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Seed and Oil Productivity upon Foliar Spray of Soybean (*glycine max* l.) with Humic and Ascorbic Acids with or without Seed Irradiation

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THE STUDY evaluates the beneficial effects of soybean foliar spray with humic acid (HA) and ascorbic acid (AA) antioxidants at 2000 mg L^{-1} HA and 300 and 600 mg $L.^{-1}$ AA; and seed irradiation of 15 and 30Gy gamma rays. The split-plot experiment was conducted on a sandy soil in Ismailia Governorate, Egypt, during 2010 summer season. Main plots were for foliar spray treatments of: none, HA, AA1, AA2," HA+AA1"," HA+AA2"; AA1 and AA2, *i.e.* 300 and 600 mg L^{-1}. Sub-plots were for irradiation of, none, 15Gy and 30Gy. 100-seed weight, straw and pod yields as well as protein, N, P, K and oil contents; protein and oil yields and N, P and K uptake increased by 15Gy than by 30Gy. Main effect of spray shows a general descending order of "HA+AA2" > "HA+AA1" > HA > AA2 > AA1. Highest straw yield (5.82 Mg ha^{-1}) was by HA+AA1+15Gy. Highest seed yield (2.99 Mg ha^{-1}) was by HA+AA2+30Gy. Highest uptake of P (23.2 kg ha^{-1}) and K (206 kg ha^{-1}), respectively at straw were achieved owing to the addition of HA+AA1+15Gy gamma ray while treatment of HA+AA2 with 15Gy gamma ray gave highest N-uptake (163 kg ha^{-1}). Highest N, P and K uptake in seeds (149, 19.1 and 49.0 kg ha^{-1}, respectively) were by (HA+AA2+15Gy gamma ray dose). The treatment of HA+AA2 with 15Gy gamma ray was superior to the other treatments.

Keywords: Sandy soil, Soybean, Humic and ascorbic acid, Seed irradiation with gamma ray

Soybean (*Glycine max* L.) is an important oil and protein crop; it contains about 30% of cholesterol free oil and about 40% of protein beside vitamins. In Egypt, soybean oil has been used as edible oil during the past 40 years; and its extraction ratio of oil is about 20.5% (El-Agroudy *et al*., 2011). Recently, attention has been directed to increase productivity of soybean to be used as protein source (particularly for animal feeds and oil for human food). Total production of soybeans in Egypt reached 23000 tonnes in the year 2013, produced from an area of 8000 ha (FAO, 2013). Therefore, it is of great importance to increase its production.

Gamma irradiation can be useful for alteration of physiological characters (Kiong *et al.*, 2008). The biological effect of gamma rays leads to useful changes in seeds (Kovacs and Keresztes, 2002). Pre-sowing seed irradiation is an effective method increases seed production and improves seed quality since it ionizes molecules and causes free radicals to attack DNA breaking one or two of their molecules (Jyoti *et al.,* 2009). Gamma irradiation in a low dose (10, 20 and 30Gy), increased seed yield of sesame plants (Farag and El-Khawaga, 2013).

The use of humic acid as a fertilizer has increased with increasing agricultural production and could be applied directly to the soil or as foliar spray to plants. Bio-organic fertilizers are used to reduce environmental pollution along with reducing the production cost and to improve crop quality (Asik *et al.,* 2009). The action of humic acid on plant growth can be divided into direct and indirect effects. It affects plant membranes increasing the transport of plant nutrients, enhancing protein synthesis, photosynthesis, microbial activity and solublization of micronutrients, reducing the active levels of toxic elements (Saruhan *et al.,* 2011). In a study on effects of bio and mineral fertilizers and humic substances on growth and yield of cowpea Magdi *et al*. (2011) reported that, chemical fertilizer with humic substances improve growth and yield of cowpea. Mahmoud (2006) found that treatment of humic acid increased straw and seed yields as well as oil and protein content in peanut.

Ascorbic acid in plants functions as an antioxidant and an enzyme cofactor. It participates in a variety of processes, including photosynthesis, cell wall growth and cell expansion, resistance to environmental stresses and synthesis of ethylene, gibberellins, anthocyanine and hydroxyl proline (Galal *et al.*, 2000 and Smirnof & Wheeler 2000).

The objective of the present study was to examine the impact of foliar applications with ascorbic acid as an antioxidant and humic acid on seed yield, seed quality and uptake of nutrients in soybean cultivated in a newly reclaimed sand soil after seed treatment with two doses of gamma irradiation, *i.e.* 15 and 20 Gy or without irradiation.

Materials and Methods

A field experiment was carried out during the successive summer season of 2010 and at private farm in Ismailia Governorate, Egypt, in order to investigate the effect of foliar applications with an antioxidant, *i.e.* ascorbic acid and humic acid on yield, seed quality and nutrients uptake of soybean *(Glycine max L.* cv Giza 35*).* Soil samples were taken at the depth of 0 – 30cm before planting for physical and chemical analysis as shown in Table 1 (Page *et al.,* 1982).

TABLE 1. Physical and chemical properties of the investigated soil .

