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Stimulatory Effect of Hormones, Vitamin C on Growth, Yield and Some Metabolic Activities of *Chenopodium quinoa* Plants in Egypt

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Abstract

This research examine the actual growth, yield and certain metabolic activities of quinoa plants in response to foliar treatments with GA_3 50 ppm, JA 20 ppm and Asc. 50 ppm. Plants were grown in natural clay loamy soil conditions and treated with every of the aforementioned treatments. The treated plants showed significant responses in most of the growth and yield characteristics (lengths of shoots and roots, number of branches/plant, number of leaves/plant, plant biomass and weight of 1000-seed). Also, these treatments caused significant increases in the contents of photosynthetic pigments, soluble carbohydrates, soluble proteins and total phenols content. This was the case during the entire duration of time period of the experiment.

Keywords: Quinoa; Foliar treatment; Gibberellic acid; Jasmonic acid; Ascorbic acid

Introduction

Increasing yield for an ever growing world population has currently become a topic of great concern with regard to food security. Especially in Africa, agricultural productivity has not been able to cope with population growth, leading to increased annual imports and food insecurity [1].

The year 2013 was declared The International Year of the Quinoa (IYQ2013) by the Food and Agriculture Organization of the United Nations (FAO) in recognition of the indigenous peoples of the Andes who have maintained, controlled, protected and preserved quinoa as human food for present and future generations using their traditional knowledge and practices of living in harmony with the earth and nature [2]. Because it is already part of existing high-value agro biodiversity, quinoa is poised to play an important role in strategies designed to adequately feed the growing world population in a sustainable manner [3].

In comparison to most cereals, quinoa seeds have a higher nutritional value [4]. Quinoa is a good source of essential amino acids such as lysine and methionine. Quinoa contains relatively high quantities of vitamins (thiamine, vitamin C) and minerals [5].

Quinoa is a highly nutritious food crop, with an outstanding protein quality and a high content of a range of vitamins and essential minerals [6]. Quinoa has enormous potential in the food industry being gluten-free and highly nutritious [7]**.** This is of great importance for the nutritional value of cereals, because a high content of dietary fibre has positive effects on the reduction of the cancer risk. In general, quinoa contained higher total mineral contents than the other cereals such as rye and wheat [8].

Quinoa (*Chenopodium quinoa* Willd) is one of the most important economic crops belongs to the family *chenopodiaceae*. It is able to grow under conditions normally inhospitable to other cereals. These conditions include low rainfall, high altitude, sub-freezing or high temperatures [9]. In comparison to other cereal, it has a higher protein content, better amino acid composition, minerals, and vitamin values and also has a high oil content meet or exceed the requirements of human [10,11]. It is considered to be the most yield-limiting micronutrient in crop production in various parts of the world [12,13].

In fact Improvement of crops in both quantity and quality is among the goals of the modern applied science and technology. In this regard, the effects of spray of phytohormones, such as Gibberellic acid (GAs), Jasmonic acid (JA) are plant hormones but GAs have many different chemical forms [14,15].

Gibberellins influence many aspects of plant growth and development. GA_3 is an essential growth hormone that is known to be actively involved in various physiological activities such as growth, flowering and ion- transport [16]. Jasmonic acid (JA) is collectively referred to as jasmonates and are important cellular regulators which are involved in diverse developmental processes such as seed germination, root growth, fertility, fruit ripening, and senescence [17]. JA is important components of the complex signaling networks that mediate plant defense responses against pathogens and are implicated in systemic resistance responses. However, the nature of the mobile signal for establishing sys-temic resistance remains elusive [18].

Ascorbic acid (vitamin C) has a regulatory role in promoting productivity in many plants, Ascorbic acid acts as a cofactor for several enzymes and regulates the phytohormone-mediating signaling processes [19] and many physiological processes in plants [20,21]. Ascorbic acid is cofactors for enzyme activity, and effects on plant antioxidation capacity, heavy metal evacuation and detoxification and stress defense [22].

The scope of the present analysis would be to discover the potent results of gibberellic acid, jasmonic acid, Ascorbic acid, on growth and productivity of quinoa plant.

Materials and Methods

Methods of planting, treatments and collection of samples

Uniform quinoa seeds were planted in Botanical garden; Botany and Microbiology Dept., Fac. of Sci., Al-Azhar Univ., Nasr City, Cairo,

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Egypt, Seeds of quinoa were sown in plots (4 m width and 10 m length). The plot contained 12 rows, 70 cm apart and the hills were spaced at 20 cm distance. Lit of seeds were sown in each hill, and the stand was later thinned to two plant per hill. Land preparations, agricultural operations followed the normal practices of crops cultivation in the clay loamy soils, the 12 rows divided into 4 groups representing the following treatments:

1. Tap water (control)
2. Gibberellic acid (50 ppm)
3. Jasmonic acid (20 ppm)
4. Ascorbic acid (50 ppm)

The plants of *Chenopodium quinoa* Willd were treated triple with the above mentioned treatments (as foliage spraying). The first treatment was made when the age of plants was 30 days, while the second treatment was made when the age of plants was 60 days and the third treatment was made when the age of plants was 90 days. The plant samples were collected for analysis when the plants were 40 (Stage I), 70 (Stage II) and 100 (stage III) days old. At the end of the growth season (170 days), analyses of the seeds yielded from the different treatments as well as the control were done.

Analysis of soil

Analysis of soil were record Physical properties and chemical properties (Tables 1 and 2). *Physical and chemical properties of the soil.

