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Effect of Sowing Dates and Gibberellin Foliar Spraying on Growth of Soybean

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Abstract

Two field experiments were conducted at Agricultural Research Farm of the Faculty of Agriculture, Benha University, Egypt, during two growing seasons of 2018 and 2019 to study the effect of sowing dates (May 5, May 20 and June 3), three gibberellin concentrations (0, 50 and 100 ppm) and their interaction on growth attributes of soybean (Giza 111 cultivar). The outcome of this study indicated that early planting date (May 5) improved plant height and No. of pods (at 70 and 90 days after planting) and improved the absolute growth rate (AGR) and net assimilation rate (NAR) relatively to the other treatments ($p < 0.05$). Furthermore, applying GA_3 (100 ppm) recorded the maximal values of the growth parameters, except RGR and chlorophyll content which were at 0 and 50 ppm. At 90 DAP, the tallest plants (120.54 cm), No. of leaves/plant (34.11), No. of pods/plant (55.09), and dry weight of stem (21.67 g), pods (23.55 g) and plant (68.75 g) were obtained following the combined effect of May, 5 planting date and GA_3 at 100 ppm.Whereas the interaction between the early planting date and GA_3 at 50 ppm produced the maximum values of the AGR (1.074 g/day), RGR (0.019 g/day) and NAR (1.074 g/day).

Keywords: Soybean; Gibberellin; Planting date; Absolute growth rate; Chlorophyll.

Introduction

Soybean (*Glycine max* L.) is a vital legume/oilseed crop grown for its protein and oil. It is planted on over 6% of land dedicated to agriculture **(Hartman *et al.*, 2011)**. Seeds of soybean are utilized in different purposes, from protein meal for livestock (as feedstuff) to vegetable oil for human food (**Bateman *et al.* 2020).** Among the oilseed crops, soybean seed has the maximal content of protein (40-45%) and contains a good amount of oil (20 -23%) and other nutrients including calcium, phosphorus, iron and vitamins **(Rahman, 2001)**. Soybean protein has a balanced amino acid profile with low content of anti-nutritional ingredients and does not contain toxic compounds, thus it has a significant role to avoid and/or solve malnutrition issues (**Ruhul *et al*., 2009**). Thus, application of soybean in food is imperative for the economic feasibility of industries.

Moreover, soybean production improved from around 17 million tons in 1960 to 230 million tons by 2008 **(Hartman *et al*., 2011)**. Consequently, soybean production is truly substantial to the economic structure of the worldwide food system/network (**Raeisi *et al.* 2013**). Many factors can affect the soybean growth and then its productivity such as management strategies, environmental conditions and genetic traits of the cultivar **(Nleya *et al.* 2020)**. Therefore, researchers and breeders are still searching for the best agronomic strategies as planting dates and plant growth to enhance soybean growth and yield, which are economically and technically favorable for industries.

Bastidas *et al*. (2008) found that sowing date is a critical management decision that affects the growth attributes of soybean. **Cox *et al.* (2008)** reported that soybean planted in mid-May gave the highest value of pods/branch, which contributed to increased pods/plant than those planted in late May; however late-May planting produced highest seeds/pod. The authors observed that soybean planted in mid-June had more plants/unit area but fewer pods and seeds/plant, and lower seed yield as compared to those planted in mid/ late-May. **Chen and Wiatrak (2010)** reported that seed yield is generally greater for earlier planted soybean due to the longer duration of vegetative and reproductive stages. Also, **Ngalamu *et al.* (2012)** noticed that, at early planting, there was more time elapsed for plant growth and development, and consequently increased seed yield of soybean. **Rehman *et al.* (2014)** revealed that and soybean plants sowing in January 28 gave the maximum No. of pods (29.53) and seeds (81.23) per plant. On the other hand, late sowing date (February 18) led to reduction in the same parameters. **Kumagai (2017)** reported that early sowing significantly increased pods number, CGR (Crop Growth Rate) and seed yield by increasing cumulative intercepted solar radiation, which enhanced the growth during early reproductive stages.