Property			**Value**	**Property**		**Value**
Particle size distribution				**Soluble ions (mmolc L^{-1})**		
Clay %			3.89	EC (dSm^{-1}) in soil paste		0.66
Silt %			2.71	Na^{+}		0.65
Fine sand %			25.3	K^{+}		1.59
Coarse sand %			68.1	Ca^{++}		2.55
Textural class			Sand	Mg^{++}		1.31
pH [Soil suspension 1:2.5]			7.79	Cl^{-}		1.32
Organic matter (g kg^{-1})			7.38	HCO_3^{-}		3.19
$CaCO_3$			4.56	$SO_4^{=}$		1.59
Available macro and micronutrients (mg kg^{-1} soil)						
N	**P**	**K**	**Fe**	**Mn**	**Zn**	
27.3	3.18	83.5	2.98	0.88	0.33	
***Critical levels of nutrients in soil after Page *et al.*, (1982)**						
Limits	**N**	**P**	**K**	**Fe**	**Mn**	**Zn**
Low	< 40.0	< 5.0	< 85.0	< 4.0	< 2.0	< 1.0
Medium	40 -80	5 -10	85 - 170	4 - 6	2 - 5	1 - 2
High	> 80.0	> 10.0	> 170	> 6.0	> 5.0	> 2.0

*Extractants of available nutrients: NH_4HCO_3-DTPA (P, K, Fe, Mn and Zn), KCl (N) .

The experiment was in a randomized complete block design, split-plot involving two factors:-

Factor 1 " main plots": Foliar spray (F) with the following 6 treatments:-

1-No spray; 2- Humic acid spray (HA); 3- Ascorbic acid spray1 (AA1); 4- Ascorbic acid spray2 (AA2); 5- " HA+AA1"; 6-" HA+AA2". Concentrations of spray solutions were: 2000 mg K-humate L^{-1} for HA, 300 mg L^{-1} for AA1 and 600 mg L^{-1} for AA2.

Factor 2 " sup plots": Seed irradiation with gamma ray (Gy) with the following treatments:-

A-No irradiation, B- irradiation dose of 15 Grays (15Gy) and C- irradiation with 30 Grays (30Gy). Irradiation source was cobalt 60 gamma chamber 4000-A-India, Egyptian Atomic Energy Establishment, (EAEE), Inshas, Egypt.

Spraying with HA was done in two occasions: at 30 and 45 days after seeding, (DAS). Humic acid material (85%) was used as a commercial product supplied by Biotech for Bio-acids Fertilizer Company, Egypt while ascorbic acid was in a form of commercial product. Seeds of soybean (*Glycine max* L. c.v. Giza 35) was sown after soil preparation. Seeding was carried on June 15th, 2010. Spraying with AA was done in three occasions 10, 20 and 30 DAS. Spraying with combinations of HA+AA was done separately for each material not in one mixed solution.

The plot area was 5 X 4 m^2. Each plot consisted of 12 rows 40 cm apart with two plant / hill every 20 cm and thinned to a single plant per hill 21 days after seeding.

Seeds were treated with an effective strain of *Bradyrhizobium japonicium* just before seeding. All plots received N, P and K. Nitrogen was added at 120 kg N ha^{-1} as ammonium sulphate, AS (206 g N kg^{-1}) in three equal splits: immediately after planting as a starter, 40 and 60 DAS. Phosphorus was added at 31 kg P ha^{-1} as calcium superphosphate (67.6 g P kg^{-1}) during seedbed preparation; and potassium was added at 100 kg K ha^{-1} as potassium sulphate (400 g K kg^{-1}) in two equal splits 30 and 45 DAS.

At maturity, ten plants were taken randomly from each plot and used for yield assessment. The 100-seed weight was measured. In addition, plants of two rows in each plot were harvested; air dried, then yields of Pods, straw and seeds were determined and expressed in megagrams per hectare (Mg ha^{-1}); (Mg=10^6 g). Also, shelling percentage% was determined = seed yield / pod yield X 100. Seeds were analyzed for contents of oil, N, P and K. Protein content was determined by multiplying seed N% by 5.71 (FAO, 2003). Protein yield (kg ha^{-1}) = protein content (g kg^{-1}) X grain yield, Mg ha^{-1}. Oil yield (kg ha^{-1}) = oil content (g kg^{-1}) X grain yield, Mg ha^{-1}.

Methods of analysis

Plant samples were digested with a mixture of concentrated sulfuric and perchloric acids for nutrient determinations using the methods described by Chapman & Pratt (1961). Soil analyses were done by methods described by Black *et al.* (1965) and Lindsay & Norvell, (1978). Nutrients in digests were measured using Inductively Coupled Plasma (ICP) Spectrometer model 400 while, N was determined by kjeldahl. Oil content was determined using Soxhlet method (AOAC, 1990).

Results and Discussion

Yield and yield components

100-seed weight

Data relating the 100-seed weight and yields of soybean are presented in Table 2. The growth parameter of 100-seed weight significantly increased due to foliar spraying with HA and/or AA; and also duo to seed gamma irradiation. As for the foliar spray, the main effect shows that spray with HA and/or AA spray followed this descending order: "HA+AA2" > "HA+AA1" = AA2 > AA1 > HA. Regarding the response to gamma irradiation, 15Gy was > 30Gy. Farag and El-Khawaga (2013) reported that gamma irradiation of sesame and N-application increased the 1000-seed weight. These results are in agreement with those of Sary *et al.* (2009) and Kandil *et al.* (2011).

