Scientific Journal of Agricultural Sciences

Print (ISSN 2535-1796) / Online (ISSN 2535-180X)

Effect of Spraying With Some Materials to Reduce Climate Change on The Productivity and Quality of Garlic Plants

Fawzy Y.O. Mansour[1], Hamada M.B. El- Metwaly[1] and Enas A. Bardisi[2]

[1]Veg. Res. Dep., Hort. Res. Inst., Agric. Res. Center, Giza, Egypt.
[2]Hort. Dept. Fac. Agric. Zagazig University, Egypt.

Citation: Fawzy Y.O. Mansour, Hamada M.B. El-Metwaly and Enas A. Bardisi (2024). Effect of Spraying With Some Materials to Reduce Climate Change on The Productivity and Quality of Garlic Plants. Scientific Journal of Agricultural Sciences, 6 (3): 15-33. https://doi.org/10.21608/sjas.2024.304523.1442.

Publisher :
Beni-Suef University, Faculty of Agriculture

Received: 15 / 7 / 2024
Accepted: 31 / 8 / 2024

Corresponding author:
Bardisi, Enas

Email:
enasbardisi@gmail.com

ABSTRACT

At a private farm in the village of Meet Faris, Dekarns, Dakahlia Governorate, Egypt, a field experiment was conducted over the course of two consecutive winter seasons in 2021/2022 and 2022/2023 to investigate the effects of various materials (brassinolide, proline amino acid and melatonin) applied as a foliar spray under two planting dates (15th September and 15th October) on growth, productivity, and storability of garlic cv. Sids 40 using a drip irrigation system in clay soil.

Garlic planting on 15th October and spraying with brassinolide at 5 ppm increased the number of leaves/ plant, total dry weight/plant, total yield/ fed. at harvesting and after curing, bulb diameter, number of cloves/ bulb, average clove weight after curing, N, P and K contents in bulbs at harvesting, whereas the percentage of weight loss in bulbs decreased during storage periods. While, planting on 15th September and spraying with melatonin at 30 ppm increased total soluble solids (TSS), dry matter (DM) and pungency after curing as well as reduced weight loss (%) in bulbs after six month from storage periods.

KEYWORDS: Garlic, planting date, melatonin, proline amino acid, brassinolide, yield and storability

1. INTRODUCTION

Allium sativum, L., or garlic, is one of the earliest vegetables to be produced. Its therapeutic benefits have been demonstrated for millennia. Garlic cloves are the part of the plant that can be eaten. Garlic has a variety of enzymes, amino acids, trace minerals, and antibiotics such as allistatin and garlicin. It can be eaten on its own or added to dishes to enhance flavour. Moreover, it goes into making items with smoked meat and several medications. These days Malý *et al.* (1998) appreciate it for the essential oils it contains.

It is known that garlic is a crop that is light- and temperature-sensitive (Jones and Mann, 1963). The growing environment, which includes cool weather and well-drained soils, has a major influence on its vegetative growth and bulb formation (Rahim and Fordham, 1988). Furthermore, when garlic plants are planted determines their performance since bulb development benefits from long days and

warm temperatures, while vegetative growth is encouraged by short days and low temperatures (Subrata *et al*. 2010).

There were significant differences between planting date regarding plant growth, yield and bulb quality (Ali, 2009; Abdalla *et al*., 2011; El-Zohiri and Farag, 2014; Youssef and Tony, 2014; Hassan *et al*., 2016; El-Shabasi *et al*., 2018; Mohammad, 2018; Ibrahim *et al*., 2020 and Sultana *et al*., 2022). Heat stress causes the membrane's flexibility to be disrupted, which lowers photosynthesis, growth, and yield. In order to counteract heat stress, exogenous melatonin administration lowers oxidative damage and increases heat shock factors (Iqbal *et al*., 2021).

As found in pollen, seeds, leaves, stems, roots, and flowers of other plants, Brassinolide, a growth regulator also known as a raw fatty extract extracted from *Brassica nupus*, is also present in plants in their unprocessed form or in combination with sugars or fatty acids. About 70 steroid compounds were also extracted from plants. In this connection , spraying with brassinolide enhances yield and quality of some vegetable crops (El-Bassiony *et al*., 2012 on snap bean, Hayat *et al*., 2012 on tomato, Serna *et al*., 2012 on lettuce, Susila *et al*., 2012 on watermelon, Aiman *et al*., 2014 on tomato, Sheshglani and Asghari, 2020 on strawberry, Yadav *et al*., 2022 on cucumber).

Proline is essential to the physiological responses of many plant species to stress because it can accumulate in the cytosol without endangering cellular structures. Proline can preserve membrane integrity and boost protein stability because of its ability to generate hydrogen bonds. Proline can also improve a cell's ability to absorb water and activate enzymes, which helps shield cells. Hosseinifard *et al*., (2022) state that proline is an osmolyte that possesses strong antioxidant, metal chelating, protein stabilising, ROS scavenger, and programmed cell death inhibitory properties. When applied externally, proline can improve photosynthetic and transpiration rates, stomatal conductance, antioxidants, and the ability of the plant to remain turgid under stress. It can also shield plants from harmful radiation. Even in the presence of abiotic stresses, all of these advantages aid in the growth and increased output of plants. However, overusing proline may have negative effects on plants. (Ilyas *et al*., 2020).

Application of proline amino acid to plants significantly increased growth and yield (Kaya *et al*., 2007 on muskmelon, El-Sherbeny and Da Silva, 2013 on beetroot, Jamil *et al*., 2018 on red pepper, Orsini *et al*., 2018 on lettuce, and Awad-Allah *et al*., 2020 on garlic). First identified in 1995, melatonin (N-acetyl-5-methoxytryptamine) is a widely distributed and extremely conserved chemical across species. Melatonin has been proposed as a natural bio-stimulant for a sustainable and eco-friendly agriculture (Huang *et al*., 2022). Melatonin helps many physiological systems, including stomatal conductance, photosynthesis, root dynamics, absorption of carbohydrates, and water relations, to withstand abiotic pressures. Melatonin treatment also improves respiration, ROS scavenging, and antioxidant enzyme activities, which collectively reduce oxidative damage to lipids, proteins, and nucleic acids (Moustafa *et al*., 2020).

In this regard, spraying with melatonin significant enhanced the growth, yield, and quality of some vegetable crops (Wang *et al*., 2016 on cucumber, Hanci and Bingo, 2020 on garlic, Ibrahim *et al*., 2020 on tomato, Zahedi *et al*., 2020 on strawberry, Yakupoglu, 2020 on bean, Yagmur and Hanci, 2021 on onion, Brengi *et al*., 2022 on cucumber, El-Yazied *et al*., 2022 on potato, Khosravi *et al*., 2023 on hot pepper and Abdel-Razik *et al*., 2024 on potato).

The goal of this work is to determine the most appropriate planting time with the best spraying material in order to confront climate change and obtain the high yield with a best storability of garlic.

2. MATERIALS AND METHODS

A field experiment was carried out during the two successive winter seasons of 2021/2022 and 2022/2023 at a private farm in the village of Meet Faris, Dekarns, Dakahlia Governorate, Egypt to study the effect of some materials (brassinolide, proline amino acid and melatonin) as foliar spray under two planting dates on growth, yield and its

components and storability of garlic cv. Sids 40 using a drip irrigation system in clay soil .

The experimental soil physical and chemical analyses and the meteorological data at Dakahlia Government during the experimental seasons are presented in Tables A and B, respectively.

Table A. The experimental soil's chemical and physical characteristics

Soil properties	2021/2022 season	2022/2023 season
Physical properties		
Sand (%)	21.20	17.29
Silt (%)	20.19	18.96
Clay (%)	58.61	60.75
O.M (%)	1.97	1.88
Chemical properties		
pH	7.69	7.66
Total N (%)	0.18	0.19
Available P_2O_5 (%)	0.030	0.039
Available K_2O (%)	0.65	0.67

Samples of the soil were obtained from 25 –cm soil surface.