On the other hand, **Yamaguchi and Kamiya (2000)** found that gibberellins (GA_3) play an essential role in many aspects of plant growth and development as stem elongation and the flowering. **Khatun *et al.* (2016)** showed that application of GA_3 at vegetative stage produced the tallest plants (61.16 cm) and spray at flower initiation stage provided maximum chlorophyll content (50.38). **Sarkar *et al.* (2002)** realized that GA_3 at 100 ppm concentration exerted regulator effect for enhancing the plant height, No. of branches, No. of leaves and No. of pods/plant compared to their control.

Although, some works on growth of soybean, have been reported. However, the influence of sowing dates and GA_3 concentrations on growth attributes of soybean under Egyptian conditions has not yet been assayed in depth. This research, therefore, aimed to examine the effect of different planting dates and GA_3 concentrations on growth characters and growth analysis of soybean.

Materials and Methods

Two field trials were conducted at Agricultural Research Farm of the Faculty of Agriculture, Benha University, Egypt, during the two summer seasons of 2018 and 2019, to examine the growth characters and growth analysis of soybean under three planting dates (May 5, May 20 and June 3), GA_3 concentrations levels (0, 50 and 100 ppm) and their interaction.

The experimental design was split plot design with four replications. Planting dates were randomly for main-plots and GA_3 concentrations in sub-plots. Experimental unit was 10.5 m^2 (3×3.5 m) and each unit 5 rows (spaced 60 cm apart and 3 m along).

The earlier winter crop was berseem clover (*Trifolium alexandrinum*, L.) in the two seasons. The experimental field was prepared and calcium super phosphate (15.5% P_2O_5) was added during soil preparation at the rate of 150 kg/fed. Herbicides were applied as pre-planting (200 L/fed.) on soil surface and followed by irrigation in the same day. Soybean seeds were thoroughly inoculated with *Bradyrhizobium japonicum* strain before sowing. Seeds were hand sown in hills spaced of 20 cm on one side of ridges of 60 cm apart. Seeds at a rate of 30 kg/fed were sowing (at a soil depth of 3 to 5 cm). After three weeks from sowing, plants were thinned (two healthy plants) on each hill. Afterward, nitrogen fertilizer was added in the form of urea (46.5% N) at the rate of 15-20 kg N/fed. The rest of the planting practices for soybean growing were followed according to the recommended procedures of soybean**.**

2.1. Measurements and calculations

A. Growth characters:

At 70 and 90 days after planting (DAP), a representative five plants were randomly collected from each experimental unit of the four replicates to quantify the following indicators:

1. Plant height (cm)
2. Number of branches/plant.
3. Number of pods/plant
4. Dry weight of leaves (g/plant)
5. Dry weight of stem (g/plant)
6. Dry weight of pods (g/plant)
7. Dry weight of plant (g)
8. Number of leaves/plant
9. Total chlorophyll content: Leaf chlorophyll content was analyzed using a SPAD-502 (Minolta Co. Ltd., Osaka, Japan). Chlorophyll content was measured in upper fully developed 3^{rd} trifoliate leaf.

B. Growth analysis:

B.1. Absolute growth rate

Absolute growth rate (AGR) was estimated according to the following equation as outlined by **Hunt (1990)**.

$$AGR = \frac{W_2 - W_1}{t_2 - t_1}$$

Where AGR is absolute growth rate ($g.day^{-1}$); W_1 is the dry weight of plant at the start period (g); W_2 is the dry weight of plant at the end period (g); t_1 is the start period (70 days after planting); and t_2 is the end period (90 days after planting).

B.2. Relative growth rate

Relative growth rate (RGR) was calculated according to **Poorter and Garnier (1996) and Philipson *et al.* (2012)** as follows:

$$\mathrm{RGR} = \frac{\ln \mathrm{W}_2 - \ln \mathrm{W}_1}{\mathrm{t}_2 - \mathrm{t}_1}$$

Where RGR is the relative growth rate (g/day).