Measurement of soil and growth parameters

Shoot length (cm), root length (cm), number of leaves per/plant, number of branches per/plant, fresh and dry weights of shoots (g/plant), fresh and dry weights of roots (g/plant), weight of 1000-seeds (g) were determined at different growth stages.

Chemical analysis

Photosynthetic pigments were estimated using the method of Ref. [23] Contents of soluble carbohydrates were measured according to the method of Ref. [24]. Contents of soluble proteins were estimated according to the methods of Ref. [25]**.** Phenolic compounds were estimated according to the methods of Ref. [26]. total lipids were estimated according to the methods of Ref. [27]. Total saponin were estimated according to the methods of Ref. [28,29].

Statistical methods

All statistical calculations were done using computer programs. Microsoft excel version 10 and spss (statistica package for the social science version 20.00) statistical program at 0.05 level of probability [30] the One-way ANOVA was presented using percentage, mean ±standard error. The discernment, Pearson correlation and automatic linear models analysis were estimated to show the relationship of the physiological parameter to each other [31].

Results and Discussion

Growth and yield responses

It was revealed from results (Figures 1-9) that significant differences were reported for all studied traits of seeds. One of the most of investigated growth qualities percentage were (shoot length (I-14.26%, II -64.47%, III 22.14%) and root length (I-17.53%, II - 15.42%, III 15.31%), number of leaves/plant (I-19%, II - 26.65%, III 7.95%), number of branches/plant (III - 11.86%), fresh weight of shoots (I-108.43%, II - 73.84%, III 21.50%), dry weight of shoots (I-25%, II - 46.25%, III 70.20%), fresh weight of roots (I-44.44%, II - 43.75%, III 7.88%), dry weight of root (I-11.76%, II - 64.71%, III 82.78%) and the weight of 1000-seeds 55.42%) of quinoa plant life have been markedly significant increase when compared with control plant. Responding to the application of GA_3. These consequences had been more powerful

Texture class	Sand	Clay	Silt
Clay loamy	30.70	47.81	22.14

Table 1: Physical properties of the used soil as percentage %.

TSS ppm	pH	E.C. mmhos/cm	Cations meq/L				Anions meq/L			
768	7.9	2.65	Na^+	K^+	Ca^{++}	Mg^{++}	Cl^-	$SO4^{--}$	$HCO3^-$	$CO3^{--}$
			2.5	0.5	2	1	4	1	1	Zero

Table 2: Chemical properties of the used soil.

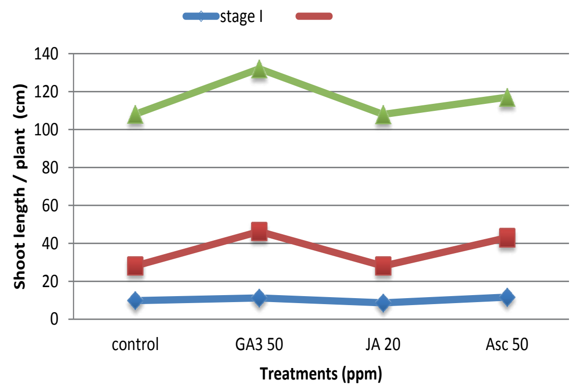


Figure 1: Effect of gibberellic acid, jasmonic acid and Ascorbic acid on shoot length/plant of (*Chenopodium quinoa* Willd) plants.

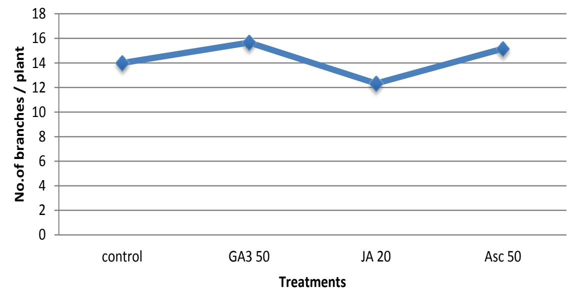


Figure 2: Effect of gibberellic acid, jasmonic acid and Ascorbic acid on No.of branches/plant of (*Chenopodium quinoa* Willd) plants.

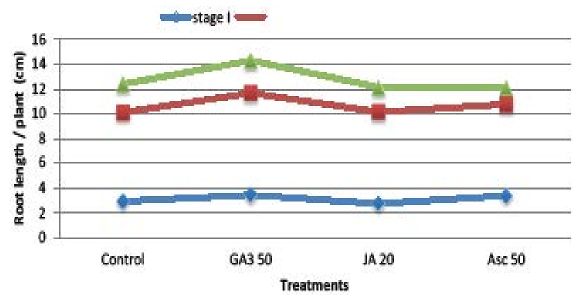


Figure 3: Effect of gibberellic acid, jasmonic acid and Ascorbic acid on root length/plant of (*Chenopodium quinoa* Willd) plants.

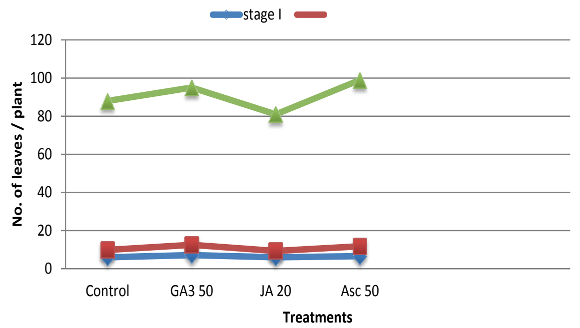


Figure 4: Effect of gibberellic acid, jasmonic acid and Ascorbic acid on no.of leaves/plant of (*Chenopodium quinoa* Willd) plants.

