Response of garlic and associated weeds to bio–stimulants and weed control

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Abstract: Weeds are one of the main threats to crop yield. Field experiments were carried out to investigate the efficiency of bio–stimulants (amino acid, humic acid, gibbrillic acid) and weed control methods (clethodium, fluzifop–butyl, clodinafop–propargyl, diclofop–methyl and two hand hoeing) as well as their interactive effects on garlic plant and weeds in Nubaria, Egypt. Application of amino acids at the concentration 100 ppm caused markedly increases in dry weight weeds species under investigation compared with control. Clodinafop–propargyl treatment coefficient has exceeded the rest of the treatments in reducing the narrow weeds accompanying the garlic plants. Application of clethodium treatment produced the maximum values of growth, blub yield and yield attributes. Moreover, two hand hoeing produced the maximum values of photosynthetic pigments and biochemical constituents. The interaction between bio–stimulants and weed control had a significant effect on total dry weight of narrow–leaved weeds, average bulb weight and bulb garlic yield. Clethodium herbicide integrated with amino acid at the concentration 100 ppm application produced the maximum values of garlic blub yield. It can be suggested that the use of clethodium or diclofop herbicide combined with amino acid has better the growth and yield of garlic plants under newly reclaimed soil conditions.

Keywords: garlic, amino acid, clethodium, fluzifop–butyl, clodinafop–propargyl, diclofop–methyl, narrow–leaved weeds, blub yield

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1 Introduction

Garlic (*Allium sativum* L.) is the oldest plants known in Egypt where it was found inscribed on the temples of the Pharaohs. Egypt has an advantage high relative productivity of this crop. Egyptian garlic occupies a prominent position in the world among the important export commodities on which Egypt depends on export trade. This comparative advantage makes Egypt highly competitive in foreign markets for the export of garlic under the world trade agreement. The success of garlic cultivation in the new land, high productivity, quality and low use of pesticides to fight its pests have led to the possibility of expanding its cultivation in these lands and increasing its export opportunities. Especially, if cultivars such as the 40% crop.

Currently, the main challenges of plant scientists and agronomists are to increase the crop yields, in more supply, efficient and environmentally safe cropping system (Amino acids, humic acid and gibberellic acid). Amino acids are the essential active ingredients for the operation of protein structure. In this regard, amino acids that are safe with various metabolic processes within the plant were used to increase plant growth (Coruzzi and Last, 2000). Also, Maxwell and Kieber (2004) specific relate of methionine to the biosynthesis of bio–substances materials, e.g. cytokinins, auxins and brassinosteroids in plants. Moreover, the role of tryptophan has recently been shown in the bio–synthesis of toxins, the phytoalexincamalexin, phenyl propanoids

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and other compounds within the plant (Tao et al., 2008). Studies have also shown that amino acids can act directly or indirectly in physiological processes, that are important for plant growth and development. According to Sarojnee et al. (2009) amino acids increasing the fertilizer absorption, improve uptake of nutrients and water, reinforce the photosynthetic average, dry matter sections and increase yield and quality of paper plant. In this trend, amino acids application increased free amino acids and total protein which reflected on improving onion growth characters and reduced nitrogen dose application (Abd El–Wahed et al., 2016).

Growth promoting hormones have an essential role in plants and their processes, plant growth and development (Stem elongation, leaf extension, flower and fruit set and their structure) and their contents are usually associated with their application (Shah et al., 2007). The influence of gibberellic acid (GA3) on early growth behaviors of garlic gave an indication of promoting of garlic growth (Rahman et al., 2008). The maximum number of leaves per plant was obtained from treated cloves with 100 and 200 ppm GA3. In this connection, Govind et al. (2015) reported that the application of GA3 improved vegetative growth (plant height, leaf number and basal diameter), bulb yield, fresh and dry weight of bulb as well as TSS. Also, the application of humic acid as a foliar spraying and addition in the soil enhance the absorption of nutrients from the soil and plant nutrient efficiency (Zeinali and Moradi, 2015). The use of humic acid leads to positive effects on plant growth as a result of stimulating the growth of the root and increasing its efficiency. Also, the use of humic acid increases the plant's ability to absorb the major and minor elements, especially nitrogen, phosphor, potassium, magnesium and calcium. Application of humic acid in the garlic plant led to a significant increase in yield and yield components (Shafeek et al., 2016).