Table B. Meteorological data at Dakahlia Governorate during the two growing seasons 2021/2022 and 2022/2023

Months	Temperature (ºC)		Relative humidity (%)	
	2021/2022 Season	2022/2023 Season	2021/2022 Season	2022/2023 Season
September	36.83	37.38	52.35	51.97
October	32.23	31.91	58.05	57.63
November	28.57	26.77	64.26	60.55
December	20.35	23.99	68.59	66.70
January 2022	17.58	21.43	68.17	69.46
February	18.92	19.95	68.03	69.08
March	21.78	26.75	61.32	53.47
April	32.19	31.76	48.38	48.82

These data were obtained from the Central Laboratory for Agricultural Climate (CLAC).

This experiment included eight treatments, which were the combinations between two planting dates (15th September and 15th October) and three materials as foliar application (brassinolide at 5 ppm, proline at 50 ppm, melatonin at 30 ppm, beside spraying with water as control).

Three replications of each of these treatments were placed in a split plot design. In the main plots, the planting dates were assigned at random, and in the sub plots, the spraying treatments were assigned at random.

12.0 m^2 made up the experimental unit area. There were four 5 m long and 60 cm wide dripper lines within. Three dripper lines were used to determine yield, and one dripper line was utilized to quantify vegetative growth in the samples.

A guard area 1.5 m in width was left between each two experimental units to avoid the overlapping infiltration of spraying treatments .

Sids 40 cultivar was used. Garlic cloves were selected for uniformity in shape and size. The cloves were sown on both sides of the dripper line at a distance of 10 cm apart.

Plants were sprayed with brassinolide, proline and melatonin five times at 60, 75, 90, 105 and 120 days after planting, using a manual atomizer. In the meantime, the untreated plants (control) received a single application of water.

Equal amounts of commercial fertilizers were given to each experimental unit, including potassium sulphate (48%-52% K_2O), ammonium sulphate (20.6% N), 50% P_2O_5 as orthophosphoric acid (8.5%), and 50% P_2O_5 as

calcium superphosphate (15.5% P_2O_5). The recommended doses of N, P, and K for these commercial fertilizers were added at 160, 60, and 100 kg/fed, respectively. When the soil in the middle of the row was being prepared, one-third of the ammonium and potassium sulphates, as well as 50% of P_2O_5 as calcium superphosphate were added. One month after planting, the remaining amounts of N, P and K fertilizers were added by irrigation water (fertigation) at intervals of seven days. The normal agricultural practices were carried out as commonly followed in the district.

2.1. Data recorded

2.1.1. Growth Parameters

In both study seasons, at 135 days following planting, one randomized sample of 10 plants each were selected from each plot to measure the growth characteristics of garlic plants, which were expressed as follows; plant height (cm) and number of leaves/ plant. In addition, the different parts of garlic plant, i.e., leaves and bulb were oven dried at 70 ºC till constant weight and then dry weight of leaves, bulb /plant and total dry weight / plant.

2.1.2. Yield and Its Components

Bulbs in each plot were harvested at the appropriate bulb maturity stage (15th April in both seasons) and weighed to determine the average bulb weight and total yield per feddan, then transferred to a shaded place on the same day for curing for approximately two weeks in a shaded place at a temperature of 25±5 °C and a relative humidity of 60-75%, then they were weighed and converted to record total yield (tons/fed.). A random sample (10 bulbs) was taken from each treatment to determine average bulb weight, diameter, number of cloves/bulb, and clove weight.

Some Agro-meteorological indices: such as growing degree days (GDD) and heat use efficiency HUE according to (Nuttonson, 1995) were computed according the following equations:

Growing degree days (GDD) = $\Sigma\ [(T_{max} + T_{min}) / 2 - T_b]$, where T_b = Base temperature = 1.6 ºC

Heat use efficiency (HUE) = $\frac{\text{Yield of garlic (kg /fed.)}}{\text{GDD}}$

2.2. Bulb Quality at Harvesting Date

2.2.1. Nitrogen, phosphorus and potassium contents

A sample of 100 gm of bulbs in all plots after harvesting were oven dried at 70 ºC till constant weight and the following N, P and K were determined according to the methods described by According to A.O.A.C. (2000). Using a Carl Zeis refractometer set, the total soluble solids (TSS) in the bulb's bulk content was measured, and the percentage of dry matter was calculated. Pungency, or pyruvic acid, was measured in bulb tissues at the time of harvest, as reported by Schwimmer and Westen 1961.

2.2.2. Storability

Four kilograms of uniformly cured bulbs were placed in palm crates for each plot after curing (which began on 1st May), and the draped plant tops were disposed of. The bulbs were then kept at room temperature. The storage zero time was on 1st May and ended on 1st November in both seasons due to the storage being extended to the sex months. The average room temperature and relative humidity during storage months are presented in Table C.

Table C. The average room temperature and relative humidity during storage months

Months	Temperature (ºC)		Relative humidity (%)	
	1st Season	2nd Season	1st Season	2nd Season
May	30	30	61	58
June	30	28	59	57
July	32	32	61	62
August	31	32	60	59
September	29	29	59	64
October	25	24	64	63
November	22	21	66	68

2.2.3. Weight loss (%)

The cumulative weight loss percentage was computed by weighing the bulbs of each treatment at 30 days intervals.

2.3. Statistical Analysis:

Snedecor and Cochran (1980) provided the statistical analysis of variance for the recorded data and Duncan (1955) provided the means separation.

3. RESULTS AND DISCUSSION

3.1. Plant growth

3.1.1. Effect of planting date

Data in Tables 1 to 5 show that there were significant differences between two planting dates (15th September and 15th October) in height plant, leaves dry weight, bulb dry weight, and total dry weight / plant, but there were no significant differences between them in leaves number / plant in both seasons and leaves dry weight in the 1st season at 135 days after planting date. Planting on 15th September gave taller plants, whereas planting on 15th October gave higher leaves dry weight in 2nd season and bulb dry weight and total dry weight / plant in both seasons. The increases in total dry weight / plant were about 1.8 and 2.13 g for planting on 15th October over planting on 15th September in the 1st and 2nd seasons, respectively.

Garlic growth is significantly impacted by the planting of dates. According to Jones and Mann (1963), garlic is a crop that is sensitive to temperature and light, and the growing environment has a significant impact on both its vegetative growth and bulb production. (Rahim and Fordham, 1988).

These results agree with those reported by Ali (2009) and Abdalla *et al*. (2011) found that, the highest leaf area/plant and dry weight/plant were obtained with late planting date than those planted in early date of garlic.

3.1.2. Effect of some stimulants

Spraying garlic plants with brassinolide at 5 ppm, proline at 50 ppm and melatonin at 30 ppm increased plant height, leaves number / plant, leaves dry weight, bulb dry weight, and total dry weight / plant compared with spraying with control at 135 days after the planting date in both seasons (Tables 1 to 5). Brassinolide at 5 ppm gave the highest values of height plant, leaves number / plant, leaves dry weight, bulb dry weight and total dry weight / plant compared to the other treatments. The increases in total dry weight / plant were about 6.48 and 6.66 g for brassinolide at 5 ppm, 3.05 and 3.61 g for proline at 50 ppm, and 3.47 and 3.91 g for melatonin at 30 ppm over the control in the 1st and 2nd seasons, respectively.

A growth regulator called brassinolide, also called a raw fatty extract from *Brassica nupus*, has been found in pollen, seeds, leaves, stems, roots, and flowers of other plants. It can also be found in plants in their unprocessed form or combined with sugars or fatty acids. Approximately 70 steroid compounds have been extracted from plants. Results are harmony with El-Bassiony *et al*., 2012 on snap bean and Yadav *et al.*, 2022 on cucumber as for brassinolide effect, Awad-Allah *et al*., 2020 on garlic regarding proline effect and Yagmur and Hanci, 2021 on onion and El-Yazied *et al*., 2022 on potato.