The treatment of HA + AA2 irradiated with 15Gy gamma irradiation caused the highest increase in 100-seed weight (33.4%).

Straw, pod and seed yields

The obtained results exhibited significant increases due to the applications of application foliar spray, irradiation and their combinations compared to the non-treated plants. Low gamma ray radiation increases enzymatic activation, stimulating cell division, and germination as well as vegetative growth (Ashri, 2007). The favorable effect of ascorbic acid may be due to its role as a growth regulator that influences many physiological processes such as the synthesis of enzymes, nucleic acids, proteins and acts as co-enzyme (El-Greadly, 2002). Humic acids contain various bio-chemicals and growth promoting substances (phytohormones) which have favourable effect on cell wall membranes cytoplasm, including more photosynthesis and respirations rates in plants, enhanced protein synthesis and promote seed germination and root elongation (Chen and Aviad, 1990). Bakry *et al.* (2013) stated that the humic acid and ascorbic acid gave the highest straw and grain yield of wheat grown under newly reclaimed sandy soil.

Main effect shows the following order: "HA+AA1" > "HA+AA2" > AA2 > HA > AA1 for straw yield; "HA+AA2" > "HA+AA1" > AA2 = HA > AA1 for seed yield and "HA+AA2" ≥ "HA+AA1" > AA2 = HA > AA1 for pod yield. As for the main effect of irradiation the order was: 15Gy > 30 Gy. For pod yield, the main effect shows no significant difference.

TABLE 2. Yield components of soybean as affected by gamma irradiation and foliar applications.

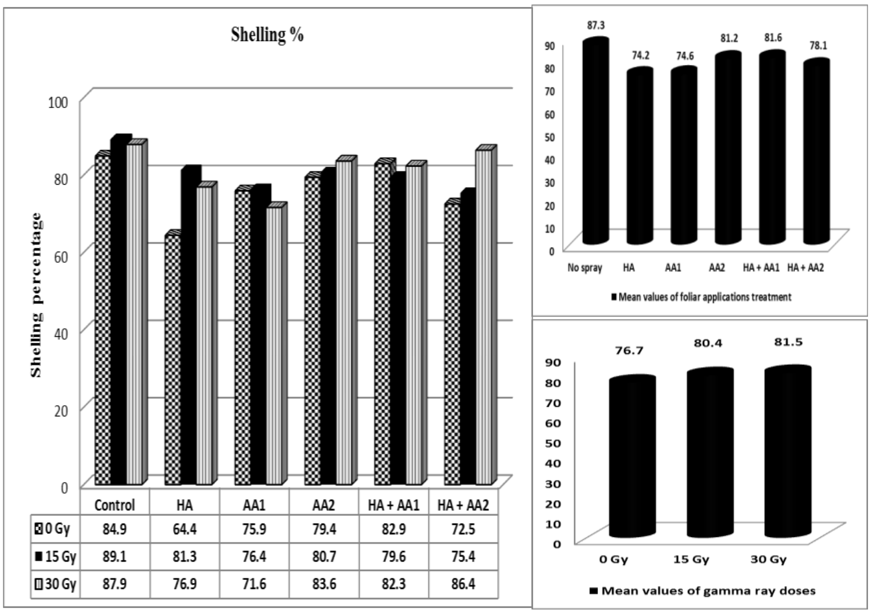
Item	Gamma dose (G)	*Foliar application (F)								
		No-spray	HA	AA1	AA2	HA+AA1	HA+AA2	Mean	F-test	
100-seed Weight (g)	0	59.5	63.1	61.5	62.5	63.2	64.6	62.4 c	F:	**
	15	67.9	72.6	68.3	71.6	73.7	79.4	72.2 a	G:	**
	30	62.2	71.1	65.2	69.9	70.4	73.5	68.7 b	FxG:	**
	Mean	63.2 d	68.9 b	65.0 c	68.0 b	69.1 b	72.5 a	67.8		
Straw yield (Mg ha^{-1})	0	2.92	3.88	3.58	4.04	4.28	4.13	3.80 c	F:	**
	15	4.11	5.01	4.49	5.26	5.82	5.60	5.05 a	G:	**
	30	4.04	4.43	4.24	4.53	5.71	5.10	4.68 b	FxG:	**
	Mean	3.69 f	4.44 d	4.10 e	4.61 c	5.27 a	4.94 b	4.51		
Seed yield (Mg ha^{-1})	0	1.14	1.52	1.17	1.39	1.77	1.85	1.47 c	F:	**
	15	1.76	2.64	1.96	2.56	2.85	2.92	2.45 a	G:	**
	30	1.71	2.36	1.69	2.42	2.69	2.99	2.31 b	FxG:	NS
	Mean	1.53 d	2.17 c	1.60 d	2.12 c	2.44 b	2.58 a	2.08		
Pod yield (Mg ha^{-1})	0	1.34	2.37	1.54	1.75	2.14	2.55	1.95 b	F:	**
	15	1.97	3.24	2.56	3.17	3.58	3.87	3.07 a	G:	**
	30	1.95	3.06	2.36	2.90	3.26	3.46	2.83 a	FxG:	NS
	Mean	1.75 d	2.89 b	2.15 c	2.61 b	2.99ab	3.29 a	2.61		