Weeds not only compete with garlic crop for environmental factors, but also serve as alternative hosts for several insect pests and diseases (Yadav et al., 2015). Garlic plants at the early stage of her life are slow growth so less able to compete with the weeds plants in the initial period of her life (Ghosheh, 2000; Abouziena and Radwan, 2015; Aghabeigi and Khodadadi, 2017). Due to the nature of this growth so garlic plants can't cover the soil surface in this period of her life (El–Metwally et al., 2010; Rahman et al., 2012; Siddhu et al., 2018). Weed competition decrease the average garlic production by 85% compared with the unweeded check (Qasem, 1996). The presence of weeds, during the whole growing season of onion, reduced bulb yield by 61.4%, 92.3% and up to 100% of the marketable yield (Ghosheh, 2004; Waiganjo et al., 2009).

The purpose of this experiment was to investigate the qualitative and quantitative yield of native garlic that influenced by amino acid, humic acid and gibbrilic acid foliar spraying as well as weeds control treatments.

2 Materials and methods

A field experiment was carried out during two winter seasons of 2015/2016 and 2016 /2017 at the Experimental Station of the National Research Centre at Nubaria, Behaira Governorate, Egypt to study the effect of some bio regulator and weed control treatments on growth characters, plant chemical composition, as well as yield and bulb quality of garlic plants (cv. Balady) grown in sandy soil under drip irrigation system. The physicochemical characteristics of the investigated soils were presented in Table 1 (average 2 seasons). Soil was analyzed according to the methods described by Cottenie et al. (1982).

Table 1 Some physical and chemical properties of the used soil

Sand (%)	Silt (%)	Clay (%)	Texture	O.M (%)	$CaCO_3$ (%)			
68.7	24.5	6.8	Sandy loam	0.16	7.00			
pH	EC (ds m^{-1})	Cations (meq^{-1})				Anions (meq^{-1})		
		Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3–	Cl–	SO_4^{2}–
7.8	0.20	3.00	2.00	2.09	0.23	1.41	0.70	5.29
Macronutrients (mg 100 g^{-1} soil)			Micronutrients (mg kg^{-1})					
N	P	K	Fe	Mn	Zn	Cu		
14.5	9.20	16.0	7.36	3.19	1.66	3.0		

The experiment was established with a split plot design having four replicates. The main plots included amino acids (100 ppm), humic acid (4 g L^{-1}), gibbrillic acid (50 ppm) as foliar spraying and untreated plot (water). The chemical analysis of amino acids was shown in Table 2 and the guaranteed and physical analysis of humic acid is presented in Table 3. Sub–plots were assigned to six weed control treatments (clethodium, fluzifop–butyl, clodinafop–propargyl, diclofop–methyl, two hand hoeing (20 and 40 days after sowing) and unweeded control. Common trade and chemical names of herbicides as well as rates used and time of application used in this study were presented in Table 4. All treatments under investigation were sprayed by tribenuron–methyl to control the associated weed broadleaved of garlic.

Table 2 The chemical analysis of amino acids compound (w v^{-1})

Component	%
Free amino acids	8.4
N	6.6
P_2O_5	6.0
K_2O	4.2
Fe	0.036
Mn	0.06
Mo	0.012
Zn	0.084

Garlic cloves were planted on 24 and 26 September on both sides of the dripper lines at 10 cm distance in the first and second seasons, respectively. The area of the experimental unit was 14.4 m^2. It contained four dripper lines each of 6 m length and 0.60 m width. The recommended amounts of mineral N, P and K fertilizers for garlic cultivation under sandy soil conditions were applied to all experimental units as soil application. 400 kg fed^{-1}. ammonium sulphate (20.5% N) 350 kg fed^{-1}. calcium superphosphate (16%-18% P_2O_5) and 200 kg fed^{-1}. potassium sulphate (48% K_2O). Calcium superphosphate was added at soil preparation. The other two thirds ammonium sulphate and potassium sulphate were divided into 12 equal portions and were added weekly through drip irrigation water beginning after planting. The other normal agricultural treatments for growing garlic plants, except fertilization treatments were practiced.

Table 3 The guaranteed and physical analysis of humic acid

Guaranteed Analysis	
Humic acid	80%
Potassium (K_2O)	10%–12%
Zn, Fe, Mn, etc.	100 ppm
Physical Analysis	
Appearance	Black powder
pH	9–10
Water solubility	>98%

Table 4 Common, trade and chemical names of herbicides as well as rates used and time of application used in the study

Trade name	Common name	Chemical name	Rate of application ha^{-1}	Time of application
Select supper	Clethodium	(±)–2– [(E) –1– [(E) –3– chloroallyloxyimino]propyl] –5– [2–(ethylthio)propyl] –3– hydroxycyclohex–2–enone	0.625 L	After 30 days from sowing
Illoxan	Diclofop–methyl	methyl 2– [4– (2,4–dichlorophenoxy)phenoxy]propanoate	1.25 L	After 30 days from sowing
Topik	Clodinafop–propargyl	Prop–2–yn–1–yl (2R) –2–{4– [(5–chloro–3–fluoropyridin–2–yl) oxy] phenoxy} propanoate.	0.350 kg	After 30 days from sowing
Fusalide super	Fluzifop– butyl	R–2– [4–. [[5– (trifluoromethyl) –2– pyridinyl]oxy]phenoxy] propanate	1.25 L	After 30 days from sowing