B.3. Net assimilation rate (NAR)

NAR is an imperative indicator to explore the photosynthetic efficiency. NAR was quantified according to **Gregory (1926) and Watson (1952)** as follows:

$$\mathrm{NAR} = \frac{(\mathrm{W}_2 - \mathrm{W}_1)(\ln \mathrm{W}_{L2} - \ln \mathrm{W}_{L1})}{(\mathrm{t}_2 - \mathrm{t}_1)(\mathrm{W}_{L2} - \mathrm{W}_{L1})}$$

Where W_{L1} is the dry weight of leaves at the start period (t_1); and W_{L2} is the dry weight of leaves at the end period (t_2).

2.2. Data analysis

Using MSTAT statistical package (MSTAT-C with MGRAPH version 21), experimental data were statistically performed. The combined analysis was done for the results of the two seasons (2018 and 2019) after testing the homogeneity of error variances as an outlined by **Gomez and Gomez (1984)**. LSD (Least Significant Difference) was examined at 0.05 significance level as described by **Snedecor and Cochran (1980)**.

3. Results and discussion

3.1. Effect of planting dates

3.1.1. Growth Characters

Results of measured growth parameters of soybean plant analyzed using the combined analysis over two years (2018, 2019) are listed in Table (1). The differences between the mean values of plant height, No. of branches, No. of leaves, No. of pods, dry weight of leaves, stem, pods,the whole plant and chlorophyll content were significantly affected by planting dates at 70 and 90 days after planting.

Plant height varied according to the planting dates (Table 1). The tallest plants of 108.56 and 118.22 cm were recorded after the earliest planting date on May 5, while the shortest plants (92.18 and 101.56 cm) were realized from the delayed planting date of June,3 at 70 and 90 DAP, respectively. Differences between the two planting dates at May 5 and May 20 were not significant at 90 days after planting. These results may be due to the relatively longer period of growth with the optimal environmental conditions.

. Furthermore, the obtained results indicated that there was no significant effect ($p > 0.05$) between the May 5 and 20 in increasing No. of branches at 70 and 90 DAP (days after planting) and the minimal value was the delayed of planting date at 70 and 90 DAP. Additionally, the obtained data in Table (1) showed that No. of leaves was not significantly affected by planting dates at 70 days after planting with significant difference of 90 DAP. Planting at May 20 achieved maximal No. of leaves (26.70 and 33.09, respectively) at 70 and 90 DAP. However, the minimal ranges were resulted from planting at May 5.

Dry weight of stems, pods and the whole plant (15.46, 11.98 and 46.43 g, respectively) increased by planting at May 20 as compared to the other sowing dates. The lowest values for such respective parameters (12.97, 8.63 and 40.83 g, respectively) were realized for the delayed planting date on June 3 at 70 DAP. Results of this study also proved that dry weight of stem remarkably increased ($p < 0.05$) when planting at May 5 and 20 over late sowing date (June 3). Whereas there was no significant difference among early (May 5) and middle (May 20) planting date ($p > 0.05$) at 70 DAP.

Regarding No. of pods/plant, experimental data showed differences among sowing dates (Table 1). Maximum No. of pods (38.42 and 48.37 pod/plant) were observed for May 5 and the minimum No. of pods (29.86 and 39.17 pod/plant) were found in June 3 at 70 and 90 DAP, respectively. Results also revealed that there was no difference between two planting dates (early and middle-May). Whereas, planting in May 5 and 20 have remarkable effect on No. of pods ($p < 0.05$) in comparison with the untreated plants at 70 DAP. Such observations are similar with the results of **Nishioka and Okumura (2008)** who noticed that No. of pods/plant of soybean reduced with the delay in planting date.

Moreover, no differences ($p > 0.05$) were observed between plots in the total No. of nodes, No. of branches/plant and main stem's length, at the harvesting time. These results may be due to the variation of day and night temperature and photoperiod occurred at the three planting dates on the period of vegetative growth. The recording vegetative growth stages terminated when plants reached the beginning of flowering. The duration of vegetative and reproductive growth periods was estimated according to the No. of days between first node to beginning bloom upon to beginning maturity.

