials used in the experiment

conductivity: EC (μscm^{-1}/g). 50 seeds were weighted and soaked in 250 ml of deionized water at 25°C for 24 hours was estimated according to (**ISTA 1999**) 12. Thousand-seed weight (g) 13. Protein content was determined using micro Kjeldahl, according to **(Jackson 1976**) 14. The oil of sesame seeds was determined according to (**AOAC 1990**) using the Soxhlet apparatus and petrolium ether as the solvent 15. Peroxidase value and 16. Acidity.

Statistical analysis:

Data from each sesame seed experiment were statistically analysed using the Statistix-8 computer software programme in accordance with the analysis of variance (ANOVA) approach for a Randomised Complete Block Design (RCBD), in the split plot design as described by **(Gomez and Gomez 1984)**. To compare the treatment means, use a 5% probability.

Results

Plant biostimulants:

Plant biostimulants have recently been proposed as a means of achieving long-term crop production. The results in Table 2 showed that foliar application of plant biostimulants had a significant effect on plant height, number of branches/plant, number of leaves/plant, and height of the first capsules. Harvesting date in optimum date recorded the highest values of traits comparing with early harvesting date. In light of the results in Table (2) the optimum harvest date recorded the highest values of studied traits; plant height, number of branches/plant, number of leaves per plant and height of first capsules. Conversely, early harvest recorded the lowest values. The highest plant (98.7 and 102.26), number of branches/plant (2.55 and 2.70), number of leaves/plant (86.13 and 80.27), and height of first capsules (30.40 and 30.51) in both seasons.

Spirulina+chlorella had the highest value for this trait, followed by Spirulina (2%), Chlorella (2%), and Vinasse (2%). When using a combined foliar application of spirulina and chlorella, the tallest plant height (113.67 and 106.17 cm), the highest number of branches/plant (3.44 and 3.63), and the highest number of leaves/plant (106.33 and 97.00) were achieved. The height of the first capsules (44.67 and 45.28) was achieved with the control treatment. In order to fully implement a circular economy strategy, modern agriculture must be revaluated and expanded its business models and practices. To accomplish this, it must incorporate opportunities from a variety of adjacent sectors and value chains, including the bio-based industry. The information gathered and presented in Table (3) showed that the best harvesting date ever observed highest number of capsules/p (151.33 and 146.36), seed yield/plant (g) (20.33 and 2024), biological yield/fed.(ton) (2.66 and 2.91) and seed yield/fed (ardab) (4.78 and 4.62).

Table (3) shows that biostimulants had a significant effect on the number of capsules per plant, seed yield/plant (g), biological yield/fed. (tonne), and seed yield/fed (ardab). Spirulina+chlorella had the highest values followed by 2% spirulina, 2% chlorella, and 2% vinasse. The highest number of capsules plant (196.33 and 201.73), Seed yield/plant gave (28.23 and 28.23), biological yield obtained (4.17and4.42), seed yield/fed (ardab) recorded (6.47 and 6.82) recorded when using combined spirulina+chlorella followed by spirulina 2%, chlorella 2% and vinasse 2%.

TABLE 2. Plant height, number of branches per plant, number of leaves per plant, and height of first capsules as affected by foliar spray with biostimulants, harvest dates, and their interactions during the 2020 and 2021

Treatments	Plant height (cm)		Branches/plant		Leaves/plant		First capsules height (cm)	
	2020	2021	2020	2021	2020	2021	2020	2021
A.Plant biostimulants								
Control	73.33	75.78	1.57	1.60	47.83	35.67	44.67	45.28
Vinasse 2%	90.83	96.18	1.77	1.88	62.50	68.67	31.17	37.12
Spirulina 2%	104.17	101.89	2.56	2.44	85.67	84.50	27.50	32.40
Chlorella 2%	94.83	99.73	2.53	2.80	95.17	79.50	23.00	25.12
Spirulina+ Chlorella	113.67	106.17	3.44	3.63	106.33	97.00	21.17	21.26
F test	**	ns	*	*	ns	**	**	**
LSD 0.05	11.99	-	1.16	1.04	-	16.98	5.72	5.39
B Harvest dates								
1. (120 days)	98.07	102.26	2.55	2.70	86.13	80.27	30.40	30.51
2. (105 days)	92.67	89.63	2.20	2.24	72.87	65.87	28.60	33.97
F test	ns	ns	*	*	ns	**	ns	ns
LSD 0.05	-	-	0.35	0.40	-	7.65	-	-
AXB	**	**	**	**	**	**	**	**

ns-not significant **. significant at 0.05 level of probability.