2.1 Data recorded

2.1.1 Weeds

Weeds were hand pulled from one square meter of each experimental at 90 days, then identified and classified into narrow leaved weeds species. The numbers of weeds were recorded of m^2. The samples were dried in an electric oven at temperature of 70°C until constant weight. After drying, the dry weights of weeds were recorded.

2.1.2 Plant growth characters

A random sample of ten plants from each experimental unit was taken at 90 days after planting and the following data were recorded:

1. Plant height (cm), 2. number of leaves/plant, 3. Neck diameter (cm), 4. Bulb diameter (cm), and 5. total dry weight/plant (g).

2.1.3 Yield and its components

At proper maturity stage of bulbs in every plot were harvested (150 days after sowing) then translocate to a shady place in the same day for curing. The following yield parameters were calculated as follow:

1. Number of cloves/ blub, 2. cloves weight (g), 3. cloves

diameter (cm), 4. average bulb weight (g), and 5. total blub yield (ton/fed).

2.1.4 Chemical analysis

Photosynthetic pigments (chlorophyll a, b and carotonids) were determined in fresh leaves of garlic plant at vegetative stage by spectrophotometer according to Lichenthaler and Wellburn (1983) at 90 days after planting. At harvest fresh cloves of garlic were dried in oven at 70ºC to constant weight and dried sample was taken to determinate the following chemical analysis: Lipid content was determined according to AOAC (2000), total phenols according to Danial and George (1972), total flavonoids according to Chang and Wen (2002) and total indoles according to Glickman and Dessaux (1995).

2.1.5 Statistical analysis

The obtained data from each season were subjected to the proper statistical analysis of variance according to Gomez and Gomez (1984).

3 Results and discussion

3.1 Weeds growth

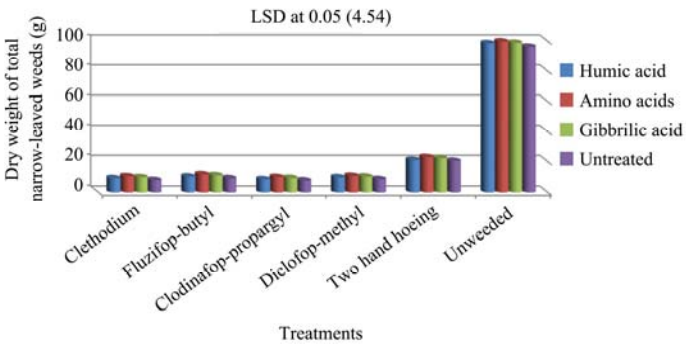
The current under weeds were classified research area conditions and found to contain the following: wild oat (*Avena fatua* L.) and ryegrass (*Lolium temulentum* L.) as narrow-leaved weeds. Bio-stimulants application led to increase the vegetative growth characters of grown narrow weeds in garlic plant. Amino acids application rate (100 ppm) caused markedly increases in dry matter weight of wild oat, ryegrass and all narrow weeds compared with untreated plants in both seasons. According to the results in Table 5 number of wild oat, ryegrass and total narrow weeds after 90 days from sowing (DFS) were insignificantly affected by humic acid, gibberellic acid and amino acids treatments. This result may be due to the effect of biostimulants on improving the physiological processes in the weeds, which reflect on the enhancement of competition between the weeds and garlic plant. Similar results were obtained by El–Metwally and Dawood (2016). In contrast, the number of narrow-leaved weeds after 90 days from sowing was insignificantly affected by bio-stimulants in both seasons as shown in Table 5.