Table 1. Effect of planting dates on growth characters of soybean at 70 and 90 DAP (days after planting) combined over two growing seasons (2018 and 2019).

Planting dates	Plant height (cm)	No. of branches /plant	No of leaves /plant	Dry weight of leaves (g/plant)	Dry weight of stem (g/plant)	No of pods/ plant	Dry weight of pods (g/plant)	Dry weight of plant (g/plant)	Chlorophyll content
				At 70 days after planting					
May 5	108.56	2.33	25.53	17.79	15.32	38.42	11.08	44.19	40.27
May 20	106.16	2.27	26.70	18.99	15.46	37.79	11.98	46.43	41.60
June 3	92.18	1.46	26.58	19.23	12.97	29.86	8.63	40.83	41.12
LSD at 0.05	**2.15**	**0.21**	**n.s**	**n.s**	**0.99**	**1.39**	**0.63**	**1.51**	**0.63**
				At 90 days after planting					
May 5	118.22	2.90	30.95	21.76	20.49	48.37	22.10	64.34	32.52
May 20	117.23	2.90	33.09	23.25	19.53	46.43	21.39	64.17	39.40
June 3	101.06	2.54	29.56	23.19	15.80	39.17	17.27	56.26	38.71
LSD at 0.05	**2.24**	**0.15**	**1.20**	**0.81**	**0.84**	**1.22**	**0.88**	**1.43**	**0.63**

At 90 DAP, the highest dry weight of stems, pods and plant of soybean were achieved for the early-May (May 5) planting which were 20.49, 22.10 and 63.34 g, respectively and the reduction was observed when delayed sowing was to June 3 (15.80, 17.27 and 56.26 g). Differences ($p < 0.05$) on the dry weight of stems, pods and plant were observed due to early and mid-May planting as compared to late sowing of June 3. For dry weight of pods and plants, they were influenced ($p < 0.05$) by the three planting dates, especially May 20 planting at 90 DAP. This phenomenon is possibly credited to the earlier

soybean planting which can increase crop yield potential by allowing plants to produce earlier stem nodes. Moreover, sowing date exerted significant effect ($p < 0.05$) on dry weight of leaves/plant. Maximum values were resulted from the delayed planting date (June 3) at 70 DAP (19.23 g/plant) and May 20 at 90 DAP (23.56 g/plant), whereas the minimum weights (17.97 and 21.76 g/plant, respectively) were noticed at the early planting date at 70 and 90 DAP.

Concerning total chlorophyll content, planting at May 20 provided the highest values (41.60 and 39.40), while the least values were obtained from planting on June 3 (40.27 and 32.52) for 70 and 90 DAP, respectively.

3.1.2. Growth analysis

Data presented in Table (2) showed that there was not significant difference between the three planting dates on the RGR (Relative Growth Rate). The highest value of RGR (0.019 $g.day^{-1}$) which was resulted when planting at May 5; whereas the lowest value (0.016 $g.day^{-1}$) was recorded from planting at May 20 and June 3. These results of the present study agreed with **Tandale and Ubale (2007)** who found that the maximum RGR was observed during vegetative stage and reduced rapidly with the extensive development of growth stages. Concerning the studied of growth analysis AGR and NAR were of the maximum values which recorded at May 5 whilst the lowest values were of June 3 (0.772 and 0.771 g/day, correspondingly).

The improved growth analysis (AGR and NAR) may be correlated with the high dry matter accumulation in leaves which are active photosynthetic, inducing an enhancement in crop growth due to more penetration of light into canopy and less shadow for leaves. The reduction of RGR may be attributed to decrease the dry matter accumulation, which probably resulted from excessive mutual shading.

Table 2. Effect of planting dates on growth analysis of soybean at 70 and 90 DAP (days after planting) combined over two growing seasons (2018 and 2019).