TABLE 3. Number of capsules/p, seed yield/plant (g), biological yield/fed (tonne), and seed yield/fed (ardab) as affected by foliar spray with biostimulants, harvest dates, and their interactions during 2020 and 2021

Treatments	Capsules/plant		Seed yield/plant (g)		Biological yield/ fed.(ton)		Seed yield/fed, (ardab)	
	2020	2021	2020	2021	2021	2021	2020	2021
A.Plant biostimulants								
Control	79.67	77.96	11.48	10.32	1.32	1.57	3.04	2.96
Vinasse 2%	98.67	115.61	15.25	15.28	1.59	1.84	3.79	3.75
Spirulina 2%	139.17	129.18	17.33	17.43	2.67	2.85	3.99	4.06
Chlorella 2%	147.00	164.43	23.71	23.36	2.88	3.13	4.91	4.82
Spirulina+corella	196.33	201.73	28.23	28.23	4.17	4.42	6.47	6.82
F test	*	**	**	**	**	**	**	**
LSD 0.05	47.15	46.15	4.05	3.17	0.79	0.74	0.83	0.73
B.Harvest dates								
1. (120 days)	151.33	146.36	20.33	20.24	2.66	2.91	4.78	4.62
2. (105 days)	113.00	129.20	18.06	17.60	2.39	2.61	4.10	4.34
F test	**	**	**	**	**	**	**	ns
LSD 0.05	23.22	11.54	0.57	1.14	0.09	0.12	0.38	-

ns-not significant **. significant at 0.05 level of probability.

Influence of plant biostimulants, harvest date, and storage time on seed quality

Table (4) exhibits that the addition of biostimulants as foliar spray resulted in pronounced responses in germination percentage, seedling length, seedling dry weight, and seedling vigour index when compared to the control. Long storage conditions reduce seed quality due to the length of the storage period. It is the cause of the declining germination parameters.

Table (4) shows that 18 months of storage resulted in the lowest values for germination percentage, seedling length, seedling dry weight, and seedling vigour index when compared to other periods. Which, combined spirulina+chlorella recorded highest germination percentage (97.1 and 97.4), seedling length (14.11 and 17.82), seedling dry weight (0.064 and 0.065) and seedling vigor index (1373 and 1152) in both seasons.

The data in Table (4) showed that the early harvest date recorded the highest seed quality regarding germination percentage (94.4 and 94.9), seedling length (11.94 and 11.82), seedlings dry weight (0.054 and 0.055) and seedling vigor index (1247 and 1096).

Table (5) displays the parameters related to seed quality that are impacted by the foliar spraying of vinasse, spirulina, and chlorella either separately or in combination. Thousand seed weight, electrical conductivity, relative density and moisture percentage as affected by biostimulants, harvest date and storage periods during 2020 and 2021. Data in Table (5) indicated 1000 seedling dry weight, electrical conductivity, relative density and moisture percentage as affected by harvesting date during 2020 and 2021. Combined Spirulina+chlorella achieved highest thousands seed weight (4.65 and 4.65), E.C µ-mhos (23.49

TABLE 4. The foliar spray application of plant biostimulants on seedling vigour in sesame plants in 2020 and 2021.