Table 5 Effect of biostimulants and weed control treatments on number and dry weight of garlic weed during 2015/2016 and 2016/2017 seasons

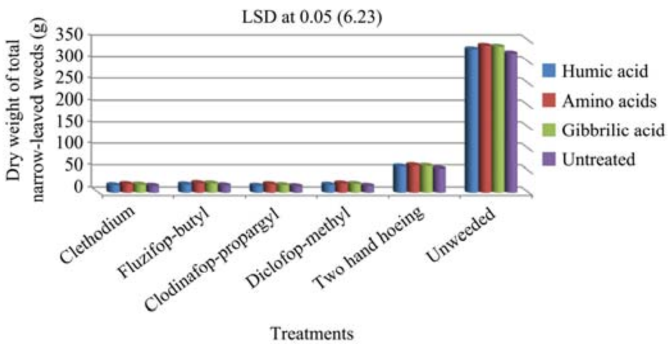
Treatments	Ryegrass				Wild oat				Total narrow weeds			
	Number		Dry weight (g)		Number		Dry weight (g)		Number		Dry weight (g)	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Bio–stimulants												
Humic acid	13.87	11.93	38.93	42.08	15.48	14.48	37.13	34.68	29.35	26.42	76.07	76.77
Amino acids	14.18	12.55	41.32	44.37	16.72	15.25	38.73	36.35	30.88	27.8	80.05	80.72
Gibbrilic acid	14.05	12.28	40.77	43.55	15.87	14.85	37.93	35.63	29.92	27.13	78.7	79.18
Untreated	13.7	11.43	37.92	39.83	15.13	13.77	35.43	33.48	28.33	25.2	73.35	73.15
LSD 0.05	NS	NS	2.11	2.27	NS	NS	1.78	2.07	NS	NS	2.57	2.34
Weed control												
Clethodium	4.53	3.93	8.48	8.55	6.38	5.68	10.75	9.7	10.9	9.6	19.23	18.25
Fluzifop– butyl	20.1	4.63	9.75	9.35	6.88	6.2	11.7	10.65	23.28	10.83	21.45	20
Clodinafop–propargyl	4.18	3.63	8.03	7.78	6.08	5.63	10.4	9.3	10.23	9.1	18.43	17.08
Diclofop–methyl	5.08	4.2	9.25	6.63	6.4	5.88	11.23	10.18	11.68	10.08	20.48	19.05
Two hand hoeing	11.98	10.23	29.5	33.4	12.45	11.5	27.43	25.93	24.43	21.73	56.93	59.33
Unweeded	51.8	45.7	173.4	186.8	56.43	52.8	152.35	144.48	108.23	98.5	325.75	331.03
LSD 0.05	2.13	3.21	7.16	9.18	2.11	2.98	10.23	10.77	8.75	9.43	19.69	21.12

Weed control practices significantly decreased the number and dry weight of wild oat, ryegrass and total grassy weeds at 90 DFS as compared to the unweeded check (Table 5). Clodinafop–propargyl was more effective than other weed control treatments against wild oat and ryegrass weeds. Clethodium came in the second rank followed by diclofop–methyl, Fluzifop– butyl and two hand hoeing. The maximum significant decreasing percentage in dry matter weight of weeds was obtained by clodinafop–propargyl (94.3%-94.8%) followed by clethodium (94.1%-94.5%), diclofop–methyl (93.7%-94.2%), fluzifop–butyl (93.4%-93.9%) and two hand hoeing (82.5%-82.1%) compared with unweeded treatment after 90 days from sowing in both seasons, respectively. The decreasing of weed total number and dry weight may be due to the inhibition result of herbicide treatments on the development of weeds. The variations of herbicides effect reflect the efficacy of inhibition to weeds emergence and growth. According to results in Table 5 number wild oat, ryegrass and total grassy weeds after 90 DFS were insignificantly affected by clodinafop–propargyl, clethodium, diclofop–methyl and fluzifop–butyl treatments. These results are in accordance with those recorded by Ghosheh (2000), El–Metwally et al. (2015) and Govind et al. (2015).

Data in Figure 1 showed that there was significant effect due to the result of interaction among bio-stimulants and weed control treatments on total dry matter weight of grassy weeds at 90 days. Application of clodinafop–propargyl markedly decreased total dry weight of garlic weeds m^{-2} without bio–stimulants was applied affected ryegrass and wild oat number and dry weight. While, the highest dry weight of garlic weeds was recorded with unweeded treatment with amino acids application interaction compared with the other interactions. In this trend, the interaction between herbicides (clethodium, fluzifop–butyl, clodinafop–propargyl, diclofop–methyl, two hand hoeing and unweeded) and biostimulants (Humic acid, amino acids, gibbrillic acid and untreated) significantly decreased the narrow–leaved weeds dry weights compared with unweeded. It appeared that herbicides effects were more effective on seeds weed germination and growth through inhibition of biostimulants effect on the physiological processes in narrow–leaved weeds. The results of the present investigation are in trend with those obtained by El–Metwally and Dawood (2016).