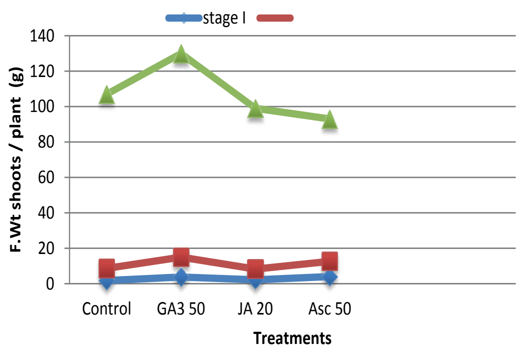


Figure 5: Effect of gibberellic acid, jasmonic acid and Ascorbic acid on fresh weight of shoots/plant of (*Chenopodium quinoa* Willd) plants.

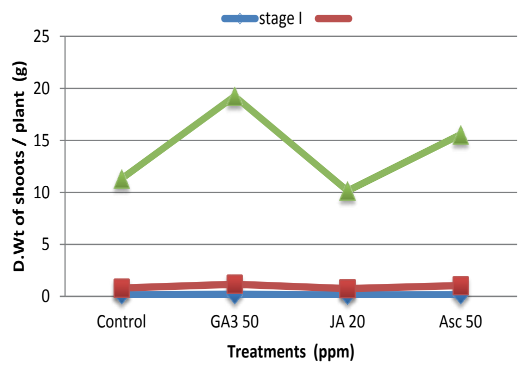


Figure 6: Effect of gibberellic acid, jasmonic acid and Ascorbic acid on dry weight of shoots/plant of (*Chenopodium quinoa* Willd) plants.

with the levels I, II and III of development. The stimulative effects of GA_3 on plant growth were also obtained by many workers [32] reported that GA_3 application significantly affected leaves fresh and dry weight of *Coleus amboinicus* L. At the same time, [33] Furthermore, Ref. [34] working on ajwain Plants, confirmed that foliar application of GA_3 at 50 ppm significantly increased plant height, number of leaves, number of brunches and dry biomass/plant as compared to the control plants. Ref. [35] reported that exogenous application of gibberellic acid concentration at (50 ppm) on carrot plants led to significantly increased plant height cm, number of branch/plant, number of flower/plant, shoot fresh weight (gm), shoot dry weight (gm) and dry weight of biological weight gm/plant when compared with controlling plants.

As this has been mentioned in JA had markedly significant reduced on vegetative growth variables percentage of quinoa when compared with control plant, except weight of 1000-seeds obtained considerably significantly increased (Figures 1-9). The result of JA implying which may be in charge of the decline from the growth relevant traits.

These results are also consistent with Ref. [36] who reported that shoot fresh weight, root fresh weight and root length were reduced by MJ treatment in Scots pine. Ref. [37] observed that jasmonic acid treated seeds resulted in decreased root length and shoot length of *Brassica napus* as compared to control plant. Ref. [38] noticed that spraying cucumber plants with 0.75mM MJ significantly showed a decrease in plant height, dry weight of leaves and number of leaves per plant compared to the untreated control.

Every one of the progress qualities like vegetation height, quantity of results in number of branches/vegetation, shoot fresh weight, root fresh weight, root length and the weight of 1000-seeds products of

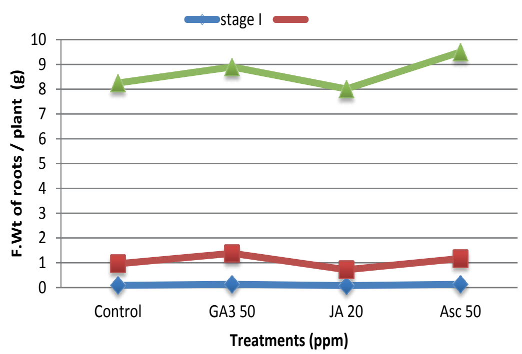


Figure 7: Effect of gibberellic acid, jasmonic acid and Ascorbic acid on fresh weight of roots/plant of (*Chenopodium quinoa* Willd) plants.

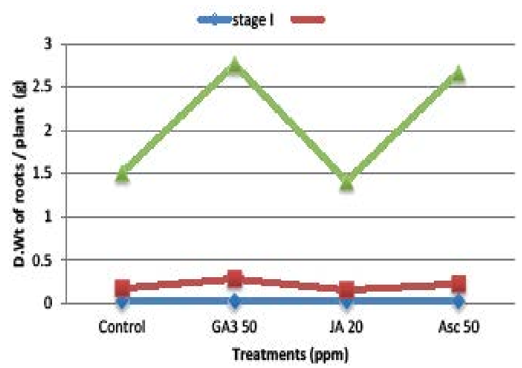


Figure 8: Effect of gibberellic acid, jasmonic acid and Ascorbic acid on dry weight of roots/plant of (*Chenopodium quinoa* Willd) plants.

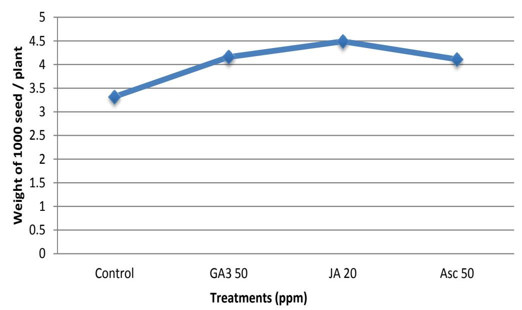


Figure 9: Effect of gibberellic acid, jasmonic acid and Ascorbic acid on weight of 1000 seeds per treatment (gm.) of (*Chenopodium quinoa* Willd) plants.

quinoa plants were actually significantly improved by exogenous use of Ascorbic acid as compared to the unsprayed vegetation (Figure 1-9).