3.1.3. Effect of the interaction

The combination between planting date and spraying with some stimulants had a significant effect on increased height plant, leaves number / plant, both leaves, bulb dry weight and total dry weight / plant at 135 days after planting date in both seasons (Tables 1 to 5). The combination between planting on 15th September and spraying with brassinolide at 5 ppm increased height plant, whereas the interaction between planting on 15th October and spraying with brassinolide at 5 ppm increased leaves number / plant, leaves dry weight, bulb dry weight and total dry weight / plant.

This means that the best treatments for enhancing plant growth of garlic (number of leaves/ plant, dry weight of leaves, dry weight of bulb, and total dry weight/ plant) was planting on 15th October and spraying with brassinolide at 5 ppm. These results agree with those reported by Susila *et al.*, (2012) on watermelon.

Table 1. Effect of planting date, spraying with some stimulants and the combination between them on height plant (cm) at 135 days after planting of garlic in both seasons

Planting date (PD)	Stimulants				Mean (PD)
	Spraying with water (control)	Brassinolide (5ppm)	Proline (50 ppm)	Melatonin (30 ppm)	
			2021/2022 season		
15th September	76.05 d	91.97 a	80.58 c	82.02 c	82.65 A
15th October	71.68 f	84.32 b	74.06 e	75.54 d	76.40 B
Mean (S)	73.86 D	88.14 A	77.32 C	78.78 B	
			2022/2023 season		
15th September	76.22 d	91.29 a	80.52 c	81.09 c	82.28 A
15th October	72.82 e	87.32 b	76.05 d	77.47 d	78.41 B
Mean (S)	74.52 C	89.30 A	78.28 B	79.28 B	

Duncan's multiple range test revealed that values with the same alphabetical letter(s) did not substantially differ at the 0.05 level of significance.

Table 2. Effect of planting date, spraying with some stimulants and the combination between them on leaves number / plant at 135 days after planting of garlic in both seasons

Planting date (PD)	Stimulants				Mean (PD)
	Spraying with water (control)	Brassinolide (5ppm)	Proline (50 ppm)	Melatonin (30 ppm)	
			2021/2022 season		
15th September	10.07 d	11.88 b	10.98 c	11.12 c	11.01 A
15th October	10.88 cd	12.87 a	11.34 bc	11.48 bc	11.64 A
Mean (S)	10.47 C	12.37 A	11.16 B	11.30 B	
			2022/2023 season		
15th September	10.59 cd	12.50 a	11.25 b	11.61 b	11.48 A
15th October	10.44 d	13.04 a	11.07 bc	11.53 b	11.52 A
Mean (S)	10.51 D	12.77 A	11.16 C	11.57 B	

Duncan's multiple range test revealed that values with the same alphabetical letter(s) did not substantially differ at the 0.05 level of significance.

Table 3. Effect of planting date, spraying with some stimulants and the combination between them on leaves dry weight (g) at 135 days after planting of garlic in both seasons

Planting date (PD)	Stimulants				Mean (PD)
	Spraying with water (control)	Brassinolide (5ppm)	Proline (50 ppm)	Melatonin (30 ppm)	
			2021/2022 season		
15th September	9.38 c	12.34 ab	10.56 c	10.48 c	10.69 A
15th October	9.88 c	13.04 a	10.94 bc	10.62 bc	11.12 A
Mean (S)	9.63 C	12.69 A	10.75 B	10.55 BC	
			2022/2023 season		
15th September	7.20 e	12.04 b	10.28 c	10.62 c	10.03 B
15th October	8.58 d	13.04 a	10.84 c	10.56 c	10.75 A
Mean (S)	7.89 C	12.54 A	10.56 B	10.59 B	

Duncan's multiple range test revealed that values with the same alphabetical letter(s) did not substantially differ at the 0.05 level of significance.

Table 4. Effect of planting date, spraying with some stimulants and the combination between them on bulb dry weight (g) at 135 days after planting of garlic plants in both seasons

Planting date (PD)	Stimulants				Mean (PD)
	Spraying with water (control)	Brassinolide (5ppm)	Proline (50 ppm)	Melatonin (30 ppm)	
			2021/2022 season		
15th September	7.00 d	10.06 b	8.50 c	9.60 b	8.79 B
15th October	8.00 cd	11.78 a	10.36 b	10.50 b	10.16 A
Mean (S)	7.50 C	10.92 A	9.43 B	10.05 B	
			2022/2023 season		
15th September	8.92 e	10.66 bcd	9.76 de	10.44 bcd	9.94 B
15th October	10.30 cd	12.58 a	11.35 b	11.20 bc	11.35 A
Mean (S)	9.61 C	11.62 A	10.55 B	10.82 B	

Duncan's multiple range test revealed that values with the same alphabetical letter(s) did not substantially differ at the 0.05 level of significance.

Table 5. Effect of planting date, spraying with some stimulants and the combination between them on total dry weight (g) at 135 days after planting of garlic plants in both seasons

Planting date (PD)	Stimulants				Mean (PD)
	Spraying with water (control)	Brassinolide (5ppm)	Proline (50 ppm)	Melatonin (30 ppm)	
			2021/2022 season		
15th September	16.38 f	22.40 b	19.06 de	20.08 cd	19.48 B
15th October	17.88 ef	24.82 a	21.30 bc	21.12 bc	21.28 A
Mean (S)	17.13 C	23.61 A	20.18 B	20.60 B	
			2022/2023 season		
15th September	16.12 e	22.70 b	20.04 cd	21.06 bc	19.98 B
15th October	18.88 d	25.62 a	22.19 b	21.76 bc	22.11 A
Mean (S)	17.50 C	24.16 A	21.11 B	21.41 B	

Duncan's multiple range test revealed that values with the same alphabetical letter(s) did not substantially differ at the 0.05 level of significance.

3.2. Total yield and average bulb weight at harvesting and after curing

3.2.1. Effect of planting date

Data in Tables 6 and 7 show that there were significant differences between two planting dates (15th September and 15th October) in total yield at harvesting and after curing in both seasons. Planting on 15th October gave higher total yield at harvesting (11.210 and 11.109 ton/ fed.) and after curing (6.474 and 6.675 ton/ fed.) than 15th September (10.179 and 10.1581 ton/ fed. at harvesting) and (5.903 and 6.156 ton/ fed.) in the 1st and 2nd seasons, respectively. The reduction in total yield after curing were about 4.276 and 3.995 ton/ fed. (42.01 and 39.36 %) for planting on 15th September and 4.736 and 4.434 ton/ fad. (42.25 and 39.94%) for planting on 15th October in the 1st and 2nd seasons, respectively.

Respecting, average bulb weight, data in Tables 8 and 9 indicated that planting on 15th October gave higher average bulb weight at harvesting (93.70 and 93.86 g) and after curing (54.11 and 55.79 g) than 15th September (85.13 and 84.14 g at harvesting) and (49.37 and 51.49 g) in the 1st and 2nd seasons, respectively. The decreases in average bulb weight after curing were about 35.76 and 32.65 g (42.01 and 38.89 %) for planting on 15th September and 39.59 and 37.07 g (57.47 and 60.07%) for planting on

Table 6. Effect of planting date, spraying with some stimulants and the combination between them on total yield (ton/fed.) at harvesting of garlic in both seasons

Planting date (PD)	Stimulants				Mean (PD)
	Spraying with water (control)	Brassinolide (5ppm)	Proline (50 ppm)	Melatonin (30 ppm)	
			2021/2022 season		
15th September	8.224 f	11.152 c	10.000 d	11.342 c	10.179 B
15th October	9.225 e	12.419 a	11.438 c	11.759 b	11.210 A
Mean (S)	8.725 D	11.786 A	10.719 C	11.551 B	
			2022/2023 season		
15th September	8.158 f	10.978 c	10.051 d	11.418 b	10.151 B
15th October	9.139 e	12.179 a	11.511 b	11.608 b	11.109 A
Mean (S)	8.649 C	11.579 A	10.781 B	11.513 A	

Duncan's multiple range test revealed that values with the same alphabetical letter(s) did not substantially differ at the 0.05 level of significance.