Treatments	**Germination percentage**		**Seedling length (cm)**		**Seedlings dry weight (g)**		**Seedlings vigor index**	
	2020	**2021**	**2020**	**2021**	**2020**	**2021**	**2020**	**2021**
A.Biostimulants								
Control	80.8	82.1	11.38	11.38	0.036	0.038	934	938
Vinasse 2%	94.2	94.8	11.62	11.57	0.050	0.086	1100	1064
Spirulina 2%	96.2	96.8	12.16	12.1	0.050	0.052	1184	1089
Chlorella 2%	94.5	94.6	13.36	13.26	0.056	0.056	1271	1078
Spirulina+corella	97.1	97.4	14.11	17.82	0.064	0.065	1373	1152
F test	**	**	**	*	**	ns	**	**
LSD 0.05	1.16	1.02	0.297	4.75	2.375	-	35.5	4.904
B.Harvest dates								
1. (120 days)	90.8	91.4	11.94	11.82	0.048	0.029	1097	1032
2. (105 days)	94.4	94.9	13.11	14.63	0.054	0.055	1247	1096
F test	**	**	**	ns	**	ns	**	**
LSD 0.05	0.73	0.65	0.188	-	1.502	-	22.46	3.10
C.Storage periods								
0 months	97.9	97.7	13.83	16.06	0.076	0.098	1358	1138
6 months	96.0	96.3	12.48	12.44	0.042	0.043	1200	1087
18 months	83.8	85.5	11.27	11.17	0.037	0.038	959	966
F test	**	**	**	*	**	**	**	**
LSD 0.05	0.90	0.79	0.230	3.68	1.840	0.036	27.5	3.798
Interactions								
AxB	**	**	**	ns	**	ns	**	ns
AxC	**	**	**	ns	ns	ns	**	ns
BxC	**	**	**	ns	**	ns	**	ns
AxBXC	ns	ns	ns	ns	ns	ns	ns	ns

ns-not significant **. significant at 0.05 level of probability.

and 23.50), relative density (g/mm3) (2.32 and 2.33) and moisture percentage (4.143 and 4.129) compared with the control treatment.

Seed oil content is one of the significant economic values for sesame seeds. Protein and oil percentage were significantly impacted by biostimulants, as indicated by the data presented in Table 6.

Foliar application of spirulina+chlorella improves the quality of protein and oil percentage while, peroxidase value and acidity as affected by biostimulants, harvest date and storage periods during 2020 and 2021.

Table (6) shows that the Spirulina+corella treatment resulted in a significant increase in protein content and seed oil percentage when compared to the control, followed by Chlorella 2%, Spirulina, and vinasse. Table (6) shows that early harvest improved seed protein percentage, seed oil percentage, peroxidase value, and acidity,

TABLE 5. Thousand seed weight, electrical conductivity, relative density and moisture percentage as affected by biostimulants, harvest date and storage periods during 2020 and 2021

Treatments	Thousand seed weight (gm)		E.C µ-mhos		Relative density (g/mm3)		Moisture (%)	
	2020	2021	2020	2021	2020	2021	2020	2021
A.Biostimulants								
Control	4.36	4.37	24.02	24.02	2.17	2.18	4.431	4.439
Vinasse 2%	4.52	4.54	23.61	24.65	2.21	2.25	4.353	4.346
Spirulina 2%	4.32	4.37	23.73	23.76	2.25	2.26	4.286	4.275
Chlorella 2%	4.55	4.57	23.83	23.83	2.28	2.29	4.208	4.221
Spirulina+corella	4.65	4.65	23.49	23.50	2.32	2.33	4.143	4.129
F test	**	**	**	Ns	**	**	**	**
LSD 0.05	0.08	0.068	0.093	-	0.015	0.035	0.019	0.028
B.Harvest dates								
120 days	4.41	4.44	24.11	24.54	2.30	2.328	4.335	4.331
105 days	4.56	4.56	23.36	23.36	2.19	2.204	4.233	4.233
F test	**	**	**	**	**	**	**	**
LSD 0.05	0.05	0.04	0.059	0.802	9.77	0.022	0.012	0.017
C.Storage periods								
0 months	4.58	4.59	22.68	22.70	2.369	2.384	4.311	4.308
6 months	4.52	4.53	23.75	24.36	2.234	2.246	4.307	4.307
18 months	4.34	4.38	24.79	24.79	2.145	2.169	4.234	4.231
F test	**	**	**	**	**	**	**	**
LSD 0.05	0.06	0.05	0.072	0.982	0.012	0.027	0.015	0.021
Interactions								
AxB	ns	ns	*	ns	ns	ns	**	**
AxC	**	**	ns	ns	**	ns	ns	*
BxC	ns	ns	ns	ns	**	ns	*	**
AxBXC	ns	ns	ns	ns	ns	ns	*	ns

ns-not significant **. significant at 0.05 level of probability.