(a) 2015/2016 seasons



(b) 2016/2017 seasons

Figure 1 Interactive effects of bio–stimulants and weed–control treatments on total garlic narrow–leaved weeds dry weights during 2015/2016 (a) and 2016/2017 (b)seasons

3.2 Garlic growth

Regarding to humic acid, gibberellin acid and amino acids treatments effects, it was found that all growth parameters under investigation were significantly increased by all biostimulants treatments at 90 days from sowing relative to untreated (Table 6). The highest markedly increment in plant height, number of leaves/plant and total dry weight/plant resulted from gibberellin acid followed by amino acid and humic acid treatments in both seasons. While, the maximum values of neck diameter and bulb diameter were recorded with amino acids treatments followed by gibberellin acid and humic acid treatments. In this regard, there was no significant difference between gibberellin acid and amino acids in the most characters in both seasons. These increments in plant growth may be due to the increment effects of amino acid on cell enlargement (Baffel and Ibrahim, 2008), DNA replication and endogenous phytohormones in plant (Bartoli et al., 1999). The enhancement effect of amino acids on growth parameters of garlic plants were in good accordance with those reported by Tarek and El-Ramady (2014), Chattopadhyay et al. (2015), Shafeek et al. (2016) and Fikrte (2017).

In both seasons from the data in Table 6 which reveal that weed control treatments were significant influence of growth characters in garlic. Clethodium treatment significantly increased growth characters as compared to the weed control treatments. Clodinafop-propargyl came in the next position after clethodium in the most characters without significant differences. On the other hand, the lowest values of pervious characters were recorded with control plots.

The treatments proved to be effectual in controlling weeds and as a result the rivalry was limited and lighter, water and nutrients were obtainable to promote the garlic growth if compared to the other weed control treatments. The results of the present investigation are in trend with those obtained by Ghosheh (2000), Mahmood et al. (2002), El–Metwally et al. (2012), Hassanein et al. (2012) and Rahman et al. (2012).

Table 6 Growth characters of garlic as affected by bio-stimulants and weed control treatments during 2015/2016 and 2016/2017 seasons

Treatments	Growth characters									
	Plant height (cm)		Number of leaves/plant		Neck diameter (cm)		Bulb diameter (cm)		Total dry weight/plant (g)	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Bio-stimulants										
Humic acid	73.55	75.82	8.27	9.10	1.44	1.63	3.53	3.75	16.01	16.75
Amino acids	75.53	76.88	8.80	9.25	1.68	1.89	3.81	4.11	16.21	17.64
Gibbrilic acid	75.59	79.72	9.15	9.62	1.56	1.82	3.65	3.90	16.56	18.40
Untreated	68.62	71.78	7.92	8.17	1.32	1.47	2.60	3.24	11.75	14.42
LSD 0.05	1.16	1.33	0.43	0.52	0.14	0.11	0.23	0.31	1.49	1.93
Weed control										
Clethodium	77.25	79.10	9.15	9.65	1.75	1.95	3.81	4.03	16.56	18.34
Fluzifop–butyl	73.94	76.38	8.43	8.88	1.38	1.68	3.54	3.80	15.48	17.01
Clodinafop–propargyl	76.00	78.78	8.90	9.37	1.67	1.83	3.70	3.92	16.21	17. 85
Diclofop–methyl	75.13	78.00	8.60	9.03	1.55	1.79	3.61	3.89	15.81	17.68
Two hand hoeing	73.03	75.13	8.25	8.80	1.38	1.58	3.48	3.67	14.96	16.40
Unweeded	64.35	68.93	7.88	8.48	1.28	1.38	3.01	3.19	11.79	13.53
LSD 0.05	1.56	1.33	0.78	0.92	0.16	0.22	0.42	0.47	1.55	1.62

3.3 Garlic blub yield and yield attributes

Results in Table 7 showed that the foliar application of bio-stimulants had significant effect on number of cloves/blub, cloves weight (g), average bulb weight (g) and total yield (ton/fed.). Amino acids application at the concentration 100 ppm significantly produced the highest blub yield and yield attributes compared to control. Gibbrillic acid concentration (50 ppm) came in the second rank followed by humic acid at the rate of 4 gm L^{-1}. This increasing in blub yield amounted to 24.8%-19.4%, 19.1%-16.7% and 13.1%-8.0% more than untreated plants in 1st and 2nd seasons, respectively. There was no significant difference between amino acids and gibbrillic acid on blub yield of garlic. The increasing in blub yield and yield attributes may be due to which stimulation and/or enhancing the metabolism processes in plant tissues. Furthermore, the application of amino acid as foliar application could provide the plant parts which promote synthesis of plant organs consequently. Also, humic acid stimulate plant development by the assimilation of macro and micronutrients, enzyme activation and /or inhabitation, changes in membrane permeability, protein synthesis and finally the activation of dry matter production. Similar results were reported by Gad et al. (2012), Tarek and El–Ramady (2014), Singh et al. (2014) and Shafeek et al. (2016).