Table 7. Effect of planting date, spraying with some stimulants and the combination between them on total yield (ton/fed.) after curing of garlic in both seasons

Planting date (PD)	Stimulants				Mean (PD)
	Spraying with water (control)	Brassinolide (5ppm)	Proline (50 ppm)	Melatonin (30 ppm)	
			2021/2022 season		
15th September	4.671 f	7.096 b	5.264 e	6.582 cd	5.903 B
15th October	4.935 f	7.515 a	6.579 d	6.868 bc	6.474 A
Mean (S)	4.803 D	7.305 A	5.921 C	6.725 B	
			2022/2023 season		
15th September	4.968 e	7.341 b	5.434 d	6.884 c	6.156 B
15th October	5.080 e	7.650 a	6.825 c	7.145 b	6.675 A
Mean (S)	5.024 D	7.495 A	6.129 C	7.014 B	

Duncan's multiple range test revealed that values with the same alphabetical letter(s) did not substantially differ at the 0.05 level of significance.

Table 8. Effect of planting date, spraying with some stimulants and the combination between them on average bulb weight at harvesting time (g) of garlic in both seasons

Planting date (PD)	Stimulants				Mean (PD)
	Spraying with water (control)	Brassinolide (5ppm)	Proline (50 ppm)	Melatonin (30 ppm)	
			2021/2022 season		
15th September	68.85 f	93.19 c	83.55 d	94.95 c	85.13 B
15th October	77.12 e	103.85 a	95.53 c	98.31 b	93.70 A
Mean (S)	72.98 D	98.52 A	89.54 C	96.63 B	
			2022/2023 season		
15th September	65.29 f	91.74 c	83.98 d	95.58 b	84.148 B
15th October	76.41 e	101.84 a	96.14 b	97.05 b	92.860 A
Mean (S)	70.85 C	96.79 A	90.06 B	96.31 A	

Duncan's multiple range test revealed that values with the same alphabetical letter(s) did not substantially differ at the 0.05 level of significance.

Table 9. Effect of planting date, spraying with some stimulants and the combination between them on average (g) bulb weight after curing of garlic in both seasons

Planting date (PD)	Stimulants				Mean (PD)
	Spraying with water (control)	Brassinolide (5ppm)	Proline (50 ppm)	Melatonin (30 ppm)	
2021/2022 season					
15th September	39.10 f	59.30 b	43.98 e	55.10 cd	49.37 B
15th October	41.26 f	62.84 a	54.95 d	57.42 bc	54.11 A
Mean (S)	40.18 D	61.07 A	49.46 C	56.26 B	
2022/2023 season					
15th September	41.59 e	61.34 b	45.40 d	57.63 c	51.49 B
15th October	42.47 e	63.97 a	57.00 c	59.74 b	55.79 A
Mean (S)	42.03 D	62.65 A	51.20 C	58.68 B	

Duncan's multiple range test revealed that values with the same alphabetical letter(s) did not substantially differ at the 0.05 level of significance.

15th October in the 2021/2022 and 2022/2023 seasons, respectively.

The reason for the increase in bulb yield and its components after planting late may be that the plants had enough early cool weather and shorter days, which aided in their vegetative growth prior to the formation of their bulbs. This, in turn, allowed the plants to assimilate more carbohydrates and translocate them to the bulbs, increasing the yield and components of head bulbs (Hassan *et al*., 2016). Results are in harmony with those reported by Youssef and Tony (2014), Hassan *et al*. (2016) and Mohammad (2018) on garlic.

3.2.2. Effect of some stimulants

Spraying garlic plants with brassinolide at 5 ppm, proline at 50 ppm and melatonin at 30 ppm increased total yield at harvesting and after curing compared to control (Tables 6 and 7). Brassinolide at 5 ppm gave the highest values of total yield at harvesting (11.7886 and 11.579 ton / fed.) and after curing (7.305 and 7.495 ton / fad.) compared to the other treatments in the 1st and 2nd seasons, respectively. The decreases in total yield after curing were about 4.481 and 4.084 ton / fed. (38.11 and 35.33 %) for brassinolide at 5 ppm in both seasons.

As for average bulb weight, spraying with brassinolide at 5 ppm gave the highest values of average bulb weight at harvesting (98.52 and 96.79 g) and after curing (61.07 and 62.65 g) compared to the other treatments in the 1st and 2nd seasons, respectively (Tables 8 and 9).

A foliar spray containing proline increases enzymes activity, leaf proline, and reduces lipid peroxidation, as demonstrated by a recent study (Hanif *et al*., 2021). This ultimately improves chlorophyll contents and yield per plant. When compared to heat stress applied singly, concurrent heat was more dangerous, and the greatest reduction in stress was achieved with the delivery of 30 mM proline. These results agree with those reported by Aiman *et al*., 2014 on tomato, Sheshglani and Asghari, 2020 on strawberry and Yadav *et al.*, 2022 on cucumber regarding brassinolide, Kaya *et al*., 2007 on muskmelon, El-Sherbeny and Da Silva, 2013 on beetroot, Jamil *et al*. 2018 on red pepper, Orsini *et al*., 2018 on lettuce and Awad-Allah *et al*., 2020 on garlic concerning the response to proline spraying.

3.2.3. Effect of the interaction

The interaction between planting date and spraying with some stimulants had significant effect on total yield at harvesting and after curing (Tables 6 and 7). The interaction between planting on 15th October and spraying with brassinolide at 5 ppm increased total yield at harvesting and after curing. Concerning average bulb weight, the interaction between planting on 15th October and spraying with brassinolide at 5ppm increased average bulb weight at harvesting and after curing (Tables 8 and 9).

In addition to, having a positive effect on enzyme activity and osmotic adjustment under stress, proline is a compatible organic solute that accumulates in the cytoplasm of

plant cells growing in biotic environments. It also protects enzymes against denaturation or inhibition of activity (Costa and Morel, 1994). It has been proposed that enhancing crop heat tolerance in higher plants can be accomplished through the exogenous application of proline (Heuer, 2003).

3.3. Bulb traits

Bulb traits including bulb diameter, number of cloves and average clove weight after curing

3.3.1. Effect of planting date

Data in Tables 10 to 12 illustrate that there were significant differences between two planting dates (15th September and 15th October) in bulb diameter, number of cloves / bulb and average clove weight after curing in both seasons. Planting on 15th October gave higher bulb diameter (5.57 and 5.58 cm), number of cloves / bulb (15.97 and 16.92) and average clove weight (3.35 and 3.31 g) than 15th September (5.30 and 5.13 cm, 14.93 and 15. 54 and 3.22 and 3.23 g, respectively), in the 1st and 2nd seasons, respectively.

The obtained results are in a good accordance with those recorded by Hassan *et al*., 2016; El-Shabasi *et al*., 2018; Mohammad, 2018; Mohamed and Ibrahim *et al*., 2020 and Sultana *et al*., 2022. They found that there were significant differences between planting date regarding bulb diameter, number of cloves and average clove weight.

3.3.2. Effect of some stimulants

Spraying with brassinolide at 5 ppm gave the highest values of bulb diameter (6.047 and 6.01 cm), number of cloves/ bulb (17.70 and 18.57) and average clove weight (3.35 and 3.55 g) in the 1st and 2nd seasons, respectively (Tables 10 to 12).

