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Roles of Irrigation Intervals and Growth Regulators on Faba Bean Productivity and its Components

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ABSTRACT

One of the most significant factors limiting plant output on the majority of agricultural fields across the world is water stress, which is one of the environmental stresses. Salicylic acid (SA) and gibberellic acid regulates plant growth, makes plants more tolerant to water shortages and play a key role in many physiological processes. The present work was designed with the objective to investigate the effects of addition of SA and GA and irrigation intervals (14, 21, 28 days) on growth parameters, morphological parameters, photosynthetic pigments, protein, total carbohydrates and productivity of faba bean. This is achieved through a field experiment during winter season of 2016/2017 at Tag El-Ezz farm Mansoura city, Egypt. All vegetative growth parameters, yield parameters and chemical content were found to be increased by widening the irrigation periods from 14 days to 21 days, while narrowing the irrigation intervals to 28 days gave reverse effect. Addition of SA (1.0 ppm) and/ or GA (150 ppm) to faba bean at 14-21 days' irrigation period show maximum increase in plant characteristics (i.e. plant height, fresh, dry weight, chlorophyll and micronutrients contents).

Keywords: Salicylic acid, Gibberellic acid, Faba bean, Growth regulators, Irrigation periods

INTRODUCTION

The 4th most common cultivar in the world is faba bean (*Vicia faba L.*) (Singh *et al.*, 2013; Ibrahim *et al.*, 2019) which has been widely utilized in the Mediterranean region as the source of protein in both human and animal nutrition, whether fresh or dried (Abusin 2015; Yucel 2013). Faba bean is generally used as a vegetable, green or dried, fresh or canned human food (Singh and Singh 2017). Due to faba beans' capacity to fix nitrogen and symbiosis of Rhizobium bacteria, they have large nitrogen content in the soil air and play a key role in cultivated rotation (Fan *et al.*, 2006). Exogenous hormones cause changes in the endogenous contents of plants, which affects their growth and development. However, it's unclear if exogenous hormones directly affect growth or are linked to endogenous hormone changes (El-Mergawi and Abd El-Wahed 2020). SA also serves as a signaling molecule for activating plant defence responses in response to various stressors (Wani *et al.*, 2017). The endogenous SA reached its maximum 3 days after exogenous application of SA, and then gradually reduced until it reached the level of control plants 7 days later (Cai *et al.*, 2018). Development regulators including salicylic acid (SA) and gibberellic acid (GA3) are commonly utilized to control ornamental flowering plant growth and flowering. Salicylic acid (SA) is a hormone-like phenolic molecule generated by plants that play a significant role in plant responses to abiotic stressors and pathogen attacks (Abdelaal 2015). Salicylic acid (SA) is one of the plant growth regulators (Rivas-San Vicente and Plasencia, 2011) that is naturally occurring in very low plants as a phenolic compound and has a significant impact on different plant life aspects (i.e. physiological processes and plant growth) (Hassoon and Abduljabbar 2019).

The natural plant hormone SA is used to improve the resistance of plants to unwanted biotic effects (i.e. pathogens) and biotic stress resistance tolerance (Kissoudis *et al.*, 2014; Vinod and Sabah 2018) and to control their physiological processes (Singh and Gautam 2013). The effect of SA on plant growth, photosynthesis, evaporation, transmission, absorption and nutrient uptake is highly important (Youssef *et al.*, 2017) and leads to changes in leaf anatomy and chloroplast structures (Poór *et al.*, 2019). Salicylic acid (SA) is a plant phenolic phytohormone, existing ubiquitously in plants, and it has been recognized as a molecule essential to contribute to the abiotic stress response (Sharma *et al.*, 2019). The physiological functions of SA are extensive and include thermogenesis (Yusuf *et al.*, 2013), induction of flora (Gondor *et al.*, 2016), photo-synthesis (Janda *et al.*, 2014), nutrient absorption (Khan *et al.*, 2010) and plant water supply (Singh and Usha 2003). SA may also play a significant role in plant water linkages and ion retention (Liu *et al.*, 2016). Foliar SA application improves the negative effect of water stress (Yildirim *et al.*, 2008) and re-establishment of the wheat growth process (Matysiak *et al.*, 2020). On the other hand, irrigation practices and irrigation water have always limited the crops productivity (Clemmens and Molden 2007). Optimization of this vital process leads to much better yields, where the recommended amount of irrigation at the reproductive and even the vegetative growth stages must be applied correctly and timely (El-Kholy *et al.*, 2005). PGRs such as GA3 can enhance plant growth (Rashad and Hussien 2014), uptake, transport of ions (Tuna *et al.*, 2008) and subsequently use nutrients under salt stress (Shaddad *et al.*, 2013) depending on plant species.