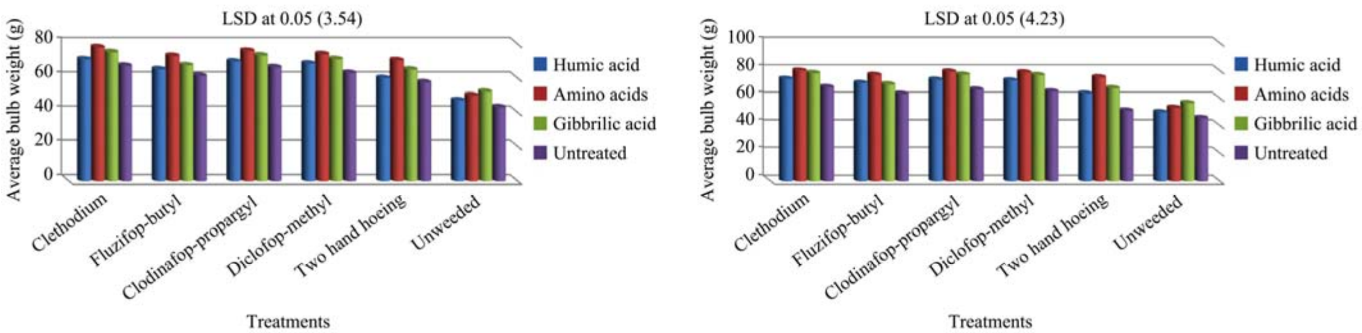
Results in Table 7 showed significant effect of weed management on number of cloves/blub, cloves weight (g), average bulb weight (g) and total blub yield (ton/fed.). The maximum values of the blub yield and yield components were obtained from clethodium application followed by clodinafop–propargyl, diclofop–methyl, fluzifop–butyl and two hoeing. However, the lowest ones were obtained from the control. The increment in total bulb yield resulting from clethodium, clodinafop–propargyl, diclofop–methyl, fluzifop–butyl herbicides application amounted to 83.8%, 78.7%, 75.5% and 67.7% in the first season and 89.3%, 87.3%, 83.4% and 77.3% in the second season, respectively over than unweeded. Such dominance of these weeded treatments may be associated with reducing weed–crop competition (Table 3).

Table 7 Effect of biostimulants and weed control treatments on yield and it's attributes of garlic during 2015/2016 and 2016/2017 seasons

Treatments	Yield and yield attributes									
	Number of cloves/blub		Cloves weight (g)		Cloves diameter (cm)		Average bulb weight (g)		Total blub yield (ton/fed)	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Bio-stimulants										
Humic acid	12.35	13.17	2.04	2.18	0.96	1.03	63.71	67.55	6.99	7.18
Amino acids	13.78	14.40	2.69	3.12	1.13	1.20	70.39	73.99	7.71	7.94
Gibbrilic acid	12.78	13.67	2.49	3.03	1.04	1.12	67.53	71.12	7.36	7.76
Untreated	10.53	11.10	1.85	2.05	0.92	1.02	59.90	59.98	6.18	6.65
LSD 0.05	1.12	1.34	0.87	0.45	NS	NS	3.23	4.11	0.26	0.31
Weed control										
Clethodium	14.00	14.88	2.59	2.95	1.13	1.22	73.03	75.22	8.03	8.33
Fluzifop- butyl	12.43	12.95	2.25	2.61	0.99	1.05	66.94	70.42	7.33	7,80
Clodinafop -propargyl	13.40	14.03	2.38	2.79	1.07	1.13	71.51	74.15	7.67	8.07
Diclofop–methyl	13.33	14.13	2.46	2.85	1.10	1.17	69.58	73.48	7.84	8.24
Two hand hoeing	11.75	12.50	2.24	2.43	0.96	1.03	63.41	64.34	7.15	7.51
Unweeded	9.28	10.03	1.74	1.93	0.84	0.95	48.11	51.36	4.30	4.40
LSD 0.05	1.02	1.12	0.23	0.34	NS	NS	3.11	3.67	0.33	0.52