Table 10. Effect of planting date, spraying with some stimulants and the combination between them on bulb diameter (cm) after curing of garlic in both seasons

Planting date (PD)	Stimulants				Mean (PD)
	Spraying with water (control)	Brassinolide (5ppm)	Proline (50 ppm)	Melatonin (30 ppm)	
2021/2022 season					
15th September	4.19 f	5.89 b	5.47 d	5.65 c	5.30 B
15th October	4.42 e	6.20 a	5.82 b	5.85 b	5.57 A
Mean (S)	4.30 D	6.04 A	5.64 C	5.75 B	
2022/2023 season					
15th September	3.98 f	5.91 b	5.14 d	5.49 c	5.13 B
15th October	4.21 e	6.12 a	5.99 b	6.00 b	5.58 A
Mean (S)	4.09 D	6.01 A	5.56 C	5.74 B	

Duncan's multiple range test revealed that values with the same alphabetical letter(s) did not substantially differ at the 0.05 level of significance.

Table 11. Effect of planting date, spraying with some stimulants and the combination between them on cloves number / bulb after curing of garlic in the two seasons

Planting date (PD)	Stimulants				Mean (PD)
	Spraying with water (control)	Brassinolide (5ppm)	Proline (50 ppm)	Melatonin (30 ppm)	
2021/2022 season					
15th September	12.80 f	16.80 b	14.28 de	15.84 c	14.93 A
15th October	13.44 ef	18.60 a	15.12 cd	16.74 b	15.97 A
Mean (S)	13.12 D	17.70 A	14.70 C	16.29 B	
2022/2023 season					
15th September	12.62 e	17.94 b	15.06 d	16.56 c	15.54 A
15th October	14.16 d	19.20 a	16.32 c	18.00 b	16.92 A
Mean (S)	13.39 D	18.57 A	15.69 C	17.28 B	

Duncan's multiple range test revealed that values with the same alphabetical letter(s) did not substantially differ at the 0.05 level of significance.

Table 12. Effect of planting date , spraying with some stimulants and the combination between them on average clove weight (g) of garlic after curing in two seasons

Planting date (PD)	Stimulants				Mean (PD)
	Spraying with water (control)	Brassinolide (5ppm)	Proline (50 ppm)	Melatonin (30 ppm)	
			2021/2022 season		
15th September	2.82 e	3.53 a	3.08 d	3.48 ab	3.22 B
15th October	3.07 d	3.54 a	3.37 c	3.43 b	3.35 A
Mean (S)	2.94 D	3.53 A	3.22 C	3.45 B	
			2022/2023 season		
15th September	2.75 f	3.55 a	3.28 d	3.36 c	3.23 B
15th October	2.92 e	3.56 a	3.30 cd	3.46 b	3.31 A
Mean (S)	2.83 D	3.55 A	3.29 C	3.41 B	

Duncan's multiple range test revealed that values with the same alphabetical letter(s) did not substantially differ at the 0.05 level of significance.

3.3.3. Effect of the interaction

The interaction between planting on 15th October and spraying with brassinolide at 5 ppm increased bulb diameter, number of cloves / bulb and average clove weight after curing in the 1st and 2nd seasons, respectively (Tables 10 to 12).

3.4. Heat use efficiency

Heat usage efficiency (HUE) showed how much heat was needed to create a single garlic bulb. Heat usage efficiency, or how well heat is used to accumulate dry matter, is influenced by the type of crop, genetics, and timing of sowing.

3.4.1. Effect of planting date

Data in Table 13 show that for both planting dates, HUE was higher in 1st season than HUE in the 2nd season and planting date on 15th October gave higher HUE (3.41 and 3.30 kg/ ºC day) than 15th September (2.60 and 2.41 kg/ ºC day) in the 1st and 2nd seasons, respectively. These results are consistent with those documented by El-Zohiri and Farag (2014) on garlic.

3.4.2. Effect of foliar spray

Spraying garlic plants with brassinolide at 5 ppm gave the highest HUE (3.43 and 3.11 kg/ ºC day) during growth period of the two seasons followed by spraying with proline amino acid at 50 ppm (3.13 and 2.91 kg/ ºC day), whereas spraying plants with water (control treatment) gave the lowest heat use efficiency (2.54 and 2.33 kg/ ºC day in the 1st and 2nd seasons, respectively (Table 13).

Table 13. Effect of planting date, spraying with some stimulants and their interaction between them on heat use efficiency of garlic in 2021/2022 and 2022/2023 seasons

Planting date (PD)	Stimulants				Mean (PD)
	Spraying with water (control)	Brassinolide (5ppm)	Proline (50 ppm)	Melatonin (30 ppm)	
			2021/2022 season		
15th September	2.10 f	2.85 d	2.56 e	2.90 d	2.60 B
15th October	2.98 c	4.01 a	3.70 b	2.98 c	3.41 A
Mean (S)	2.54 D	3.43 A	3.13 B	2.94 C	
			2022/2023 season		
15th September	1.94 e	2.61 c	2.39 d	2.72 c	2.41 B
15th October	2.72 c	3.62 a	3.43 b	3.45 b	3.30 A
Mean (S)	2.33 C	3.11 A	2.91 B	3.08 A	

Duncan's multiple range test revealed that values with the same alphabetical letter(s) did not substantially differ at the 0.05 level of significance.

3.4.3. Effect of the interaction

Planting garlic on 15th October and spraying with brassinolide at 5 ppm gave the highest HUE (4.01 and 3.62 kg/ ºC day) followed by planting on the same date and spraying with proline amino acid at 50 ppm (3.70 and 3.43 62 kg/ ºC day) in the 1st and 2nd seasons. While, planting on 15th September and spraying with water produced the lowest values (2.10 and 1.94 kg/ ºC day) in the 2021/2022 and 2022/2023 seasons, respectively (Table 13).

3.5. Bulb quality

3.5.1. Nitrogen, P and K contents in bulbs at harvesting

3.5.1.1. Effect of planting date

There were significant differences between two planting dates (15th September and 15th October) in N, P and K in bulbs at harvesting (Tables 14 to 16). Planting on 15th October increased N, P and K in bulbs in both season. These results are agreeable with those reported by El-Zohiri and Farag (2014) on garlic.

3.5.1.2. Effect of some stimulants

Spraying garlic plants with brassinolide at 5 ppm, proline at 50 ppm and melatonin at 30 ppm increased N, P and K contents in bulbs compared to control (Tables 14 to 16). However, spraying with brassinolide at 5 ppm gave the highest values of N, P and K contents in bulbs.

3.5.1.3. Effect of the interaction

The interaction between planting on 15th October and spraying with brassinolide at 5 ppm increased N, P and K contents in bulbs at harvesting (Tables 14 to 16).

Table 14. Effect of planting date, spraying with some stimulants and their interaction between them on nitrogen percentage in bulb of garlic at harvesting in 2021/2022 and 2022/2023 seasons

Planting date (PD)	Stimulants				Mean (PD)
	Spraying with water (control)	Brassinolide (5ppm)	Proline (50 ppm)	Melatonin (30 ppm)	
2021/2022 season					
15th September	1.88 f	2.47 b	2.11 d	2.30 c	2.19 B
15th October	1.98 e	2.61 a	2.12 d	2.39 b	2.27 A
Mean (S)	1.93 D	2.54 A	2.11 C	2.34 B	
2022/2023 season					
15th September	1.44 e	2.41 b	2.06 c	2.32 b	2.05 B
15th October	1.72 d	2.61 a	2.11 c	2.37 b	2.20 A
Mean (S)	1.58 D	2.51 A	2.08 C	2.34 B	

Duncan's multiple range test revealed that values with the same alphabetical letter(s) did not substantially differ at the 0.05 level of significance.

Table 15. Effect of planting date, spraying with some stimulants and their interaction between them on phosphorus percentage in bulb of garlic at harvesting in 2021/2022 and 2022/2023 seasons

Planting date (PD)	Stimulants				Mean (PD)
	Spraying with water (control)	Brassinolide (5ppm)	Proline (50 ppm)	Melatonin (30 ppm)	
2021/2022 season					
15th September	0.368 e	0.529 bc	0.447 d	0.505 c	0.462 B
15th October	0.421 d	0.620 a	0.500 c	0.545 b	0.521 A
Mean (S)	0.394 D	0.574 A	0.473 C	0.525 B	
2022/2023 season					
15th September	0.469 f	0.561 cd	0.514 e	0.549 d	0.523 B
15th October	0.542 de	0.662 a	0.589 c	0.638 b	0.607 A
Mean (S)	0.505 D	0.611 A	0.551 C	0.593 B	

Duncan's multiple range test revealed that values with the same alphabetical letter(s) did not substantially differ at the 0.05 level of significance.