*HA: humic acid (2000 mg L^{-1}), AA1: 300 mg L^{-1} ascorbic acid, AA2: 600 mg L^{-1} ascorbic acid

The highest straw and pod yields of 5.82 and 3.87 Mg ha^{-1}, respectively were achieved due to application of HA + AA1 and HA + AA2, respectively when irradiated with 15Gy gamma ray and the corresponding increments over the non-treated plants were 99 and 188%, respectively. The highest seed yield of 2.99 Mg ha^{-1} was observed due to addition of HA + AA2 with 30Gy gamma ray irradiation giving an increase of 162% over the non-treated.

Pod shelling percentage

Shelling percentage as influenced by foliar applications and gamma irradiation is illustrated in Fig.1. Plants which received foliar spray with HA and/or AA solely or in combination showed slight decreases. Ibrahim and Eleiwa (2008) reported that NPK increased shelling percentage of groundnut. The obtained results are in full agreement with those obtained by Hossain *et al.* (2007). Ali and Mowafy (2003) pointed out that adding K fertilizer increased shelling percentage of peanut. The spray treatments under 15 Gy can be arranged in the following order: non-sprayed > HA > AA2 > HA+AA1 > AA1 > HA+AA2. Under 30 Gy irradiation the order is: non-sprayed > HA+AA2 > AA2 > HA+AA1 > HA > AA1.



Gamma irradiation dosed, *i.e.* 0, 15 and 30 Gy

Fig.1. Shelling percentage of soybean as affected by gamma irradiation and foliar spray with humic and ascorbic acids.

Seed Quality

Seed protein content and seed protein yield

Results presented in Table 3 show that protein content and protein yield of soybean seeds significantly increased owing to foliar spray and gamma irradiation, foliar spraying with HA and AA. The highest increases in protein content (27%) as well as protein yield (851 kg ha^{-1}) were recorded in the plants treated with HA + AA2 + 15Gy. Rahimi and Abdallah (2011) stated that gamma irradiation of wheat seeds (25 and 50 Gy) increased protein content of grains. Gad El-Hak *et al.* (2012) found that foliar spray with HA and AA to peas protein content in seeds. The current results are in agreement with those reported by Morard *et al.* (2011) who reported positive response to HA spray on various plants. The main effect of irradiation shows increases and that 15Gy was superior to 30G. As for foliar spray, the main effect shows increases with a descending order of: HA + AA2 > HA+AA1 > HA > AA1 >AA2 for protein content; and: HA + AA2 > HA+AA1 > HA > AA2 >AA1 for protein yield.

TABLE 3. Protein content of soybean seeds as affected by gamma irradiation and foliar applications.

Item	Gamma dose (G)	* Foliar application (F)								
		No-spray	HA	AA1	AA2	HA+AA1	HA+AA2	Mean	F-test	
Protein content (g kg^{-1})	0	230	224	231	216	229	239	228 b	F: G: FxG:	** ** **
	15	218	254	235	234	275	292	251 a		
	30	201	238	230	229	243	253	232 b		
	Mean	216 f	239 c	232 d	227 e	249 b	261 a	237		
Protein yield (kg ha^{-1})	0	261	341	269	301	405	441	336 c	F: G: FxG:	** ** **
	15	382	670	460	598	785	851	624 a		
	30	344	560	388	555	653	756	542 b		
	Mean	329 f	523 c	372 e	485 d	614 b	683 a	501		

See footnote of Table 2

Regarding the seed protein yield, results followed the trend almost the same of protein content. This could be attributed to the organic acids which are known as a growth regulator factor that influence many physiological processes such as the synthesis of enzymes, nucleic acids, proteins and act as co-enzymes. Also, the integrated effect of humic acid and bio effect of microorganisms on increasing available nutrients for plant growth and accordingly maximizing the biological yield and grain quality (Ewees and Abdel Hafeez, 2010). Bakry *et al.* (2013) pointed out that foliar application of humic acid and/or ascorbic acid and their combinations shows significant differences and gave the highest protein % and protein yield of wheat grown under newly reclaimed sandy soil.

Seed oil content and seed oil yield

As illustrated in Fig. 2 and 3, seed oil content and seed oil yield increased due to irradiation and foliar spray with HA and/or AA. The increase ranged from 273 to 381 g kg^{-1}. The highest seed oil content and oil yield values of 381 g kg^{-1} and 1111 kg ha^{-1}, respectively were obtained as by HA + AA2 in combination with 15Gr gamma irradiation, with increases of 40% and 258%, respectively. The oil content from soybean seed determined in this study is higher than 208 g kg^{-1} reported in soybean grown in Nigeria and lower than 441 g kg^{-1} reported in soybean grown in Turkey (Cecil *et al.*, 2013). Differences in such property among different regions are attributed to variations in varieties, farming environment, ripening stage, harvesting time, and extraction methods. The oil content of soybean seeds in the present study is higher than contents in seeds of other oil seed crops such as: cotton (150-240 g kg^{-1}), but within the range of those of mustard seeds (240 - 400 g kg^{-1}) and safflower seeds (250 - 400 g kg^{-1}), (Pritchard, 1991). Main effect of foliar spray shows the following order: HA+ AA2 > HA+AA1 ≥ HA> AA2 > AA1 > non-sprayed for oil content; and HA+ AA2 > HA+AA1 > HA > non-sprayed > AA1 for oil yield.