The Asc. treatment in the current study is in accordance with that of Ref. [39] found stimulatory effect of Ascorbic acid (100 and 200 ppm) on all growth parameters (plant height, number of branches, number of leaves, root length as well as fresh and dry weights of all plant organs) of *Codiaeum variegatum* L. plants. Ref. [40] Showed the best results on fresh and dry weight of pumpkin due to 30 mg L^{-1} Ascorbic acid treatments. Ref. [41] reported that application of Asc. 50 ppm significantly increased shoot length, root length, number of leaves as well as fresh and dry weights of all plant organs) of (*Helianthus annuus*) plants.

Photosynthetic pigments

Outcomes of the present study (Figures 10 and 11) shown that, contents percentage of chlorophyll a (I- 0.14%, II- 0.58%, III- 0.49%), b (I- 6.22%, II- 63.17%, III- 2.65%), and carotenoids (I- 5.45%, II- 39.52%%, III- 55.56%), of quinoa plant life were actually dramatically significantly increased in response to the use of GA_3.

These results are in agreement with the results obtained by Ref. [35] reported that exogenous application of gibberellin concentration at (50 ppm) on carrot plants led to significantly decreased chlorophyll content when compared with controlling plants. Ref. [42] reported that foliar application (*Schefflera arboricola* L.) plants with GA_3 at 200 mg L^{-1} increased Chl. (a), (b) contents of (*Schefflera arboricola* L.) when compared to control plant.

With respect to the effect of JA on chlorophyll content percentage of quinoa plants, the obtained results showed different responses as regards the contents of chlorophylls of the three tested plants. In quinoa plants, application of JA was found to be, mostly, significant decreases percentage as regards the contents of chlorophyll a, b while increased

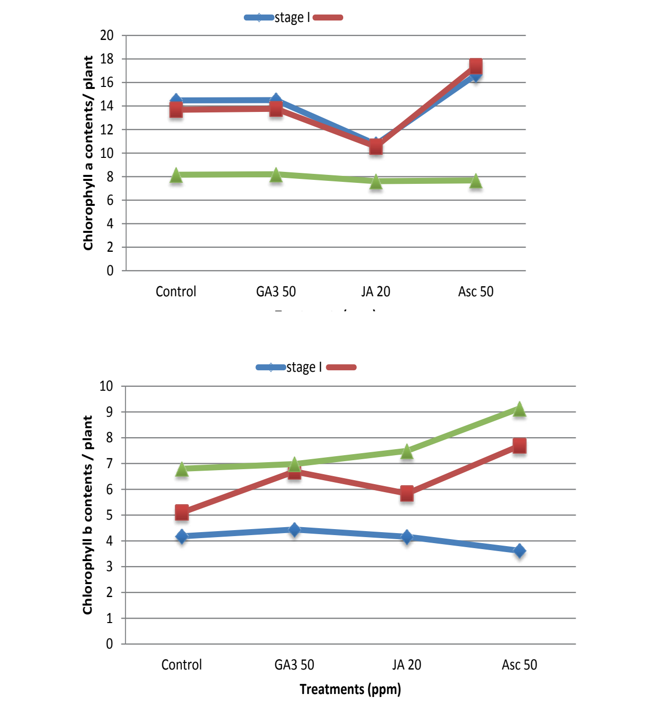


Figure 10: Effect of gibberellic acid, jasmonic acid and Ascorbic acid on chlorophyll contents (mg/g. fresh weight) of (*Chenopodium quinoa* Willd) plants.

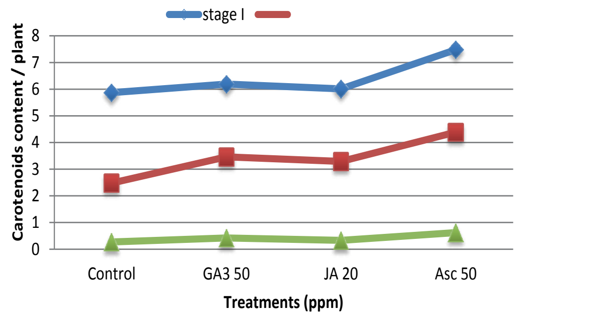


Figure 11: Effect of gibberellic acid, jasmonic acid and Ascorbic acid on carotenoids contents (mg/g. fresh weight) of (*Chenopodium quinoa* Willd) plants.

in carotenoids (I- 2.39%, II- 32.66%, III- 22.22%). These results are in harmony with those obtained by Ref. [43] who found that JA treatment decreased chlorophyll content of *Arabidopsis thaliana*.

These results are in agreement with the results obtained by Ref. [44] observed that chlorophyll content of soybean plants significantly decreased with the application of 20 µM MeJA and 30 µM MeJA. Ref. [45] found that application of the growth retardant (JA) decreased contents of chlorophyll a, chlorophyll b and carotenoids in Lemon plant.