Table 16. Effect of planting date, spraying with some stimulants and their interaction between them on potassium percentage in bulb of garlic at harvesting in 2021/2022 and 2022/2023 seasons

Planting date (PD)	Stimulants				Mean (PD)
	Spraying with water (control)	Brassinolide (5ppm)	Proline (50 ppm)	Melatonin (30 ppm)	
			2021/2022 season		
15th September	2.05 g	2.80 b	2.38 e	2.64 c	2.46 B
15th October	2.24 f	3.10 a	2.52 d	2.79 b	2.66 A
Mean (S)	2.14 D	2.95 A	2.45 C	2.71 B	
			2022/2023 season		
15th September	2.02 f	2.99 b	2.51 d	2.76 c	2.57 B
15th October	2.36 e	3.20 a	2.72 c	3.00 b	2.82 A
Mean (S)	2.19 D	3.09 A	2.61 C	2.88 B	

Duncan's multiple range test revealed that values with the same alphabetical letter(s) did not substantially differ at the 0.05 level of significance.

3.5.2. TSS, DM and pungency after curing

3.5.2.1. Effect of planting date

Data in Tables 17 to 19 show that there were significant differences between two planting dates (15th September and 15th October) TSS, DM and pungency after curing, except DM in the 1st season. Planting on 15th September gave higher TSS (32.80 and 32.51), DM (35.75 and 35.44 %) and pungency (0.159 and 0.167) than 15th October in both season. In this regard, El-Shabasi *et al*. (2018) showed that the last planting date (planting on 15th October) scored the highest values of total carbohydrates in garlic than planting on 1st or 15th September.

These results are in harmony agree with those reported El-Zohiri and Farag (2014) and Mohammad (2018).

3.5.2.2. Effect of some stimulants

Spraying garlic plants with brassinolide at 5 ppm, proline at 50 ppm and melatonin at 30 ppm increased TSS, DM and pungency in bulbs compared to control treatment (Tables 17 to 19). Spraying with melatonin at 30 ppm gave the highest values of TSS (33.66 and 32.62), DM (36.69and 35.56 %) and pungency (0.173 and 0.179) .

3.5.2.3. Effect of the interaction

Data in Tables 17 to 19 illustrate the interaction between planting on 15th September and spraying with melatonin at30 ppm increased TSS, DM and pungency after curing.

Table 17. Effect of planting date, spraying with some stimulants and their interaction between them on total soluble solids (TSS) in bulb of garlic in 2021/2022 and 2022/2023 seasons

Planting date (PD)	Stimulants				Mean (PD)
	Spraying with water (control)	Brassinolide (5ppm)	Proline (50 ppm)	Melatonin (30 ppm)	
			2021/2022 season		
15th September	32.01 d	32.24 d	33.06 c	33.89 a	32.80 A
15th October	31.28 e	32.18 d	32.08 d	33.44 b	32.24 B
Mean (S)	31.64 D	32.21 C	32.57 B	33.66 A	
			2022/2023 season		
15th September	31.98 d	32.29 c	32.60 b	33.18 a	32.51 A
15th October	30.27 g	31.32 e	31.10 f	32.07 cd	31.19 B
Mean (S)	31.12 C	31.80 B	31.85 B	32.62 A	

Duncan's multiple range test revealed that values with the same alphabetical letter(s) did not substantially differ at the 0.05 level of significance.

Table 18. Effect of planting date, spraying with some stimulants and their interaction between them on dry matter (%) in bulb of garlic plants in 2021/2022 and 2022/2023 seasons

Planting date (PD)	Stimulants				Mean (PD)
	Spraying with water (control)	Brassinolide (5ppm)	Proline (50 ppm)	Melatonin (30 ppm)	
2021/2022 season					
15th September	34.89 cd	35.14 c	36.04 b	36.94 a	35.75 A
15th October	34.10 d	35.08 c	34.97 c	36.45 ab	35.15 A
Mean (S)	34.49 C	35.11 B	35.50 B	36.69 A	
2022/2023 season					
15th September	34.86 bc	35.20 b	35.53 ab	36.17 a	35.44 A
15th October	32.99 e	34.14 cd	33.90 d	34.96 b	33.99 B
Mean (S)	33.92 C	34.67 B	34.71 B	35.56 A	

Duncan's multiple range test revealed that values with the same alphabetical letter(s) did not substantially differ at the 0.05 level of significance.

Table 19. Effect of planting date, spraying with some stimulants and their interaction between them on pungency as pyruvic acid (µmol/gm FW) in bulb of garlic in 2021/2022 and 2022/2023 seasons

Planting date (PD)	Stimulants				Mean (PD)
	Spraying with water (control)	Brassinolide (5ppm)	Proline (50 ppm)	Melatonin (30 ppm)	
2021/2022 season					
15th September	1.34 ef	1.67 b	1.51 cd	1.86 a	1.59 A
15th October	1.22 f	1.58 bc	1.43 de	1.61 bc	1.46 B
Mean (S)	1.28 D	1.62 B	1.47 C	1.73 A	
2022/2023 season					
15th September	1.42 d	1.80 a	1.63 c	1.84 a	1.67 A
15th October	1.26 e	1.66 bc	1.51 d	1.74 ab	1.54 B
Mean (S)	1.34 C	1.73 A	1.57 B	1.79 A	

Duncan's multiple range test revealed that values with the same alphabetical letter(s) did not substantially differ at the 0.05 level of significance.

3.6. Weight loss (%)

3.6.1. Effect of planting date

Planting on 15th September recorded lower weight loss (%) in bulbs during storage periods than 15th October (Tables 20 and 21). Fresh weight loss (%) increased with increasing storage period up to 180 days of storage in both seasons. While planting garlic in late date produced the highest weight loss, in both seasons. Prolonging the period of storage caused gradual increase in weight loss percentage. The obtained results are in harmony with those reported by Hassan *et al.* (2016) on garlic.

3.6.2. Effect of some stimulants

Data in Tables 20 and 21 illustrate that spraying garlic plants with brassinolide at 5 ppm, proline at 50 ppm and melatonin at 30 ppm decreased weight loss (%) compared to control (spraying with water). In this regard, the lowest values of weight loss (%) in bulbs during storage periods were scored by spraying plants with melatonin at 30 ppm in both seasons .

3.6.3. Effect of the interaction

Data in Tables 20 to 21 show that the interaction between planting on 15th September and spraying with melatonin at 30 ppm decreased weight loss (%) in bulbs during storage periods.

Table 20. Effect of planting date, spraying with some stimulants and their interaction between them on weight loss (%) in bulb during storage of garlic in 2021/2022 season

Planting date (PD)		Days after storage					
		30	60	90	120	150	180
Effect of planting date							
15th September		4.09 a	7.24 b	14.2 b	19.57 b	25.00 b	33.31 b
15th October		4.45 a	8.15 a	16.7 a	22.25 a	27.81 a	36.05 a
Effect of stimulants							
Spraying with water (control)		5.06 a	9.40 a	18.54 a	24.73 a	29.91 a	38.19 a
Brassinolide (5ppm)		4.06 c	7.26 c	15.41 b	20.89 b	26.45 b	35.40 b
Proline (50 ppm)		4.46 b	7.96 b	15.60 b	20.65 b	26.64 b	34.70 b
Melatonin (30 ppm)		3.51 d	6.15 d	12.46 c	17.39 c	22.63 c	30.42 c
Effect of interaction							
15th Sep.	**Spraying with water (control)**	4.92 b	8.88 ab	17.26 b	23.31 b	29.07 ab	37.17 b
	Brassinolide (5ppm)	3.91 d	6.84 de	13.98 c	19.85 c	25.61 cd	34.32 c
	Proline (50 ppm)	4.22 c	7.39 de	14.18 c	19.14 c	24.69 d	33.08 cd
	Melatonin (30 ppm)	3.34 e	5.85 f	11.70 d	16.01 d	20.65 e	28.67 e
15th Oct.	**Spraying with water (control)**	5.20 a	9.92 a	19.83 a	26.16 a	30.75 a	39.21 a
	Brassinolide (5ppm)	4.22 c	7.69 cd	16.85 b	21.93 b	27.29 bc	36.49 b
	Proline (50 ppm)	4.71 b	8.54 bc	17.02 b	22.17 b	28.60 b	36.32 b
	Melatonin (30 ppm)	3.69 d	6.46 ef	13.22 cd	18.77 c	24.61 d	32.18 d

Duncan's multiple range test revealed that values with the same alphabetical letter(s) did not substantially differ at the 0.05 level of significance.