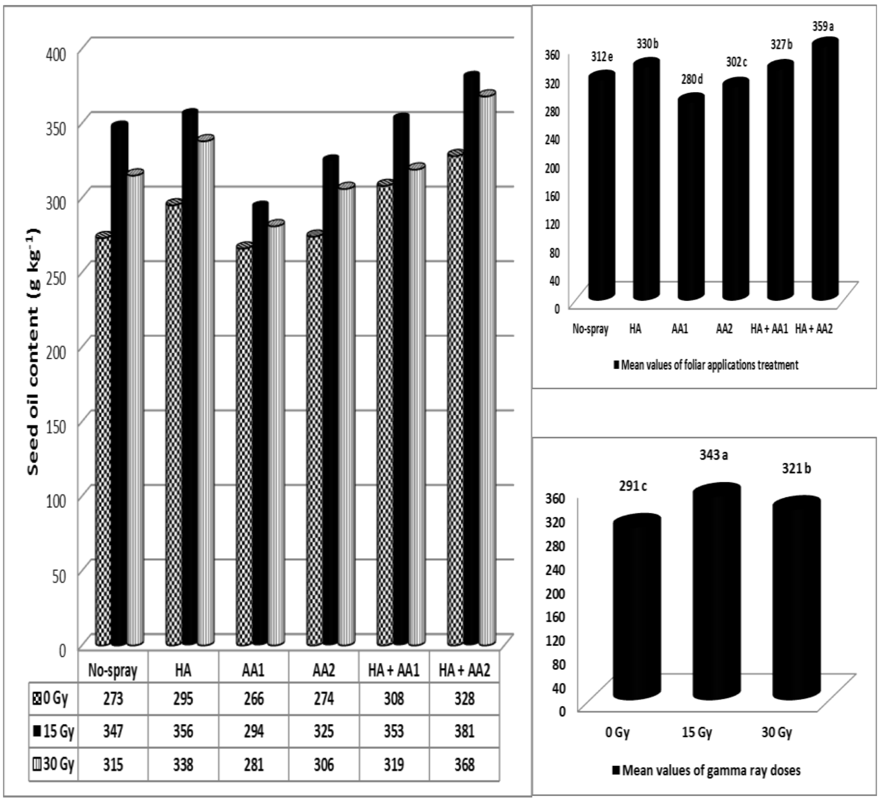


Fig. 2. Oil content, g kg^{-1} of soybean as affected by gamma irradiation and foliar applications.

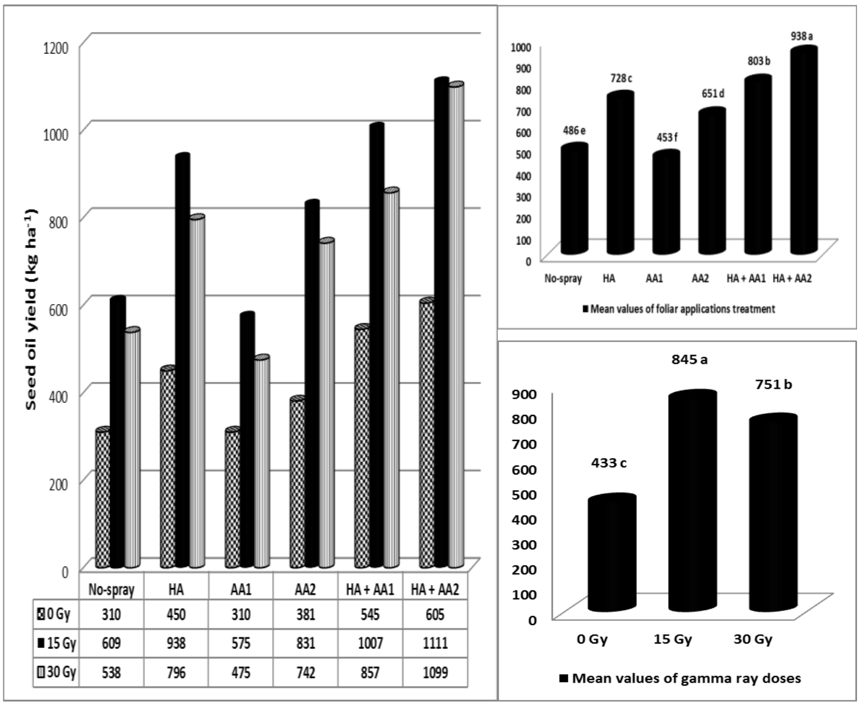


Fig. 3. Oil yield, kg ha^{-1} of soybean as affected by gamma irradiation and foliar applications.