TABLE 6. Protein percentage, oil percentage, peroxidase value and acidity as affected by biostimulants, harvest date and storage periods during 2020 and 2021

Treatments	Seed protein%		Seed oil %		Peroxidase value		Acidity	
	2020	2021	2020	2021	2020	2021	2020	2021
A.Plant biostimulants								
Control	22.41	22.42	51.39	51.42	8.445	8.460	13.86	13.98
Vinasse 2%	22.63	22.66	52.37	52.57	8.254	8.298	12.79	12.79
Spirulina 2%	22.85	22.88	52.87	52.90	8.068	8.066	11.96	12.00
Chlorella 2%	22.85	22.87	52.95	52.99	7.826	7.856	11.46	11.57
Spirulina+Corella	23.09	23.14	53.22	53.24	7.665	7.359	10.38	10.47
F test	**	ns	**	**	**	**	**	**
LSD 0.05	0.155	-	0.166	0.337	0.064	0.308	0.297	0.286
B.Harvest dates								
120 days	21.58	21.61	51.47	51.58	8.497	8.456	13.58	13.64
105 days	23.96	21.85	53.65	53.66	7.606	7.560	10.602	10.69
F test	**	ns	**	**	**	**	**	**
LSD 0.05	0.098	-	0.105	0.213	0.041	0.194	0.188	0.1801
C.Storage periods								
0 months	24.07	24.11	54.13	54.14	7.278	7.209	9.80	9.828
6 months	22.99	23.01	52.75	52.90	8.281	8.202	12.24	12.30
18 months	21.24	93.08	50.80	50.83	8.595	8.613	14.24	14.37
F test	**	ns	**	**	**	**	**	**
LSD 0.05	0.120	-	0.129	0.261	0.050	0.238	0.231	0.221
Interactions								
AxB	*	ns	**	ns	**	ns	ns	ns
AxC	**	ns	**	**	**	**	**	**
BxC	ns	ns	**	**	**	ns	**	**
AxBXC	ns	ns	**	**	**	*	**	**

ns-not significant **. significant at 0.05 level of probability.

with seed protein percentage recorded (23.96 and 21.85), seed oil percentage given (53.65 and 53.66), peroxidase value (7.606 and 7.560), and low acidity (10.602 and 10.69) when compared to optimum harvest.

Interactions:

Respecting to the interaction effects between biostimulants, and harvest dates data in Table (7) showed Spirulina + Chlorella recorded the highest plant height (124 and 128 cm), highest No. branches/p (3.72 and 3.84), while, Chlorella 2% recorded the highest number of leaves/plant (131.67 and 87.67). Vinasse 2% recorded the highest values of first capsules highest.

Table (8) shows the results of the interaction between foliar spray and plant biostimulants application and harvest dates for the following traits for sesame plants during the 2020 and 2021 seasons: number of capsules/p, seed yield/plant (g), biological yield/fed. (tonne), and seed yield/fed (ardab). The results show that the combined treatment of Spirulina+corella at the optimal harvesting date gave the highest values of number of capsules/p (206.67 and 212.12), seed yield/plant (29.83 and 29.32), biological yield/fed. (4.42 and 4.67) and seed yield/fed (7.25 and 6.92 ardab) compared to other treats.