Planting dates	AGR (g/day)	RGR (g/day)	NAR (g/day)
May 5	1.008	0.019	1.008
May 20	0.887	0.016	0.886
June 3	0.772	0.016	0.771
LSD at 0.05	**0.031**	**n.s**	**0.040**

3.2. Effect of gibberellin (GA_3)

3.2.1. Growth characters

There were significant differences on the studied growth characters of soybean including plant height, No. of branches, leaves, pods and dry weight of pods, leaves and stem under varying GA_3 concentrations (0, 50 and 100 ppm) at 70 and 90 DAP (Table 3).

Plant height was remarkably influenced by GA_3 ($p < 0.05$). GA_3 concentration at100 ppm was superior to control in producing taller plants at 70 and 90 DAP which was 104.77 and 114.53 cm, respectively. On the other hand, plant height significantly decreased as compared with the control plants (98.28 and 107.99 cm, respectively) at 70 and 90 DAP.

Results also clarified that the tallest plants were obtained after spraying GA_3 at 100 ppm followed by 50 ppm. Whereas, there was insignificant difference among these values. These data corroborate the investigations of **Leite *et al.* (2003)** who showed that GA_3 foliar application at a rate of 100 mg/L resulted in enhanced plant height, stem diameter, leaf area, first node height and dry weight production. Such results also were consistent with those of **Emongor (2007)** who found that GA_3 increased stem elongation, plant height, dry matter accumulation.

The reason for the increased in height of the plant was probably associated with the ability of gibberellin to elongate the stem by affecting the elongation of cells and stimulating plant growth especially the internodes length of stem, which improved their division (**Rahman *et al*. 2004)**.

At 70 and 90 DAP; the highest No. of branches (2.16 and 2.97 branch/pant) was obtained from GA_3 application at high concentration (100 ppm). On the other hand, the lowest No. of branches (1.80 and 2.50) was observed under spraying distilled water (without GA_3- 0 ppm). Results of the current work verified that No. of branches clearly increased ($p < 0.05$) by spraying GA_3 at 50 and 100 ppm compared with spraying distilled water, whilst there was not significant among GA_3 at 50 and 100 ppm.

Regarding No. of leaves, the obtained data in Table (3) showed that spraying GA_3 at 50 and 100 ppm achieved greatest No. of leaves/plant (27.49 and

33.26) at 70 and 90 DAP, respectively. Whilst, the lowest No. of leaves was obtained after spraying distilled water at 70 and 90 DAP. The increase in No. of leaves might be linked to the increase in leaf primordial and leaf initiation rate thus increasing the No. of leaves.

Also, the results obviously indicated for the effect of GA_3 concentration which was significant on the dry weight of leaves and stem. Spray of GA_3 at 100 ppm produced the maximum dry weight of leaves (19.98 and 24.07 g, respectively) and stem (15.48 and 19.56, respectively) during 70 and 90 DAP relative to lower concentration of 50 ppm which had lesser values of dry weight of leaves (16.47 and 20.53 g, respectively) and dry stem (13.01 and 16.71 g).

Results also demonstrated that dry weight of leaves and stems was increased ($p < 0.05$) by spraying GA_3 at 50 and 100 ppm over spraying distilled water, whereas there was no significant difference between the two concentrations of GA_3 (50 and 100 ppm). The enhancement in dry weight of stem following application of gibberellic acid was possibly correlated with the increase of plant height. Additionally, the growth regulator (GA_3) had significant effect on the No. of pods per plant. It is interesting to note that the high GA_3 concentration (100 ppm) of GA_3 increased the No. of pods (38.14 and 50.90 pod/plant, respectively) at 70 and 90 DAP better than the lower concentration and control. The minimum No. of pods (30.68 and 36.81, respectively) were recorded with 0 ppm (the distilled water) at 70 and 90 DAP.

The increase in No. of pods/plant may be due to the influence of gibberellin on the growth of the plant, which enhanced the No. of formed flowers, causing an increase in the No. of pods. Similar results were reported by **Khatun *et al.* (2016)** who mentioned that the use of GA_3 at flower up to pod initiation stage which produced the highest No. of pods/plant (41.00).

Furthermore, GA_3 had significant effect on dry weight of soybean pods per plant. The highest values were observed in concentration of 100 ppm 11.88 and 22.00 g, while the lowest values were obtained from control plants which were 8.75 and 17.83 g at 70 and 90 DAP, respectively.