The present work, were actually taken as value the examined chlorophylls contents percentage of quinoa plant life responding to the use of Asc. In quinoa plants, treatment with Asc. caused, generally, extremely considerable and substantial raises inside the contents of chlorophyll a (I- 14.99%, II- 27.05%, III- -5.88%), b (I- -13.40%, II- 87.56%, III- 34.41%) and carotenoids (I- 27.43%, II- 77.02%, III- 129.63%). In accordance with the obtained results, Ref. [46] showed that foliar application of vitamin C significantly increased photosynthetic pigments compared with the control plants of flax plants. Ref. [47] mentioned that tomato seeds soaked before planting in Ascorbic acid (Asc.) at 50 ppm which leads to significantly increase the contents of chlorophyll a, b and carotenoids as compared with the control of (*Lycopersicon esculentum* Mill.) plants.

Soluble carbohydrates

Outcomes of the current work (Figures 12-15) reported that, contents in total soluble carbohydrates percentage were significantly considerably elevated in shoots (I- 43.52%, II- 106.99%, III- 78.71%) and produced seed products (43.81%) of quinoa plants as a result of the treatment with GA_3. It was the situation through the three stages of growth. These effects were more powerful in all stages of growth. The stimulatory results of GA_3 in regards to contents in total soluble carbohydrates in various plants were recorded by other researchers. Ref. [48] indicated that cotton plants treated with GA_3 at 100 ppm caused increase in total sugars in leaves and seeds in the two seasons compared with untreated plants. Ref. [49] indicated that treating (*Euphorbia antisyphilitica*) plants with GA_3 at 60 µm significantly increased total sugars contents. Ref. [50] found that treating gladiolus plants with GA_3 at the concentration of 1mM (as a foliar application) significantly increased total soluble sugars contents.

In our study, it had been found (Figures 12-15) that carbohydrate contents percentage in shoots (I- 11.19%, II- 21.22%, III- 78.15%) as with the produced seed products (23.87%) of quinoa plants were significantly considerably elevated as a result of the remedies with JA. In accordance with the obtained results, Ref. [51] indicated that

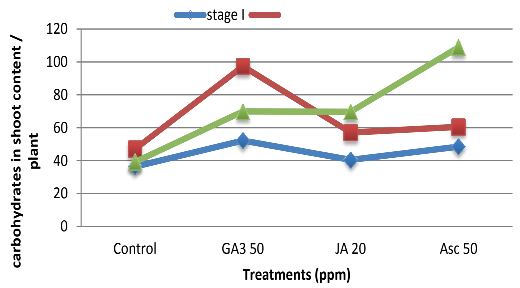


Figure 12: Effect of gibberellic acid, jasmonic acid and Ascorbic acid on total water soluble carbohydrates contents (mg/g. dry weight) of (*Chenopodium quinoa* Willd) plants.

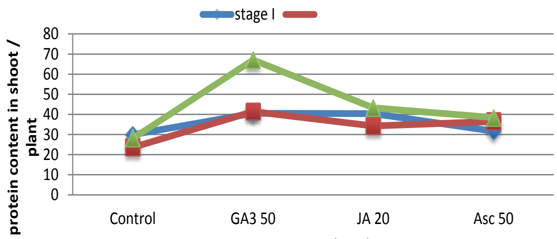


Figure 13: Effect of gibberellic acid, jasmonic acid and Ascorbic acid on total water soluble proteins contents (mg/g. dry weight) of (*Chenopodium quinoa* Willd) plants.

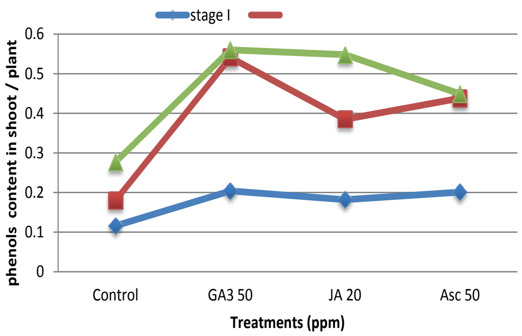


Figure 14: Effect of gibberellic acid, jasmonic acid and Ascorbic acid on total phenols contents (mg/100g. dry weight) of (*Chenopodium quinoa* Willd) plants.

Application of MJ increased total soluble sugars content of tomato fruits. Ref. [52] demonstrate that MeJA treatment caused significant increases in total soluble sugar, polysaccharides and total carbohydrate in maize plants, as compared with the corresponding untreated plants.

The acquired results revealed additionally that, use of Asc.. in regards to the carbohydrate contents percentage, in quinoa plants, items in soluble carbohydrates in shoots (I- 33.46%, II- 28.66%, III- 178.51%) as well as, within the produced seed products (27.45%) were significantly substantially elevated as a result of the treatment with Asc. Ref. [46] showed that foliar application of these vitamin C significantly increased carbohydrates accumulation in treated flax plants compared with the control plants. Ref. [53] found that, ascorbic acid caused superior effects on lettuce plant height as well as increased total carbohydrates. Ref. [41] reported that treatment of (*Helianthus annuus*) and (*Sesamum indicum*) plants with Asc. 50 ppm that increase total water soluble carbohydrates contents.

Soluble proteins

In our study, it had been found (Figures 13-15) that protein contents percentage in shoots (I- 35.25%, II- 75.66%, III- 139.13%) as with the produced seed products (58.39%) of quinoa plants were significantly considerably elevated as a result of the treatment with GA_3. In compliance using the acquired results, Ref. [54] reported that treating (*Hibiscus sabdariffa* L.) plants with GA_3 at 100 ppm increased total proteins percentage compared with untreated plants. Ref. [55] reported that treating (*chamomile recutita* L.) plants with GA_3 at (50 ppm) significantly increased crude protein content compared with untreated control plants. Ref. [48] indicated that cotton plants treated with GA_3 at 100 ppm caused increase in protein percentage in cotton seeds in the two seasons compared with untreated plants.