TABLE 7. Plant height, number of branches per plant, number of leaves per plant, and height of first capsules as affected by foliar spray interactions with biostimulants, and harvest dates for sesame plants during the 2020 and 2021 seasons

Treatments 2020		Plant height		branches/plant		No. leaves /p		Height the first capsules (cm)	
		2021	2020	2021	2020	2021	2020	2021	
Control	120 days	68.33	76.30	1.67	1.75	53.67	43.00	48.00	47.72
	105 days	78.33	75.27	1.47	1.45	42.00	28.33	41.33	42.85
Vinasse 2%	120 days	98.00	101.68	1.88	1.97	54.33	60.00	33.00	35.85
	105 days	83.67	90.67	1.67	1.80	70.67	77.33	29.33	38.38
Spirulina 2%	120 days	106.00	105.00	2.92	3.08	87.33	99.33	25.33	25.42
	105 days	102.33	98.78	2.20	1.80	84.00	69.67	29.67	39.38
Chlorella 2%	120 days	94.00	100.25	2.55	2.85	131.67	87.67	23.33	23.08
	105 days	95.67	99.20	2.51	2.75	81.00	71.33	22.67	27.17
Spirulina+ Chlorella	120 days	124.00	128.08	3.72	3.84	103.67	111.33	22.33	20.47
	105 days	103.33	84.25	3.16	3.42	86.67	82.67	20.00	22.05
F. test		ns	ns	ns	ns	ns	**	ns	*
LSD. 0.05		-	-	-	-	-	19.45	-	7.35

ns-not significant **. significant at 0.05 level of probability.

TABLE 8. Number of capsules per plant, seed yield/plant, biological yield/fed, and seed yield/fed as affected by interactions of foliar spray with biostimulants, and harvest dates for sesame plant during 2020 and 2021 seasons

Treatments 2020		No. capsules/plant		Seed yield/plant		Biological yield/ fed.(ton)		Seed yield/fed, (ardab)	
		2021	2020	2021	2021	2021	2020	2021	
Control	120 days	81.67	79.00	12.17	11.13	1.37	1.62	3.21	3.20
	105 days	77.67	76.92	10.80	9.50	1.27	1.52	2.87	2.72
Vinasse 2%	120 days	122.33	122.00	16.33	15.90	1.67	1.92	4.17	3.84
	105 days	75.00	109.22	14.17	14.65	1.52	1.77	3.42	3.65
Spirulina 2%	120 days	168.00	148.52	18.17	20.63	2.85	3.10	4.07	4.25
	105 days	110.33	109.83	16.48	14.22	2.50	2.60	3.92	3.87
Chlorella 2%	120 days	178.00	170.18	25.17	24.22	3.02	3.27	5.20	4.90
	105 days	116.00	158.68	22.25	22.50	2.75	3.00	4.62	4.73
Spirulina+Chlorella	120 days	206.67	212.12	29.83	29.32	4.42	4.67	7.25	6.92
	105 days	186.00	191.35	26.62	27.15	3.93	4.18	5.69	6.72
F test		ns	ns	ns	*	ns	ns	ns	ns
LSD 0.05		-	-	-	3.44	-	-	-	-

ns-not significant **. significant at 0.05 level of probability. Ardab 120 Kg

Discussions:

Seed quality are vital input in crop production. It is commonly known that, in their natural growing environments, crop plants are frequently impacted by a wide variety of stresses. In this study, we sprayed 2 percent of vinasse along with two different types of algae, namely chlorella and spirulina, on the sesame plants. Every field data was taken, and the harvest was completed on two separate dates. The seeds derived from the harvest dates were kept in storage for a period of 0, 6, 18 months, during which time laboratory measurements were taken. (**Dima et al., 2020**) demonstrated that the plant biostimulants effect of vinasse through foliar application is characterised by a high concentration of glycine betaine, typically between 15 and 20%. In line with these results, our findings showed that biostimulants significantly increase plant growth parameters, with respect to the previously observed seed quality differences at the storage and germinating stages. (**Rashed & Hammad, 2023**) found that using vinasse at an optimal dose outperformed other treatments in terms of bulk density, soil porosity, electrical conductivity, cation exchange capacity, N content, and protein in seeds. (**Seadh et al., 2023**) reported that it is possible to improve the germination characteristics of old and new harvested sesame seeds by using some natural and chemical substances. According to (**Hoarau et al., 2018**), vinasse is produced in large quantities around the world using a variety of feedstocks, primarily corn and sugarcane. Chlorella vulgaris may increase crop yield and growth by improving soil aeration and moisture-holding capacity. In agreement with our findings, several authors have reported an increase in yield parameters and seed quality (**Gonçalves et al. 2023**). These findings indicate that replacing chemical biostimulants with Chlorella vulgaris can boost agricultural productivity while lowering environmental impact (**Ru 2020**). Seed germination and vigour are important indicators of quality that are significantly reduced during storage. Some parameters that indicate seed ageing and an improper storage environment include delayed germination and emergence, slow growth, and an increase in susceptibility to environmental stresses during various storage periods. (**Lima et al., 2014**) described the physiological properties of sesame seeds during storage and found that seeds can be kept viable for up to 12 months in a dry cold room. Seeds can be viable for up to six months in their natural environment. (**Gebeyehu, 2020**) stated that storage is a fundamental practice in the control of the physiological quality of the seed and is a method for preserving the viability of the seeds and keeping their vigour at a reasonable level during the time between planting and harvesting. Seed deterioration begins immediately after the crop reaches physiological maturity. Overall, our findings showed that several methods are being used to prevent quantitative and qualitative losses caused by a variety of biotic and abiotic factors during storage, including seed treatment with appropriate chemicals or plant products and seed storage in a safe environment. Damage to the cell membrane and other conditions cause changes in the seed system, such as protein and nucleic acid accumulation (**Zhang 2021**). The negative effects of storage periods are also evident in the seed quality stage, with a significant decrease in quality parameters, resulting in seed death and loss of viability represents the inhibitory effect of storage on germination and seedling growth. It also depicts the harvest dates and biostimulants differences discussed in this study. As a result, it is critical to use seeds quickly rather than storing them for an extended period of time, and to control the seed storage environment. Vinasse was also investigated in laboratories for use as a fertiliser. Overall, data from this study show that the biostimulants Spirulina+ Chlorella, Vinasse, Spirulina, and Chlorella can be recommended as promising biostimulants because they are a safe way to significantly improve seed performance, improve oil quality, and reduce the consumption of chemical fertilisers for sustainable agriculture systems.

Conclusions

According to the findings, plant biostimulants have been shown to improve seed germination, seedling vigour and abiotic stress tolerance. Thus, treating seeds and seedlings with plant biostimulants is a promising and long-term approach to increasing crop productivity. Biostimulants improved growth parameters such as germination percentage, seedling length, EC, protein percentage, 1000-seed weight (g), and seed yield (ardab/fed). Results also revealed that applying vinasse, chlorella, and spirulina as a foliar spray at a rate of 2% gave the best values in sesame seeds quality i.e. seed protein, and seed oil content. In combination treatment, the highest values were achieved by using 2% of spirulina+corella.

Future Perspectives:

Because of Egypt's severe edible oil deficit, more research into increasing sesame production through improved seed germination and seedling characteristics using both natural and chemical materials is required. To achieve the goal of plant biostimulants research, it is critical to work with farmers and businesses to test these substances in commercial plantations and observe how they affect overall yield. Furthermore, it is known that biostimulants regulate genetic, physiological, and biochemical changes that lead to adaptive responses. More research is needed because the precise signalling transduction pathway of biostimulants, as well as their interactions with phytohormones and other signalling molecules, are poorly understood. Biostimulants, harvest dates, and storage times have a significant impact on seed germination and quality.

*Conflict of Interest***:** The authors declare no conflict of interest.

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تأثير محفزات النبات الحيوية ومواعيد الحصاد ومدة التخزين على نمو ومحصول وجودة تقاوى السمسم في الأراضي حديثة الاستزراع