In this regard, the highest dry weights of plant (47.34 and 65.62 g, respectively) were recorded when sprayed within GA_3 at 100 ppm, while the lowest weights were 38. 22 and 55.06 g were obtained by spraying distilled water (control) at 70 and 90 DAP. These outcomes are similar to the findings reported by **Bhatt and Srinivasa (2005)** who found that the increase in fresh weight of plant was linked to the increase in cell division, enlargement and growth. There was consistent increase in fresh weight of plant with increase of water availability. This was due to the efficacy in the assimilation rate of photosynthetic products.

Such observation also indicated different concentrations of plant growth regulator (GA_3) showed no significant variation ($p > 0.05$) on chlorophyll content of soybean leaf at 70 DAP. Whereas there was significant effect at 90 DAP.

The highest chlorophyll content (41.24 and 37.30) were recorded when the lowest GA_3 concentration was applied. While, the lowest contents (40.61 and 36.58) were recorded for the untreated plants (without GA_3 application) at 70 and 90 DAP.

Table 3 . Effect of planting dates on growth traits of soybean at 70 and 90 DAP (days after planting) combined over two growing seasons (2018 and 2019).

GA3 concentration (ppm)	Plant height (cm)	No. of branches /plant	No of leaves /plant	Dry weight of leaves (g/plant)	Dry weight of stem (g/plant)	No of pods /plant	Dry weight of pods (g/plant)	Dry weight of plant (g/plant)	Chlorophyll content
	At 70 days after planting								
0	98.28	1.81	23.91	16.47	13.01	30.68	8.75	38.22	40.61
50	103.86	2.09	27.49	19.56	15.26	37.25	11.07	45.89	41.24
100	104.77	2.16	27.41	19.98	15.48	38.14	11.88	47.34	41.13
LSD at 0.05	**1.73**	**0.17**	**0.91**	**0.79**	**0.71**	**1.12**	**0.51**	**1.22**	**n.s**
	At 90 days after planting								
0	107.99	2.50	28.56	20.53	16.71	36.81	17.83	55.06	36.75
50	113.99	2.87	31.78	23.60	19.55	46.27	20.93	64.09	37.30
100	114.53	2.97	33.26	24.07	19.56	50.90	22.00	65.62	36.58
LSD at 0.05	**2.03**	**0.14**	**1.09**	**0.73**	**0.77**	**1.11**	**0.80**	**1.30**	**0.57**

3.2.2. Growth analysis

Results of growth analysis of soybean plant under varied GA_3 concentrations are summarized in Table (4). there were no differences between GA_3 concentrations on RGR. The highest AGR and NAR were noted in GA_3 at 100 ppm. In contrast spraying distilled water as control recorded the lowest values (0.842 and 0.841 g/day). Regarding RGR, spraying distilled water resulted the greater value (0.018 g/day); nonetheless the least value of RGR was obtained from spraying plants with gibberellin at 100 ppm (0.016 g/day). Similar results were reported by **Rahman *et al*. (2004)**.

Table 4. Effect of planting dates on growth analysis of soybean at 70 and 90 DAP (days after planting) combined over two growing seasons (2018 and 2019).

GA3 concentration (ppm)	AGR (g/day)	RGR (g/day)	NAR (g/day)
0	0.842	0.018	0.841
50	0.910	0.017	0.910
100	0.914	0.016	0.914
LSD at 0.05	**0.034**	**n.s**	**0.036**

3.3. Effect of the interaction between sowing dates and gibberellin concentrations

3.3.1. Growth characters

It is noticed that the combined influence of planting dates and gibberellin were not significant on all of the studied growth traits except dry weight of pods/plant at 70 DAP (Table 5). The dry weight of soybean pods was significantly varied among treatments. The interaction between planting in May 20 and GA_3 concentration at 100 ppm exhibited the increment of dry weight of soybean pods (14.02 g/plant).