N, P and K content and uptake

The results shown in Tables 4, 5 and 6 reveal that N, P and K content and uptake in soybean straw and seeds increased due to foliar spray and seed irradiation. Gamma irradiation was reported by Xienia *et al.* (2000) to induce oxidative stress with overproduction of reactive oxygen species such as superoxide radicals (O_2^-), hydroxyl radicals (OH^-) and hydrogen peroxide (H_2O_2), which react rapidly with almost all structural and functional organic molecules, including proteins, lipids and nucleic acids. According to Rima *et al.* (2011) humic substances may enhance uptake of nutrients through stimulation of soil microbiological activity. In other words, HA application could be a hormone substance enhancing root development and proliferation. Ascorbic acid is synthesized in higher plants and enhances their plant growth and development of D-glucose metabolism which affects nutritional activity and plays an important role in electron transport systems (El-Kobisy *et al.,* 2005). Results obtained in the current study are similar to those reported by Habashy (2005) on peanut and faba bean, Zaky *et al.* (2006) on faba beans; Abdel Aziz *et al.* (2009) on gladiolus; El-Hefny (2010) on cowpea, Morard *et al.* (2011) and Gad El-Hak *et al.* (2012) on peas, Bakry *et al.* (2013) and Abd El-Hamid *et al.* (2013) on wheat and Helmy (2014) on barley.

Nitrogen content and uptake

The results shown in Table 4 reveal positive response to spray and seed irradiation. The highest N contents in seed and straw of 51.1 and 29.1 g kg^{-1}, respectively were produced by HA + AA2 with 15Gr gamma irradiation as compared with 40.3 g kg^{-1} and 21.3 g kg^{-1} in seeds and straw, respectively for the non-treated. Highest N uptake in seeds and straw of 149 and 163 kg ha^{-1}, respectively were obtained by HA + AA2 with 15Gy causing increases of 225% and 162%, respectively. Spraying with HA and AA shows the following pattern: 15Gy > 30Gy for N content and uptake. Main effects indicate seeds and straw; HA+AA2 > HA+AA1 > HA > AA1 > AA2 for N content in seeds; HA+AA2 > HA+AA1 > HA > AA2 > AA1 for N uptake in seeds; HA+AA2 > HA+AA1> HA = AA1 = AA2 for N-content in straw; and HA+AA2 ≥ HA+AA1 > AA2 > HA > AA1 for N uptake in straw.

TABLE 4. N content (g kg^{-1}) and N-uptake (kg ha^{-1}) of soybean as affected by gamma irradiation and foliar applications

Item		Gamma dose (G)	* Foliar application (F)								
			No-spray	HA	AA1	AA2	HA+AA1	HA+AA2	Mean	F-test	
Seeds	N content, g kg^{-1}	0	40.3	39.2	40.4	37.9	40.1	41.9	40.0 b	F:	**
		15	38.1	44.5	41.2	41.0	48.2	51.1	44.0 a	G:	**
		30	35.2	41.6	40.2	40.1	42.6	44.3	40.7 b	FxG:	**
		Mean	37.9 f	41.8 c	40.6 d	39.7 e	43.6 b	45.8 a	41.6		
	N-uptake, kg ha^{-1}	0	45.8	59.8	47.1	52.7	70.9	77.4	58.9 c	F:	**
		15	66.9	117	80.5	105	137	149	109 a	G:	**
		30	60.2	98.1	68.0	97.3	114	132	95.6 b	FxG:	**
		Mean	57.6 f	91.7 c	65.2 e	85.0 d	107 b	120 a	87.8		
Straw	N content, g kg^{-1}	0	21.3	18.9	19.3	18.7	22.4	24.2	20.8 b	F:	**
		15	20.4	21.7	20.7	22.5	26.4	29.1	23.5 a	G:	**
		30	18.8	19.4	19.6	21.1	23.8	25.7	21.4 b	FxG:	*
		Mean	20.2 c	20.0 c	19.9 c	20.8 c	24.2 b	26.3 a	21.9		
	N-uptake, kg ha^{-1}	0	62.2	73.3	69.2	75.5	95.8	99.9	79.3 c	F:	**
		15	83.9	109	92.9	118	154	163	120 a	G:	**
		30	75.9	85.9	83.1	95.6	136	131	101 b	FxG:	NS
		Mean	74.0 d	89.3 bc	81.7 c	96.4 b	129 a	131 a	100		

See footnote of Table 2

Phosphorus content and uptake

Table 5 clarifies the content and uptake of P in soybean seed and straw as affected by the tested treatment. Phosphorus content and uptake by soybean seeds and straw increased as a result of foliar spray and seed irradiation. The highest P content of 6.56 g kg^{-1} in seeds and 3.98 g kg^{-1} in straw was by HA+AA2 and HA + AA1, respectively with 15Gy as compared with 3.02 and

2.22 g kg^{-1} in seeds and straw, respectively for the untreated. The highest P-uptake of 19.1 kg ha^{-1} in seeds was by HA + AA2 with 15 Gy while the highest P-uptake of 23.3 kg ha^{-1} in straw was by HA+AA1; with respective increases of 457% and 258%.