In our study, it had been found (Figures 13-15) that protein contents percentage in shoots (I- 34.58%, II- 45.21%, III- 54.10%) too as with the produced seed products (18.69%) of quinoa plants were significantly considerably elevated as a result of the remedies with JA. In compliance using the acquired results.

In this regard, Ref. [56] was reported to increase protein content. Earlier studies revealed that JA treatments enhanced the protein concentration of peanut [57]. Ref. [52] found that MeJA increased total protein of maize plants compared to the corresponding untreated plant.

The acquired results revealed additionally that, use of Asc. in regards to the protein contents percentage, in quinoa plants, contents of soluble proteins in shoots (I- 5.61%, II- 54.71%, III- 36.85%) as well as, within the produced seed products (32.98%) were significantly substantially elevated as a result of the treatment with Asc.

In this regard, Ref. [46] showed that foliar application of vitamin C significantly increased proteins accumulation in vitamins treated flax plants compared with the control plants. Ref. [58] reported that foliar spray with Ascorbic acid at 200 ppm increased protein % of seeds of pea cv. plants in the two growing seasons comparing with untreated plants.

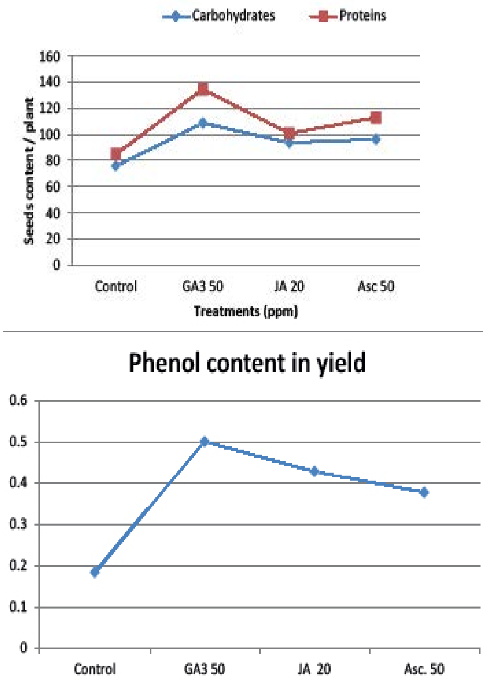


Figure 15: Effect of gibberellic acid, jasmonic acid and Ascorbic acid on total soluble carbohydrates contents (mg/g. dry weight), total soluble proteins contents (mg/g. dry weight) and total phenols contents (mg/100g.dry weight) of (*Chenopodium quinoa* Willd) plants.

Total phenols

In our study, it had been found (Figures 13-15) that phenols content percentage in shoots (I- 66.67%, II- 200%, III- 100%) as with the produced seed products (177.78%) of quinoa plants were significantly considerably elevated as a result of the remedies with GA_3. In compliance using the acquired results, Ref. [59] indicated that spraying croton plants with GA_3 at 100, 150 and 200 ppm stimulated the content of total phenols in croton plants compared with the control treatment. Ref. [48] Indicated that cotton plants treated with GA_3 at 100 ppm showed increase in phenols content in leaves throughout two seasons compared with untreated control plants.

In our study, it had been found (Figures 14-15) that phenols content percentage in shoots (I- 50%, II- 111.11%, III- 96.43%) too as with the produced seed products (138.89%) of quinoa plants were significantly considerably elevated as a result of the remedies with JA. In compliance using the acquired results. In this regard, Ref. [60] working on *Panax ginseng* plants, reported that significant increase in total phenolics contents in response to MJ treatments.

The acquired results revealed additionally that, use of Asc.. in regards to the phenols contents percentage, in quinoa plants, contents of soluble phenols in shoots (I- 66.67%, II- 144.44%, III- 60.71%) as well as, within the produced seed products (111.11%) were significantly substantially elevated as a result of the treatment with Asc. In this regard, Ref. [53] found that, in lettuce plants, treatment with Ascorbic acid caused superior effects on increased total phenols. Ref. [61] reported that treating two wheat cultivars with Asc. at two concentrations 50 and 100 ppm significantly increased total phenols concentration comparing with control.

Total saponins and lipids

The effectiveness of plants materials medicinally is because of the existence of bioactive ingredients for example saponins. Saponins would be the ingredient which prevent disease invasion of plants by parasitic fungi, hence possess some antifungal qualities. Saponins are helpful in medicine and pharmaceutical industry because of its foaming ability that creates creamy effects within the food industry. It's also utilized in the output of shampoos, pesticides various drug formulations and synthesis of steroidal the body's hormones [62].

The acquired results revealed additionally that, use of GA_3 triggered variable reactions in regards to the entire saponins contents, in quinoa plants, items in total saponins contents in the produced seed products were substantially elevated as a result of the therapy with GA_3, JA, Asc. In regards to the saponin contents percentage (Figure 16), in seeds (GA_3- 93.07%, JA- 48.51%, Asc.- 74.26%). In this regard, Ref. [63] found that saponins contents in the leaves of *Balanites aegyptiaca* plants were increased significantly by using all concentrations of GA_3 50 ppm as compared with the control in both seasons. Ref. [64] investigated the effect of different levels of GA_3 at concentration 50 ppm on biochemical activity of purwaceng plant and found that the effect of GA_3 on the levels of leaf saponins was significant increased.