The lowest weight (9.15 g/plant) was recorded from the interaction between planting at the delayed date and spraying of GA_3 with 50 ppm at 70 DAP.

Also, there were no significant impact for the interaction regarding the other growth attributes which including No. of branches, dry weight of leaves, stem, pods and whole plant as well as No. of leaves under various planting dates and concentrations of GA_3 at 90 DAP (Table 5). However, this interaction under different planting dates (May 5 –June 3) and gibberellin concentrations (0 – 100 ppm) had significant effect on plant height, No. of leaves and total chlorophyll content.

Table 5. Effect of the interaction between planting dates and gibberellin on growth characters of soybean at 70 and 90 DAP (days after planting) combined over two growing seasons (2018 and 2019).

Treatment		Plant height (cm)	No. of branches /plant	No of leaves /plant	Dry weight of leaves (g/plant)	Dry weight of stem (g/plant)	No. of pods /plant	Dry weight of pods (g/plant)	Dry weight of plant (g/plant)	Chlorophyll content
Planting date	**GA_3 (ppm)**	**At 70 days after planting**								
	0	104.71	2.13	22.79	15.68	13.97	34.23	9.26	38.91	40.03
May 5	**50**	110.45	2.33	26.76	18.10	15.57	39.80	11.78	45.44	40.24
	100	110.53	2.54	27.05	19.59	16.42	41.23	12.22	48.22	40.53
	0	101.68	2.01	24.48	16.53	14.02	32.60	9.65	40.19	41.08
May 20	**50**	108.23	2.40	27.79	20.43	16.78	40.31	12.28	49.48	41.85
	100	108.56	2.39	27.83	20.02	15.59	40.47	14.02	49.62	41.88
	0	88.43	1.29	24.47	17.20	11.04	25.23	7.33	35.57	40.74
June 3	**50**	92.90	1.53	27.93	20.14	13.44	31.64	9.15	42.73	41.63
	100	95.22	1.55	27.35	20.35	14.42	32.72	9.41	44.18	40.98
LSD at 0.05		**n.s**	**n.s**	**n.s**	**n.s**	**n.s**	**n.s**	**2.49**	**n.s**	**n.s**
		At 90 days after planting								
	0	113.87	2.63	27.49	19.45	18.34	41.48	19.56	57.35	32.57
May 5	**50**	120.25	3.09	31.25	22.29	21.45	48.54	23.20	66.93	33.41
	100	120.54	2.98	34.11	23.53	21.67	55.09	23.55	68.75	31.58
	0	113.99	2.55	30.30	21.11	17.31	37.75	18.42	56.83	39.09
May 20	**50**	118.74	2.95	33.46	24.22	20.78	45.68	22.26	67.25	40.05
	100	118.96	3.20	35.52	24.43	20.50	55.87	23.50	68.43	39.06
	0	96.11	2.31	27.90	21.02	14.47	31.19	15.61	51.00	38.58
June 3	**50**	102.98	2.57	30.62	24.31	16.44	44.59	17.34	58.09	38.44
	100	104.09	2.73	30.16	24.23	16.50	41.73	18.96	59.69	39.11
LSD at 0.05		**3.51**	**n.s**	**1.89**	**n.s**	**n.s**	**n.s**	**n.s**	**n.s**	**0.98**

Concerning plant height, the tallest soybean plants were obtained from the interaction between planting date of May 20 and high concentration of GA_3 (100 ppm) at 90 days after planting (120.54 cm) as compared with other treatments. Whereas, the shortest plants were recorded by planting date of June 3 and without GA_3 of the control (96.11 cm). Concerning No. of leaves, spraying plants with GA_3 at 100 ppm with planting soybean at May 20 accumulated the highest value (35.52 leaf/plant) at 90 DAP reference to the interaction between planting at June 3 and without GA_3 (27.90 leaf/plant). Besides, interaction effects showed that the highest total chlorophyll content

(40.05) was obtained from plants at 50 ppm those planted on May 20 at 70 DAP and the plants of May 5 grown with 100 ppm GA_3 produced the lowest value (31.58) at 90 DAP.