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يعد استخدام محفزات النبات الحيوية أحد أكثر الطرق الحديثة فعالية في تعزيز النمو وزيادة إنتاجية المحاصيل إعتمادا علي إجراء تعديلات في العمليات الفسيولوجية للبذور،حيث يمكن للمحفزات الحيوية تمديد مدة تخزين البذور وتحسين الإنبات وصفات البادرة. أجريت هذه الدراسة خلال الموسمين الصيفيين (٢٠٢٠ - ٢٠٢١) في مزرعة مركز البحوث والتجارب الزراعية بجامعة المنيا بشوشة مركز سمالوط بتصميم قطاعات كاملة العشوائية في ثلاثة مكررات في تصميم القطع المنشقة وتم رش النباتات بنوعين من مستخلص الطحالب وهي الاسبيرولينا والكلوريلا بالاضافة الي الفيناس وتم الحصاد ميعادين مختلفين وتم اخذ جميع القراءات الحقلية لكل موعد حصاد. تم تخزين البذور الناتجة من مواعيد الحصاد لمدة (٠،١٨،٦) شهر وتم اجراء القياسات المعملية لفترات التخزين وهي: (النسبة المئوية للانبات القياسي – طول البادرة - الوزن الجاف للبادرة - دليل قوة البادرة - وزن الألف بذرة – التوصيل الكهربي للبذور - الوزن النوعي للبذور - النسبة المئوية لرطوبة البذور - النسبة المئوية للبروتين في البذور - النسبة المئوية للزيت – رقم البيروكسيديز للزيت- رقم الحامض للزيت .) هدفت هذه الدراسة إلى تقييم فعالية مواعيد الحصاد وفترات التخزين تحت تأثير المنشطات الحيوية المختلفة. للوصول إلى أفضل مدة تخزين لصنف السمسم ''شنداويل ٣'' بهدف التوسع في زراعة السمسم في الأراضي المستصلحة حديثاً. أظهرت النتائج تفوق المعاملة بمخلوط مستخلص السبيرولينا مع مستخلص الكلوريلا في معظم الصفات المدروسة وهي ارتفاع النبات، عدد الأفرع/نبات، عدد الأوراق/نبات، ارتفاع الكبسولة الأولى، عدد الكبسولات/نبات، المحصول البيولوجي، محصول البذور/نبات، محصول البذور، نسبة الانبات القياسي، طول البادرات، التوصيل الكهربائي، وزن الألف بذرة، محتوى البروتين، ٪ لزيت بذور السمسم، قيمة رقم البيروكسيديز و رقم الحموضة لزيت السمسم متبوعا بالكوريلا ، السبيرولينا والفيناس منفردين. بالنسبة لموعد الحصاد فقد حقق الموعد الأمثل عند ١٢٠ يوم قيم معنوية لأغلب الصفات المدروسة مقارنة بالحصاد قبل الموعد الأمثل. أما لمدة التخزين البالغة (٠،١٨،٦) شهر على التوالي فقد سجلت أعلى القيم في إنبات وجودة بذور السمسم. حيث سجلت مدة التخزين ١٨ شهرا أقل قيم نسبة الإنبات وطول البادرات والوزن الجاف للبادرة ودليل قوة البادرات مقارنة بالمدد الأخرى. مع مراعاة تأثيرات التفاعل بين المحفزات الحيوية ومواعيد الحصاد سجلت Spirulina+ Chlorella أعلى ارتفاع للنبات وأعلى عدد فروع، بينما سجلت معاملة الكوريلا ٢٪ منفردة أعلى قيمه لعدد أوراق/نبات. سجلت سبيرولينا ٢٪ أعلى قيم من الكبسولات الأولى. أعطى استخدام سبيرولينا + كوريلا في الموعد الأمثل للحصاد أعلى القيم لعدد الكبسولات ، محصول البذور/النبات، والمحصول البيولوجي/ فدان. وإنتاجية البذور/الفدان مقارنة بالمعاملات الأخرى. وعلى ما سبق ، يمكن التوصية باستخدام مستخلص سبيرولينا مع مستخلص كلوريلا و الفيناس كمحفزات حيوية واعدة لأنها تعزز بشكل كبير أداء البذور، وتحسن جودة الزيت، وتقلل من استهلاك الأسمدة الكيماوية للزراعة المستدامة.

الكلمات الدالة: السمسم، المحفزات الحيويه، فيناس، اسبيرولينا، كوريلا، مواعيد الحصاد، فترات التخزين، جودة التقاوي