Table 21. Effect of planting date, spraying with some stimulants and their interaction between them on weight loss (%) in bulb during storage of garlic in 2022/2023 seasons

Planting date (PD)		Days after storage					
		30	60	90	120	150	180
Effect of planting date							
15th September		3.97 a	7.10 a	14.15 b	19.17 b	24.73 b	33.64 b
15th October		4.44 a	7.90 a	15.58 a	22.12 a	27.47 a	36.48 a
Effect of stimulants							
Spraying with water (control)		5.15 a	9.16 a	17.70 a	23.93 a	29.37 a	39.37 a
Brassinolide (5ppm)		3.97 c	6.95 c	14.78 b	20.64 b	25.62 b	35.21 b
Proline (50 ppm)		4.34 b	7.75 b	14.78 b	20.69 b	26.70 b	34.77 b
Melatonin (30 ppm)		3.36 d	6.14 d	12.21 c	17.34 c	22.72 c	30.91 c
Effect of interaction							
15th Sep.	**Spraying with water (control)**	4.83 b	8.75 b	17.31 a	22.16 b	28.59 ab	38.31 ab
	Brassinolide (5ppm)	3.72 d	6.51 e	14.02 c	19.21 c	24.78 c	33.21 d
	Proline (50 ppm)	4.13 c	7.53 cd	14.06 c	19.37 c	24.99 c	33.48 cd
	Melatonin (30 ppm)	3.21 e	5.62 f	11.24 d	15.96 d	20.59 d	29.59 e
15th Oct.	**Spraying with water (control)**	5.47 a	9.57 a	18.10 a	25.70 a	30.15 a	40.43 a
	Brassinolide (5ppm)	4.23 c	7.40 d	15.54 b	22.07 b	26.47 bc	37.22 b
	Proline (50 ppm)	4.56 b	7.98 c	15.51 b	22.02 b	28.41 ab	36.06 bc
	Melatonin (30 ppm)	3.52 de	6.66 e	13.18 c	18.72 c	24.85 c	32.24 d

Duncan's multiple range test revealed that values with the same alphabetical letter(s) did not substantially differ at the 0.05 level of significance.

4. CONCLUSION

Garlic planting on 15th October and spraying with brassinolide at 5 ppm was the best treatment for enhancing plant growth, total yield at harvesting and after curing, bulb traits N, P and K contents in bulbs at harvesting, whereas decreased weight loss (%) in bulbs during storage periods. While, planting on 15th September and spraying with melatonin at 30 ppm increased bulb quality and recorded the best bulb storability after six months from storage periods.

5. REFERENCES

AOAC (2000). Official methods of analysis. 17ed. A.O.A.C., Washington, Dc, USA.

Abdalla MA, Aboul-Nasr MH, Metwaly AK and Shreen HA (2011). Growth and yield of fifteen garlic ecotypes. Assiut J. Agric. Sci., 36 (5): 52-65.

Abdel-Razik FA, Ragab ME, Youssef SM and Metwally AA (2024). Growth, yield, and tuber quality of potato with foliar application of Tryptophan and its derivatives. Egypt. J. Hort., 51 (2): 161-173.

Aiman HS, Mohammad I and Shamsul H (2014). Response of tomato cultivars on yield and quality attributes applied with two different modes of BR Analogues: A Comparative study. International Conference on Advances in Agricultural, Biological & Environmental Sciences (AABES-2014) Oct. 15-16, Dubai (UAE).

Ali MAM (2009). Studies on earliness in garlic production for exportation. M.Sc. Thesis, Fac. Agric., Suze Canal Univ., Egypt.

Awad-Allah E, Attia M and Mahdy A (2020). Salinity stress alleviation by foliar bio-stimulant, proline and potassium nutrition promotes growth and yield quality of garlic plant. Open Journal of Soil Science, 10: 443-458.

Brengi SH, Khedr AEM and Abouelsaad IA (2022). Effect of melatonin or cobalt on growth, yield and physiological responses of cucumber (*Cucumis sativus* L.) plants under salt stress. J. Saudi Soc. Agric. Sci., 21: 51–60.

Costa G and Morel L (1994). Water relations, gas exchange and amino acid content in Cd-treated lettuce. Plant Physiol. Biochem., 32: 561-570.

Duncan DB (1958). Multiple Range and Multiple F-Test. Biometrics, 11: 1-5.

El-Bassiony AM, Ghoname AA, El-Awadi ME, Fawzy ZF and Grud N (2012). Ameliorative effects of brassinosteroids on growth and productivity of snap beans grown under high temperature. Gesunde Pflanzen, 64: 175-182.

El-Shabasi MSS, Osman YMM and Rizk SM (2018). Effect of planting date and some pre-planting treatments on growth and yield of garlic J. Plant Production, Mansoura Univ., 9(12): 1091-1096.

EL-Sherbeny MR and Da Silva JAT (2013). Foliar treatment with proline and tyrosine affect the growth and yield of beetroot and some pigments in beetroot leaves. J. Hort. Res., 21(2): 95-99.

El-Yazied AA, Ibrahim MFM and Ibrahim MAR (2022). Melatonin mitigates drought induced oxidative stress in potato plants through modulation of osmolytes, sugar metabolism, Aba homeostasis and antioxidant enzymes. Plants, 11, 1151. https://doi.org/ 10.3390/ plants 11091151.

El-Zohiri SSM and Farag AA (2014). Relation planting date, cultivars and growing degree-days on growth, yield and quality of garlic, Middle East. J. of Agric. Res., 3(4): 1169-1183.

Hanci F and Bingo F (2020). Effect of melatonin on salt stressed garlic plants: time dependent monitoring of leaf morphology in early plant phase. Indian J. Hort., 77(4): 681-685.

Hanif S, Farrukh SM, Muhammad S, Muhammad I, Abdul S, Ashfaq WM and Zaman KH (2021). Biochemically triggered heat and drought stress tolerance in rice by proline application. Journal of Plant Growth Regulation, 40 (1): 305-312.

Hassan GH, El-Shal MA, Soliman KHA and Ghoneim IM (2016). Effect of planting dates and periods of curing on quantitative, qualitative characteristics and storage ability of two garlic

cultivars. J. Agric. Res. Kafr El-Sheikh Univ., 42(3): 401-414.

Hayat S, Alyemeni MN and Hasan SA (2012). Foliar spray of brassinosteroid enhances yield and quality of *Solanum lycopersicum* under cadmium stress. Saudi J. Biol. Sci., 19(3): 325-335.

Heuer B (2003). Influence of exogenous application of proline and glycinebetaine on growth of salt-stressed tomato plants. *Plant Sci.*, 165: 693-699.

Hosseinifard M, Stefaniak S, Javid MG, Soltani E, Wojtyla L and Garnczarska M (2022). Contribution of exogenous proline to abiotic stresses tolerance in plants: A Review. Int. J. Mol. Sci., 23, 5186.