3.3.2. Growth analysis

The growth regulator (GA_3) exhibited a significant influence on growth analysis expect RGR (Table 6). The interaction between early planting date at May 5 and spraying GA_3 at 50 ppm produced the maximum values, but the values were decreased for the interaction of delayed planting time and spraying distilled water (0.771 and 0.775 g/day).

Table 6. Effect of the interaction between planting dates and gibberellin (GA3) on growth analysis of soybean at 70 and 90 DAP combined over two growing seasons (2018 and 2019).

Treatment		AGR (g/day)	RGR (g/day)	NAR (g/day)
Planting date	**GA_3 (ppm)**			
May 5	**0**	0.922	0.019	0.922
	50	1.074	0.019	1.074
	100	1.026	0.018	1.026
May 20	**0**	0.832	0.017	0.830
	50	0.889	0.015	0.889
	100	0.940	0.016	0.940
June 3	**0**	0.771	0.018	0.771
	50	0.768	0.015	0.768
	100	0.775	0.015	0.775
LSD at 0.05		**0.060**	**n.s**	**0.062**

Conclusions

The impact of two agronomic strategies (sowing dates and foliar spraying with gibberellin) on growth characters and growth analysis of soybean. The observations in the present work proved that early planting at May 5 was beneficial on the growth attributes in comparison with other treatments. Moreover, all growth traits of soybean markedly reduced with spraying distilled water (0 ppm GA_3) reference to 50 and 100 ppm except chlorophyll and RGR. Furthermore, the mutual action of early planting date and high concentration of GA_3 exerted good effect on the studied growth characters, as well as the interaction between early planting date and 50 ppm GA_3 was the best for growth analysis of AGR, RGR and NAR.

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تأثير مواعيد الزراعة والرش بالجبرلين على صفات نمو فول الصويا

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أجريت تجربتان حقليتان فى محطة التجارب والبحوث الزراعية بكلية الزراعة بمشتهر – جامعة بنها- جمهورية مصر العربية خلال موسمى الزراعة 2018-2019 لدراسة تأثير مواعيد الزراعة (5 مايو، 20 مايو و 3 يونيو) وثلاثة تركيزات من الجبرلين (صفر،50 و 100 جزء فى المليون) على نمو فول الصويا صنف جيزة 111. أظهرت النتائج أن ميعاد الزراعة المبكر فى 5 مايو قد أدى إلى تحسن صفة ارتفاع النبات وعدد القرون بعد 70 و90 يومًا من الزراعة ، وكذا معدل النمو المطلق (AGR) وصافى معدل التمثيل الضوئى (NAR) مقارنةً بالميعادين الأخرين فى كلا الموسمين. أعطى الرش بالجبرلين بتركيز 100جزء في المليون اعلى القيم لكل الصفات المدروسة باستثناء صفتى معدل النمو النسبى (RGR) ونسبه الكلوروفيل مقارنة بالتركيزين الآخرين فى موسمى النمو عند 90 يوما بعد الزراعة. أدى التفاعل بين الميعاد المبكر للزراعة والرش بالجبرلين بتركيز 100 جزء فى المليون الى زيادة معنوية لصفات ارتفاع النباتات (120.54 سم)، عدد الاوراق/النبات (34.11)، عدد القرون/نبات (55.09)، والوزن الجاف للسيقان (21.67 جم)، القرون (23.55 جم) والنبات الكلى (68.75 جم) مقارنة بالتركيزين الأخرين فى موسمى النمو، بينما أدى التفاعل بين ميعاد الزراعة المبكر والرش بتركيز 50 جزء فى المليون من الجبرلين إلى تسجيل أعلى زيادة لمعدل النمو المطلق (1.074 جم/يوم)، معدل النمو النسبى (0.019 جم/يوم) و صافى معدل التمثيل الضوئى (1.074 جم/يوم) ومن النتائج السابقة يتضح أن زراعة فول الصويا فى الميعاد المبكر(5 مايو) مع الرش بالجبرلين بتركيز 50 أو 100 جزء فى المليون ادى إلى زيادة صفات النمو.