The individual effect of gamma irradiation showed pronounced increases of 15Gy than 30Gy for P content in seed and straw and its uptake. The main effect of foliar applications followed the sequence: HA+AA2 > HA+AA1 > AA2 ≥ AA1 ≥ HA for P content in seeds and HA+AA2 > HA+AA1 > AA2 ≥ AA1 > HA for P-uptake in seeds, respectively. In straw the pattern was: HA+AA2 ≥ HA+AA1 > AA2 ≥ AA1 > HA for P content and HA+AA2 ≥ HA+AA1 > AA2 > AA1 ≥ HA for P-uptake. The main effect regarding irradiation shows 15 Gy > 30 Gy for content and uptake, in seeds as well as straw.

TABLE 5. P content (g kg^{-1}) and P-uptake (kg ha^{-1}) of soybean as affected by gamma irradiation and foliar applications.

Item		Gamma dose (G)	* Foliar application (F)							F-test	
			No-spray	HA	AA1	AA2	HA+AA1	HA+AA2	Mean		
Seeds	P content, g kg^{-1}	0	3.02	3.45	3.11	3.21	3.35	3.56	3.28 c	F:	**
		15	3.51	5.35	4.95	5.09	5.93	6.356	5.23 a	G:	**
		30	3.34	5.04	4.72	4.84	5.39	6.12	4.91 b	FxG:	**
		Mean	3.29 d	4.61 bc	4.26 c	4.38 c	4.89 b	5.41 a	4.47		
	P-uptake, kg ha^{-1}	0	3.43	5.26	3.63	4.46	5.93	6.57	4.88 c	F:	**
		15	6.16	14.1	9.68	13.0	16.9	19.1	13.2 a	G:	**
		30	5.71	11.9	7.97	11.7	14.5	18.3	11.7 b	FxG:	**
		Mean	5.10 e	10.4 c	7.09 d	9.73 c	12.4 b	14.7 a	9.91		
Straw	P content, g kg^{-1}	0	2.22	2.89	2.43	2.65	3.23	3.49	2.82 c	F:	**
		15	2.86	3.12	3.48	3.72	3.98	3.86	3.50 a	G:	**
		30	2.72	2.91	3.24	3.46	3.52	3.61	3.24 b	FxG:	NS
		Mean	2.60 d	2.97 c	3.05 bc	3.28 b	3.58 a	3.65 a	3.19		
	P-uptake, kg ha^{-1}	0	6.48	11.2	8.71	10.7	13.8	14.4	10.9 c	F:	**
		15	11.8	15.6	15.6	19.6	23.2	21.6	17.9 a	G:	**
		30	11.0	12.9	13.7	15.7	20.1	18.4	15.3 b	FxG:	NS
		Mean	9.74 d	13.2 c	12.7 c	15.3 b	19.0 a	18.1 a	14.7		

See footnote of Table 2

Potassium content and uptake

As shown in Table 6, K content and uptake in seeds and straw increased owing to foliar spray and seed irradiation with exception of K content in straw which was insignificantly affected by irradiation. Highest K contents of 16.8 g kg^{-1} in seeds was by HA + AA2 with 15 Gy, and highest content of 35.4 g kg^{-1} in straw was by HA+AA1 with 15Gy. Highest K uptake of 49.0 kg ha^{-1} in seeds was due to HA + AA2 and highest K uptake of 206 kg ha^{-1} in straw was by HA+AA1; with respective increases of 159% and 325%.

TABLE 6. K content, g kg^{-1} and K-uptake, kg ha^{-1} of soybean as affected by gamma irradiation and foliar applications.

Item		Gamma dose (G)	*Foliar application (F)							F-test	
			No-spray	HA	AA1	AA2	HA+AA1	HA+AA2	Mean		
Seeds	K content, g kg^{-1}	0	8.30	10.4	9.25	9.60	10.8	10.6	9.80 c	F:	**
		15	10.8	15.2	13.8	14.9	15.3	16.8	14.5 a	G:	**
		30	10.3	15.0	11.6	13.2	14.4	15.6	13.4 b	FxG:	**
		Mean	9.80 c	13.5 b	11.6 d	12.6 c	13.5 b	14.3 a	12.6		
	K-uptake, kg ha^{-1}	0	9.43	15.9	10.8	13.3	19.0	19.6	14.7 c	F:	**
		15	18.9	39.9	27.0	38.1	43.6	49.0	36.1 a	G:	**
		30	17.6	35.2	19.5	32.0	38.5	46.6	31.6 b	FxG:	**
		Mean	15.3 e	30.3 c	19.1 d	27.8 c	33.7 b	38.4 a	27.4		
Straw	K content, g kg^{-1}	0	16.6	23.6	21.2	22.4	25.3	24.5	22.3	F:	**
		15	19.4	28.7	24.6	27.3	35.4	31.8	**27.9**	G:	NS
		30	17.6	24.4	23.5	23.9	29.2	27.6	**24.4**	FxG:	NS
		Mean	17.9 d	25.6 bc	23.1 c	24.5 bc	30.0 a	28.0 ab	24.8		
	K-uptake, kg ha^{-1}	0	48.5	91.5	76.0	90.4	108	101	85.9 c	F:	**
		15	79.8	144	110	144	206	178	144 a	G:	**
		30	71.1	108	99.6	108	167	141	116 b	FxG:	*
		Mean	66.4 e	114 c	95.3 d	114 c	160 a	140 b	115		