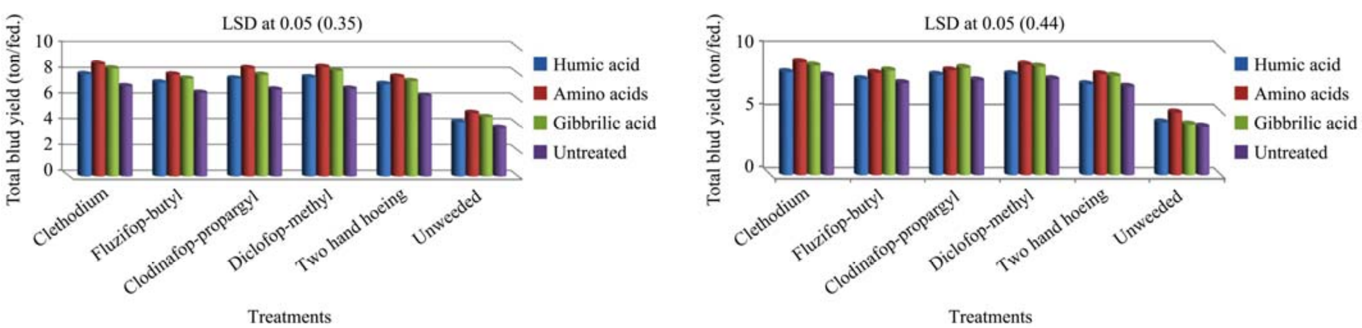
This in turns increment foliage, plant height and created more photosynthesis, motivated and accumulated in various plant partes which positively reflected on yield production. Similar results were reported by El–Metwally et al. (2010), Hassanein et al. (2012), Rahman et al. (2012) and Aghabeigi and Khodadadi (2017).

The results showed that there were significant interactions between factors under study on bulb weight (g) and total blub yield (ton/feddan) (Figures 2 and 3). The maximum values were obtained from application of amino acid at the rate of 100 ppm or gibbrillic acid at the rate of 50 ppm integrated with clethodium or clodinafop–propargyl. On the other side, the minimum superiority of herbicides treatments integrated with bio–stimulant



(a) 2015/2016 seasons (b) 2016/2017 seasons

Figure 2 Interactive effects of bio–stimulants and weed–control treatments on average bulb weight (g) at harvest during 2015/2016 (a) and 2016/2017 (b) seasons



(a) 2015/2016 seasons (b) 2016/2017 seasons

Figure 3 Interactive effects of bio–stimulants and weed–control treatments on total blub yield (ton/fed) at harvest during 2015/2016 (a) and 2016/2017 (b) seasons treatments, mainly due to the superior weed control competence and decrease competition ability of weeds gave a competitive advantage for the garlic plants in utilizing the vital demands of nutrients and water, leading to increment the garlic growth and yield. Similar results were reported by El–Metwally and Abdelhamid (2008).

3.4 Photosynthetic pigments of green garlic

The changes in chlorophyll a (chl. a), chlorophyll b (chl. b), total chlorophyll and carotenoid photosynthetic pigments in response to bio-stimulants are shown in Table 8. Data reveal that amino acids or humic acid treatments caused significant increment in photosynthetic pigment constituents as compared with corresponding controls in both seasons. The maximum values of total photosynthetic pigments were recorded by amino acids at a rate (100 ppm) followed by humic acid at the rate (4 g L^{-1}) and gibbrillic acid at the rate (50 ppm) treatments. These results may be due to amino acids role in increasing chlorophyll content in plant that reflected on stimulation of photosynthesis. Which lead to increase carbohydrates content of the plant, fundamentally cellulose, hemicelluloses and pectin and lignin which deem an important thematic compound of plant that improvement in growth characters and yield. The obtained inference is fetching to oneself conclusion with Tarek and El–Ramady (2014), Singh et al. (2014) and Shafeek et al. (2016) on garlic.

Data in Table 8 indicated that photosynthetic pigments (chl. a, chl. b, total chl. and carotenoid) were significantly varied with weed control treatments at 90 days from sowing. In this connection, two hand hoeing significantly increased aforementioned traits compared to other treatments. Clethodium herbicide gave the maximum values of photosynthetic pigments after two hoeing treatments. The treatments proved to be effective in controlling weeds and as a result the competition was incomplete and lighter on water and nutrients availability to help the garlic growth if compared to the other treatments. There was no significant difference between two hoeing and herbicides treatments on obvious characters under condition investigation. The results of the present investigation are in trend with those obtained by El–Metwally et al. (2010), Rahman et al. (2011) and Hassanein et al. (2012).