The plant hormones have an impact over the course of their life cycle to regulate the growth and development of higher plants (Davies 2012). While the most obvious function of GA is to promote stem elongation at the cellular level, it also has other functions. (Yusuf *et al.*, 2013) The exogenous application of GA has been shown to increase essential oil concentration in various plants (Prins *et al.*, 2010). GA3 is a key plant growth regulator that boosts crop growth, development, and yield. GA3 is a phytohormone and torpedoed molecule with 19–20 carbon atoms that are naturally formed in fresh leaves and germinated seed embryos, and it has been found in over 136 species (El-Mergawi and Abd El-Wahed 2020). GA3 has also been shown to aid in the maintenance of water status in plants under salinity/drought-induced water deficit stress (Hossain *et al.*, 2015) and (Nehal and Bichakjian, 2018). Up till now, enough information on SA and GA requirements to improve yield parameters is not available. Thus, to resolve low productivity by irrigation interval duration, the present research implies the impact of the foliar application of these materials on yield and increasing productivity. So, the current study aimed to investigate the effect of different SA concentrations (0.01, 0.1 and 1.0 ppm) and GA concentrations (100, 200 and 300 ppm) at three irrigation periods (14, 21, and 28 days) on morphological parameters, photosynthetic pigments, protein, and total carbohydrates.

MATERIAL AND METHODS

Experiment design

The experiment was conducted in the research farm of Tag El-Ezz located in Mansoura city (Dakhalia Governorate, Egypt) during winter seasons 2016/2017 and 2017/2018 with a view to the assessment of SA, GA applications and irrigation intervals for the growth and the yield of faba bean (*Vicia faba L*.C.V balady). The split-plot design was used in three treatments with three replicates. Each replicate was made up of 18 experimental units (2 m x 3 m). The first factor was the irrigation intervals (14, 21 and 28 days) in the main plots, while the second factor represented three different concentrations of SA (0.01, 0.1 and 1.0 ppm) and GA (100,150 and 200 ppm) in the sub-plot. The first foliar application was performed in phase 3-4 of growth and the second one was at the start of the flowering stage. At two irrigation intervals (1 with sowing and 2 with starting flora), nitrogen fertilizer (50 kg N fd-1; urea (46% -N)) was applied. According to the recommendation of the Minister of Agriculture (Tellioglu and Konandreas 2018), all practical agricultural activities were considered. The chemical and physical properties of experimental soil are presented in Table 1.

Table 1: Physical and chemical properties of experimental soil

Physical properties								
Soil Type	Fine sand %	Coarse sand %	Silt %	Clay %	EC (ds/m)	HW %	Field capacity %	HC (cm/sec)
Clay loam	29.04	9.33	36.32	35.04	6.72	6.61	35.4	2.42
Chemical properties								
pH Soil paste	Organic matter (O.M %)	Available nutrients (ppm)						
		N	P	K	Fe	Mn	Zn	Cu
7.8	1.67	61.0	226.3	254.0	13.4	10.1	1.3	0.78

EC: Electric conductivity; HW: Hygroscopic water; HC: hydraulic conductivity

Methods of analysis

Soil analysis

PH value was determined in the soil paste using a Gallenkamp pH meter (A. Gallenkamp Co.& Ltd., UK) and electric conductivity (EC) in 1: 2.5 soil: water extract was determined according to the reported procedures (Sahlemedhin and Taye 2000). Mechanical analysis was determined following the international pipette method using NaOH as a depressing agent (Wirth 1946). Available N, P, and K were described (Haluschak 2006). Organic matter was determined according to Walkley & Black chromic acid wet oxidation method (Hesse 1971). Available micronutrients in soil samples were extracted by di ethylene tri amine pent acetic acid (DTPA) solution (Lindsay and Norvell 1978) and determined using the atomic absorption spectrophotometer. Hydraulic conductivity (K) values of the soil samples columns were determined using the constant head permeameter in disturbed soil (Eq. 1) (Smith 2000).

$$K = QL/HAT \qquad (1)$$

Where: K: hydraulic conductivity coefficient (cm/sec); Q: the volume (cm^3) of water being passed through the soil column at time (T); A: cross section area (cm^2); L: length of soil column (cm); H: hydraulic head (cm).