See footnote of Table 2

The main effect of foliar spray shows: HA+AA2 > HA+AA1 ≥ HA > AA2 > AA1 for K content in seed and HA+AA2 > HA+AA1 > HA ≥ AA2 > AA1 for K-uptake by seed; HA+AA1 ≥ HA+AA2 > HA ≥ AA2 ≥ AA1 for K content by straw and HA+AA1 > HA+AA2 > HA = AA2 > AA1 for K uptake by straw. The main effect for irradiation shows 15Gy > 30Gy for contents as well as uptake of K in seeds and straw.

Conclusion

The obtained results reveal that foliar spray of soybean plants with humic acid and/or ascorbic acid antioxidants is beneficial to crop growth, yield components and nutrient uptake. Also, seed irradiated with 15 or 30Gy gamma ray showed positive results. The 15Gy was superior to the 30Gy treatment. Hence, it could be suggested that soybean plants grown may be sprayed with ascorbic acid at 300 or 600 mg L^{-1} and humic acid at 2000 mg L^{-1} to enhance growth and nutrient uptake as well as improve the quantity and quality of soybean when seeds were exposed to 15 Gy gamma rays before planting. This may reduce requirements of chemical fertilizers with no toxic substances accumulating or injurious radiation in the food chain.

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إنتاجية الحبوب و الزيت نتيجة رش فول الصويا (*Glycine max* L.) بحامضي الهيوميك والأسكوربيك مع أو بدون تشعيع البذور

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تم إجراء تجربة حقلية لتقييم التأثير المفيد للرش بأستخدام مضادات الأكسدة متمثلة في حمض الأسكوربيك بمعدلات (0 ،300 و 600 مللجرام لتر$^{-1}$) والمنشطات الحيوية متمثلة في حمض الهيوميك بمعدلات (0 و 2000 مللجرام لتر$^{-1}$) بعد تشعيع البذور قبل الزراعة بأشعة جاما بجرعات هي بدون ، 15 و 30 جراي وذلك بإستخدام تصميم القطع المنشقة مرة واحدة لوحدات كاملة العشوائية بثلاث مكررات في أرض رملية بمزرعة خاصة بمحافظة الأسماعيلية خلال موسم صيف2010. تم توزيع معاملات الرش بحامضي الهيوميك و الأسكوربيك في القطع الرئيسية وكانت بدون رش ، هيوميك أسيد ، أسكوربيك أسيد 300 مللجرام لتر$^{-1}$ ، أسكوربيك أسيد 600 مللجرام لتر$^{-1}$ ، هيوميك أسيد + أسكوربيك أسيد1 و هيوميك أسيد + أسكوربيك أسيد 2 و تم توزيع حبوب فول الصويا المعاملة بجرعات أشعة جاما في القطع المنشقة. تفوقت جرعة التشعيع 15 جراي في زيادة وزن الـ100 بذرة ، محصول القش ، القرون ، محتوي البروتين و الزيت للبذور وكذلك محتواها من العناصر الغذائية الكبري مقارنة بالمعدل 30 جراي. يظهر التأثير الرئيسي للرش تدرجاً تنازلياً بالتسلسل التالي: هيوميك أسيد + أسكوربيك أسيد2 > هيوميك أسيد+أسكوربيك أسيد1 > هيوميك أسيد > أسكوربيك أسيد 2+ . أعلي محصول للقش 5.82 ميجاجرام هكتار$^{-1}$ تم الحصول عليه نتيجة المعاملة حامض الهيوميك+حامض الأسكوربيك مع التشعيع الجامي بجرعة 15 جراي. بينما أعطت المعاملة حامض الهيوميك+حامض الأسكوربيك + مع التشعيع الجامي بجرعة 30 جراي أقصي محصول للبذور (2.99 ميجاجرام هكتار$^{-1}$). أقصي محتوي للفسفور و البوتاسيوم الممتصين للقش 23.2 و 206 كجم هكتار$^{-1}$ علي التوالي تم الحصول عليها نتيجة معاملة الأضافة حامض الهيوميك+حامض الأسكوربيك (300 ملليجرام لتر$^{-1}$) مع التشعيع الجامي بجرعة 15 جراي. بينما أقصي محتوي للنيتروجين الممتص للقش (163 كجم هكتار$^{-1}$). أعلي قيم للنيتروجين ، الفسفور و البوتاسيوم الممتصين للبذور قد تحصل عليها عند الرش بحامض الهيوميك+حامض الأسكوربيك + مع التشعيع الجامي بجرعة 15 جراي. من النتائج المتحصل عليها يوصي بأستخدام الرش بحامضي الهيوميك و الأسكوربيك مع تشعيع البذور قبل الزراعة بجرعة 15 جراي حيث كانت الأفضل بالمقارنة بباقي المعاملات وأدت لتحسين أنتاجية وأمتصاص العناصر الغذائية بواسطة فول الصويا.