In our study, it had been found that (Figure 17), total lipids content in the yielded seeds of quinoa plants were significantly increased in response to the treatments with GA_3, JA and Asc. In accordance with the obtained results, Ref. [46] showed that, the foliar application of vitamin C improved the quality of (*Linum usitatissimum*) seeds plant that induced oil yield. Ref. [65] showed that, the foliar application of Ascorbic acid at (50, 100 and 150 ppm) on *Jasminum grandiflorum* L increased oil yield compared to control plants.

Correlation

It was revealed from Table 3, that significant positive correlation was found for Weight of 1000 seeds with soluble protein contents in shoot, soluble protein contents in yield, soluble carbohydrate contents in yield, total phenol in yield, total lipid in yield and total saponin in yield. soluble protein contents in shoot was significantly positive correlated with soluble protein contents in yield, soluble carbohydrate contents in yield, total phenol in yield, total lipid in yield and total saponin. soluble carbohydrate contents in shoot was significantly positive correlated with soluble protein contents in yield total lipid in yield and total saponin. soluble protein contents in yield was significantly positive correlated with soluble carbohydrate contents in yield, total phenol in yield, total lipid in yield and total saponin. soluble carbohydrate contents in yield was significantly correlated with total phenol in yield, total lipid in yield and total saponin. Total lipid in yield and total saponin was significantly strong positive correlated with all studied traits. It was found that strong and significant correlation was reported between total plant and biochemical analysis. The significant correlations suggested that the wild plants have ability to form a lot of yield and survive in harsh, hot and dry environmental conditions. The wilds should be controlled through chemical, manual and through these of transgenic crop plants to minimize yield losses [66-75].

Automatic linear modeling and discriminant analysis

Finally when we used the yielded weight as a target we observed that the accuracy of all data about 99.8%. The effect of target weight of 1000 seed the wide line is very effect as total phenol in yield then chlorophyll b, total carbohydrate in shoots and total protein in yield, also the coefficient of target yield weight the blue color wide line is effect as total phenol in yield then chlorophyll b, total carbohydrate in shoots and total protein in yield showed in Figure 18.

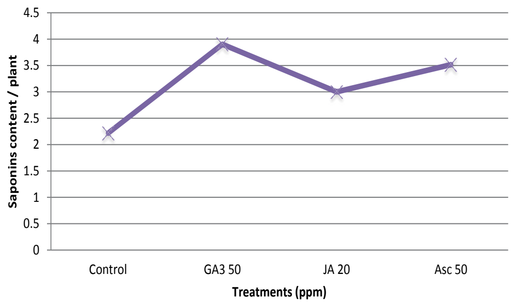


Figure 16: Effect of gibberellic acid, jasmonic acid and Ascorbic acid on total saponins contents (%) of (*Chenopodium quinoa* Willd) plants.

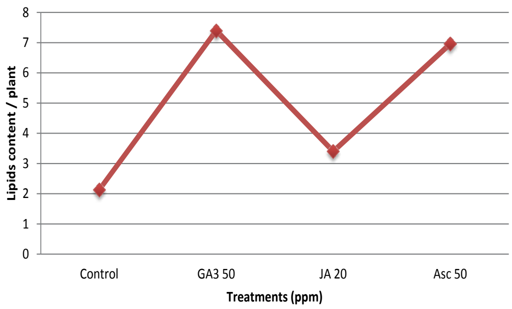
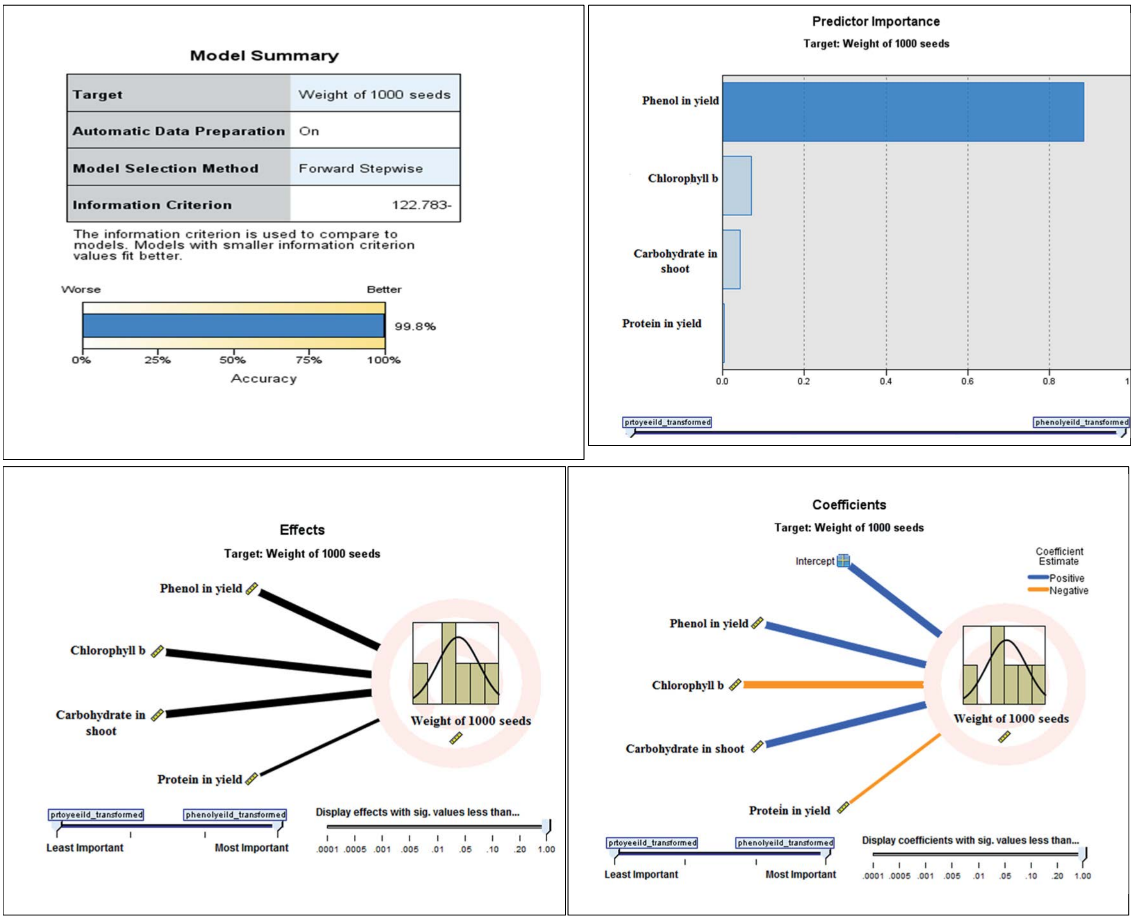