Saturation percentage (SP%) was determined according to reported procedure (Aali *et al.*, 2009).

Plant analysis

Faba bean plant was oven-dried at 70 °C till constant weight, grained and 0.2 g from each sample was then wet digested (Wirth 1946). The N, P and K and micronutrients were determined in the whole plant (Mertens 2005b, a). The total chlorophyll contents (Chl a+b) in leaves were also measured (Parry *et al.*, 2014), where the fresh leaf samples (0.2 g each) were placed in tubes containing 10 ml of 80% acetone at -4 °C for 24 h. The extracted samples were centrifuged at 10,000 g for 5 min. The absorbance of the upper layer (supernatant) was recorded at 645 and 663 nm using a spectrophotometer. The percentage of total carbohydrates was determined according to the reported method (Gul and Safdar 2009). The percentage of protein and fibre contents was measured according to AOAC, 2000 standard methods (Horwitz 2010).

Statistical analysis

Appropriate analysis of variance was performed using COSTATE V 6.4 (2005) for Windows (CoStat 2005). According to the significant differences among the mean of various treatments, the Computer Software program was established by the Least Significant Differences method (LSD) (Gomez and Gomez 1984). The displayed parameters values are the mean of the two seasons. The split-plot design was used in three treatments with three replicates. Each replicate was made up of 18 experimental units.

RESULTS

Vegetative growth parameters

Plant height, fresh and dry weight

The collected data in Table 2 illustrated the influence and interaction of irrigation periods, SA and GA on plant length and weight. The addition of SA and/ or GA at different irrigation periods seems to affect the plant height, fresh and dry weight, where extended irrigation intervals up to 21 days show a maximum increase in plant characteristics (i.e. plant height, 98.08cm; fresh and dry weight, 236.05 and 34.56g/plant). The breadth of periods to 28 days decreased the tested parameters. Foliar application of SA positively affected plant height and fresh and dry weight, increasing from 0.01 to 1.0 ppm. The addition of 150 ppm GA gave the optimum plant height (101.43 cm), while increasing the foliar application of GA up to 200 ppm the three parameters were noticed to have positive decrease. The interaction effect of irrigation periods upon adding SA and/ or GA on plant characteristics was noted in Table (2), where increasing the drought duration from 14 to 21 days led to an increase in plant functions.

Data also revealed that irrigation at 21 days with foliar application of SA (S3, 1.0 ppm), proved to be the most effective interaction in increasing plant height, fresh and dry weight 110.90 cm, 265.30 g/plant and 38.68 g /plant, respectively. The lowest increment with the same doses of SA was by irrigation every 28 days. GA gave its higher values increments by irrigation every 21 days with GA of conc.150 ppm (110.90 cm, 265.30g/plant and 38.68g/plant, respectively. This regime was followed by irrigation every 14 days with the same SA and/ or GA additions. However, irrigation every 28 days combined with SA (S1) decreased plant length and fresh and dry weight to (73.80 cm, 178.40 g/ plant and 26.72 g/ plant, respectively). The addition of GA (G3, 200 ppm) with the same irrigation intervals at 28 days decreased also plant length, fresh and dry weight (75.90 cm, 183.50 g/plant and 27.41g/ plant, respectively).

These results are convenient with previously reported and could be explained by the effect of Gibberellin that increased the cell division and cell number in the subapical meristem and extended the internode length in cells (Hashemabadi 2010). Also, the application of 300 ppm of SA to soybean increased plant height, leaf area and branch number (Maity and Bera 2009). These results also agree with those obtained on pea (Ali and Mahmoud 2013; Rasheed 2018). Previous studies have shown that a wide range of reactions may appear after exogenous application of SA led to an increase in plant height, fruit weight and fruit per plant (Khodary 2004). The importance of SA in the leaf area is due to its vital functions in cell division, organic food production, availability, and mineral nutrient movement to the leaves(Wong et al., 2015).