Table 8 Photosynthetic pigments of garlic plant after 90 days from sowing as affected by bio–stimulants and weed control treatments during 2015/2016 and 2016/2017 seasons

Treatments	Photosynthetic pigments							
	chlorophyll a		chlorophyll b		chlorophyll a+b		Carotonids	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Bio–stimulants								
Humic acid	0.461	0.491	0.207	0.226	0.668	0.717	0.387	0.412
Amino acids	0.484	0.510	0.214	0.236	0.698	0.746	0.399	0.421
Gibbrilic acid	0.415	0.457	0.175	0.201	0.590	0.658	0.333	0.379
Untreated	0.409	0.463	0.162	0.200	0.571	0.663	0.324	0.374
LSD 0.05	0.011	0.017	0.009	0.012	0.032	0.045	0.022	0.031
Weed control								
Clethodium	0.463	0.500	0.200	0.225	0.663	0.725	0.371	0.408
Fluzifop– butyl	0.420	0.465	0.179	0.209	0.599	0.674	0.349	0.388
Clodinafop–propargyl	0.440	0.419	0.191	0.214	0.633	0.693	0.356	0.394
Diclofop–methyl	0.443	0.488	0.193	0.219	0.634	0.707	0.365	0.400
Two hand hoeing	0.474	0.510	0.205	0.231	0.679	0.741	0.379	0.416
Unweeded	0.414	0.440	0.169	0.197	0.583	0.637	0.343	0.375
LSD 0.05	0.034	0.029	0.016	0.018	0.022	0.031	0.019	0.013

3.5 Biochemical constituents of bulb garlic

Amino acid application significantly increased the chemical constituents (phenol and lipid) of bulb garlic at harvest as shown in (Table 9). While gibbrillic acid gave the maximum values of flavonoid and indoles of green blub garlic at harvest. Phenol and lipid were more affected with amino acids concentration (100 ppm). This effect might be due to nitrogenous compounds assimilation of tryptophan to the others compounds as precursors for a wide range of secondary metabolites that produced through the shikimate pathway followed by the branched aromatic amino acid metabolic pathway. Additionally, carbon skeleton of the aromatic amino acids is converted to the free amino acids. Foliar and soil application of humic acid in plant increases auxin, cytokinin and GA hormones in plant (Abdel–Mawgoud et al., 2007). Also, results indicated that no significant differences between bio–stimulants application. The results of the present investigation are in trend with those obtained by Zeinali and Moradi (2015).

Table 9 Biochemical constituents of bulb garlic after 150 days from sowing as affected by bio–stimulants and weed control treatments during 2015/2016 and 2016/2017 seasons

Treatments	Biochemical constituents of green garlic plant							
	Phenols (mg g^{-1})		Lipids (%)		Flavonoids (mg g^{-1})		Indoles (mg g^{-1})	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Bio–stimulants								
Humic acid	6.19	6.61	4.67	4.93	0.62	0.72	9.55	10.10
Amino acids	6.40	6.72	4.76	5.04	0.37	0.53	10.17	10.62
Gibbrilic acid	5.99	6.38	4.23	4.43	0.69	0.77	10.47	10.87
Untreated	5.16	5.73	3.73	4.00	0.44	0.54	8.75	9.77
LSD 0.05	0.45	0.82	0.39	0.42	0.12	0.17	0.72	0.81
Weed control								
Clethodium	6.26	6.70	4.63	4.89	0.61	0.72	10.33	10.90
Fluzifop– butyl	5.83	6.23	4.20	4.42	0.47	0.57	9.25	9.88
Clodinafop–propargyl	5.99	6.45	4.35	4.59	0.50	0.61	9.60	10.32
Diclofop–methyl	6.12	6.59	4.43	4.69	0.55	0.67	10.03	10.58
Two hand hoeing	6.49	6.86	4.74	4.93	0.69	0.78	10.63	11.16
Unweeded	4.93	5.32	3.72	4.09	0.37	0.49	8.58	9.20
LSD 0.05	0.67	0.73	0.46	0.51	0.15	0.21	0.58	0.62

Total phenolic, lipid, flavonoid and indoles substance were substantially influenced by weed control treatments as shown in Table 9. In this regard, the phenolic substance of garlic bulb decreased significantly as a result of all treatments compared to control treatment. The greatest decrease was recorded with clethodium application, while the minimum decrease was recorded with two hoeing treatments. Clethodium herbicide exceeded the rest of other weeded methods for enhancing lipid, flavonoid and indoles content in garlic blub. diclofop–methyl herbicide came in the second rank followed by that of clodinafop–propargyl treatments. The obtained inference is fetching to oneself conclusion with El–Metwally et al. (2012).

4 Conclusion

It can be concluded that the application of clethodium treatment has produced the maximum values of vegetative growth and yield attributes of garlic plant. Furthermore, two hand hoeing showed the highest values of photosynthetic pigments and biochemical constituents. The interaction between bio–stimulants and weed control recorded significant effect on total dry weight of narrow–leaved weeds, average bulb weight and bulb garlic yield. Clethodium herbicide integrated with amino acids at the concentration 100 ppm application produced the greatest values of growth and yield of garlic plants under newly reclaimed soil conditions.

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