Figure 17: Effect of gibberellic acid, jasmonic acid and Ascorbic acid on total lipids contents (%) of (*Chenopodium quinoa* Willd) plants.

Correlations								
		Weight of 1000 seeds	Soluble protein contents in shoot	Soluble carbohydrate contents in shoot	Soluble protein contents in yield	Soluble carbohydrate contents in yield	Total phenol in yield	Total lipid in yield
Soluble protein contents in shoot	r	0.956**	1					
	p	0.000						
Soluble carbohydrate contents in shoot	r	0.351	0.191	1				
	p	0.263	0.553					
Soluble protein contents in yield	r	0.897**	0.923**	0.502	1			
	p	0.000	0.000	0.096				
Soluble carbohydrate contents in yield	r	0.958**	0.915**	0.564	0.966**	1		
	p	0.000	0.000	0.056	0.000			
Total phenol in yield	r	0.977**	0.879**	0.512	0.868**	0.962**	1	
	p	0.000	0.000	0.089	0.000	0.000		
Total lipid in yield	r	0.704*	0.707*	0.740**	0.921**	0.871**	0.730**	1
	p	0.011	0.010	0.006	0.000	0.000	0.007	
Total saponin in yield	r	0.879**	0.823**	0.704*	0.952**	0.973**	0.911**	0.938**
	p	0.000	0.001	0.011	0.000	0.000	0.000	0.000

**Correlation is significant at the 0.01 level (2-tailed); *Correlation is significant at the 0.05 level (2-tailed)

Table 3: Pooled correction among various biochemical traits of quinoa.



Figures 18: Show model summary of yield target.

So we make discriminant analysis that led to conclusion when use different treatments of gibberellic acid, jasmonic acid and Ascorbic acid in foliar application on quinoa plants, we resulted that the Ascorbic 50 ppm then jasmonic acid 20 ppm and finally gibberellic acid 50 ppm as in Figure 19.

Conclusion

In the preceding results and discussion, it may be came to the conclusion that best foliar use of quinoa plants with Ascorbic acid at 50 ppm, jasmonic acid at 20 ppm, gibberellic acid at 50 ppm individually at

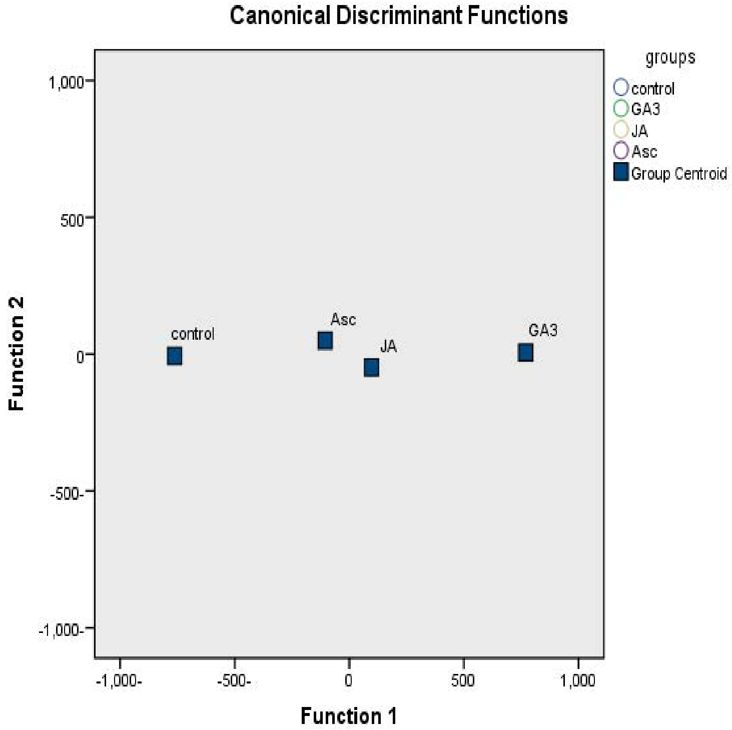


Figure 19: Show canonical discriminant function.

elongation stage, stimulate the development of quinoa plants through the enhancement from the biosynthesis of photosynthetic pigments enhanced yield by growing seed yield/plant seed products index in addition to carbohydrate, proteins and phenols content of quinoa seed products and therefore all last remedies enhanced quinoa seed quality and dietary value.

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