Huang X, Tanveer M, Min Y and Shabala S (2022). Melatonin as a regulator of plant ionic homeostasis: Implications for abiotic stress tolerance. J. Exp. Bot., 73: 5886-5902.

Ibrahim AS, Ali AA and Farag FM (2020). Interaction effects of planting date or/and clove weight on growth, yield, storability and severity of downy mildew disease on two garlic cultivars. Egypt. J. Agric. Res., 98(2): 214-239.

Ilyas N, Amjid MW, Saleem MA, Khan W and Wattoo FM (2020). Quantitative trait loci (QTL) mapping for physiological and biochemical attributes in a pasban90/frontana recombinant inbred Lines (RILs) population of wheat (*Triticum aestivum*) under salt stress condition. Saudi J. Biol. Sci., 27, 341–351.

Iqbal N, Fatma M, Gautam H, Umar S, Sofo A, D'ippolito I and Khan NA (2021). The crosstalk of melatonin and hydrogen sulfide determines photosynthetic performance by regulation of carbohydrate metabolism in wheat under heat stress. Plants,10, 1778.

Jamil M, Kharal MA, Ahmad M, Abbasi GH, Nazli F, Hussain A and Akhtar MFZ (2018). Inducing salinity tolerance in red pepper (*Capsicum annuum* L.) through exogenous application of proline and l-Tryptophan. Soil Environ., 37: 160-168.

Jones HA and Mann LK (1963). Onions and their allies. Leonard Hill (Book) Limited, London, 286.

Kaya C, Tuna AL, Ashraf M and Altunlu H (2007). Improved salt tolerance of melon (*Cucumis melo* L.) by the addition of proline and potassium nitrate. Environ. Exp. Bot., 60, 397–403.

Khosravi S, Haghighi M and Mottaghipisheh J (2023). Effects of melatonin foliar application on hot pepper growth and stress tolerance. Plant Stress, 9:1-12.

Malý I, Bartoš J, Hlušek J, Kopec K, Petíková K, Rod J and Spitz P (1998). Polní zelinářství. Agrospoj Praha: 175-185.

Mohammad IAM (2018). Effect of planting dates and nitrogen fertilization sources on productivity and quality of garlic plants under south Sinai governorate conditions. M.Sc. Thesis, Fac. Agric. Zagazig Univ., Egypt.

Moustafa FM, Mahmoud A, Arnao MB and Sheteiwy MS (2020). Melatonin-induced water stress tolerance in plants: Recent Advances. Antioxidants, 9:809. doi: 10.3390/antiox9090809.

Nuttonson MY (1995). Wheat climate relationship and use phenology in ascertaining the thermal and photo-thermal requirement of wheat. American Institute of Crop Ecology, Washington DC, 1995, 338.

Orsini F, Pennisi G, Mancarella S, Al Nayef M, Sanoubar R, Nicola S and Gianquinto G (2018). Hydroponics lettuce yields are improved under salt stress by utilizing white plastic film and exogenous applications of proline. Sci. Hortic., 233: 283-293.

Rahim MA and Fordham A (1988). Effects of storage temperature on the initiation and development of garlic cloves (*Allium sativum* L.). Sci. Hort., 37 (1-2): 25-28

Schwimmer S and Westen W (1961). Enzymatic development of pyurvic acid in onion as a measure of pungency. Agric. and Food Chem., 9(4): 301-304.

Serna P, Hernández F, Coll F and Amorós A (2012). Brassinosteroid analogues effect on yield and quality parameters of field-grown lettuce (*Lactuca sativa* L.). Scientia Horticulturae, 143, 16 August: 29-37.

Sheshglani PZ and Asghari M (2020). Impact of foliar spray with 24-epibrassinolide on yield, quality, ripening physiology and productivity of the strawberry. Scientia Horticulturae, 268(1): 109376.

Snedecor GW and Cochran WG (1980). Statistical Methods. 7th Ed. Ames, Iowa USA: Iowa State Univ. Press, 507.

Subrata C, Chattopadhayay PK and Hassan MA (2010). Dynamics of growth and yield of garlic in variable planting time and applied nutrient, Indian J. Hort., 67(3): 348-352.

Sultana A, Debsharma SK, Mondal S, Maniruzzaman S and Haque A (2022). Effect of planting time on growth and yield of garlic (*Allium sativum* L.) genotypes. Asian J. Res. Crop Sci., 7(2): 1-12.

Susila T, Reddy SA, Rajkumar M, Padmaja G and Rao PV (2012). Effects of sowing date and spraying of brassinosteroid on yield and fruit quality characters of watermelon. World J. Agric. Sci., 8(3): 223-228.

Wang LY, Liu JL, Wang WX and Sun Y (2016). Exogenous melatonin improves growth and photosynthetic capacity of cucumber under salinity-induced stress. Photosynthetica, 54(1): 19-27.

Yadav NP, Bahadur V, Singh G and Singh NV (2022). Influence of foliar spray of brassinosteroids (BR), salicylic acid (SA) and gibberellic acid (GA_3) on vegetative growth and flowering parameters of cucumber (*Cucumis sativus* L.) cv. Arpit. Inter. J. Environ. and Climate Change, 12(12): 607-615.

Yagmur F and Hanci F (2021). Effects of melatonin on flowering, seed yield and seed quality of onion under salt stress. Maejo Int. J. Sci. Technol., 15(3): 253-260.

Yakupoglu G (2020). The effects of melatonin applications on bean seedling development under moderately alkaline soil conditions, Bahçe, 49: 1-9 (in Turkish).

Youssef NS and Tony HSH (2014). Influence of different planting date on the performance of new garlic genotypes grown under El-minia governorate conditions. Nature and Science, 12(5): 112-119.

Zahedi SM, Hosseini MS, Abadía J and Marjani M (2020). Melatonin foliar sprays elicit salinity stress tolerance and enhance fruit yield and quality in strawberry (*Fragaria* × *ananassa* Duch.). Plant Physiology and Biochemistry, 149: 313-323.

الملخص العربي

تأثير الرش ببعض المواد لتقليل تغير المناخ على إنتاجية وجودة نباتات الثوم

فوزى يحيى عمر منصور[١]، حمادة ماهر بدير المتولى [١] و ايناس عبد الله برديسى [٢]

[١]معهد بحوث البساتين، مركز البحوث الزراعية، مصر
[٢]قسم البساتين، كليه الزراعه، جامعه الزقازيق

تم إجراء تجربة حقلية في مزرعة خاصة بقرية ميت فارس، دكرنس، محافظة الدقهليه ، مصر، خلال موسمين شتويين متتاليين ٢٠٢٢/٢٠٢١، ٢٠٢٣/٢٠٢٢، لدراسة تأثير بعض المواد المختلفة (البراسينوليد، الحمض الأميني البرولين والميلاتونين) رشاً ورقياً تحت موعدين للزراعة (١٥ سبتمبر و١٥ أكتوبر) على النمو والإنتاجية والقابلية لتخزين الثوم الصنف سدس ٤٠ باستخدام نظام الري بالتنقيط في التربة الطينية.

أدت زراعة الثوم في ١٥ أكتوبر والرش بالبراسينوليد بمعدل ٥ جزء في المليون إلى زيادة عدد الأوراق / نبات والوزن الجاف الكلى / نبات والمحصول الكلى عند الحصاد وبعد العلاج التجفيفى وقطر البصلة وعدد الفصوص / البصلة ومتوسط وزن الفص بعد العلاج التجفيفى ومحتوى الأبصال من النيتروجين والفوسفور والبوتلسيوم عند الحصاد، في حين انخفضت النسبه المئويه للفقد فى الوزن في الأبصال خلال فترات التخزين. بينما أدت الزراعة في ١٥ سبتمبر والرش بالميلاتونين بمعدل ٣٠ جزء في المليون إلى زيادة المواد الصلبة الذائبة الكلية ونسبه المادة الجافة والحرافه بالإضافة إلى انخفاض الفقد فى الوزن في الأبصال بعد ستة أشهر من التخزين.