In comparison to control plants, foliar application of salicylic acid dramatically boosted red sweet pepper vegetative growth, fruit yield, and quality. The importance of SA in the leaf area is due to its vital functions in cell division, organic food production, availability, and mineral nutrient movement to the leaves. (Ibrahim et al., 2019)

Table 2: Average plant length (cm), fresh and dry weight (g/plant) and their interactions as influenced by irrigation periods, SA and GA addition in two seasons

Treatments		Plant length (cm)	Fresh weight (g/plant)	Dry weight (g/plant)
Interval days				
14 days		93.03	225.90	33.18
21 days		98.08	236.05	34.56
28 days		85.08	205.48	30.39
LSD at 5%		0.14	0.33	0.02
Foliar application				
S1		78.13	188.70	28.14
S2		94.07	226.73	33.31
S3		101.30	244.40	35.60
G1		96.27	232.10	34.04
G2		101.43	244.10	35.64
G3		80.30	193.83	28.85
LSD at 5%		0.80	0.81	0.10
Interactions				
Treatments		Plant length (cm)	Fresh weight (g/plant)	Dry weight (g/plant)
14 days	S1	78.10	188.60	28.12
	S2	95.70	230.40	33.86
	S3	103.90	250.50	36.48
	G1	97.90	235.90	34.61
	G2	106.20	256.30	37.15
	G3	80.30	193.70	28.85
21 days	S1	82.50	199.10	29.57
	S2	99.60	240.20	35.09
	S3	108.70	261.90	37.90
	G1	101.80	245.50	35.82
	G2	110.90	265.30	38.68
	G3	84.70	204.30	30.28
28 days	S1	73.80	178.40	26.72
	S2	86.90	209.60	30.97
	S3	91.90	220.80	32.42
	G1	89.10	214.90	31.69
	G2	93.50	225.70	33.10
	G3	75.90	183.50	27.41
LSD at 5%		1.39	1.41	0.17
F. test		*	*	*

These results are convenient with previously reported and could be explained by the effect of Gibberellin that increased the cell division and cell number in the subapical meristem and extended the internode length in cells (Hashemabadi 2010). Also, the application of 300 ppm of SA to soybean increased plant height, leaf area and branch number (Maity and Bera 2009). These results also agree with those obtained on pea (Ali and Mahmoud 2013; Rasheed 2018). Previous studies have shown that a wide range of reactions may appear after exogenous application of SA led to an increase in plant height, fruit weight and fruit per plant (Khodary 2004). The importance of SA in the leaf area is due to its vital functions in cell division, organic food production, availability, and mineral nutrient movement to the leaves (Wong *et al.,* 2015). Compared to control plants, foliar application of salicylic acid dramatically boosted red sweet pepper vegetative growth, fruit yield, and quality**.** The importance of SA in the leaf area is due to its vital functions in cell division, organic food production, availability, and mineral nutrient movement to the leaves. (Ibrahim *et al.,* 2019).The positive effects of SA and Zn foliar spray on wheat vegetative growth under the irrigation interval were in line with the results found by some researchers (Aldesuquy *et al.*, 2012; Azimi *et al.*, 2013). Accordingly, exogenous SA application can help to reduce the negative effects of drought in different crops subject to deficit irrigation (DI) (Anosheh *et al.*, 2012; Habibi, 2012). The present study recorded that drought stress, created by DI, reduced squash plant growth parameters. However, foliar-applied SA, increased the characteristics of this growth, especially fresh and dry weight in squash plants which were previously observed in certain crops such as wheat, maize and barley (Shakirova 2007; Habibi 2012).

SA is a potential signaling molecule whose mechanism is not fully explained to improve the tolerance to drought stress. Our studies show that under some biotic stresses, including drought and salinity, the effects of exogenous SA on plant stress tolerances are not always clear. This depends not only on the application method and concentration but also on the overall condition of the plant (i.e., developmental stage, oxidative balance of the cells and acclimation by biotic or biotic stresses). The increase in the dry mass of stressed plants in response to SA can be associated with antioxidant reactions, which protect the plant from damage

(Singh and Usha 2003). The stimulation of growth, which increases shoot length, could be attributed to vegetative growth. GA3 and NAA are important plant growth regulators because they play a role in cell division and cell wall elongation, which leads to increased shoot length (Hamdy 2017). Salicylic acid's beneficial effects on physiological and biochemical processes in plants, such as ion absorption, cell elongation, cell division, and cell differentiation, could be linked to its bio regulator effects (Fahad *et al.*, 2015).

Yield parameters

Weight of 100 seeds/g, average weight of seeds g /plant and seed yield kg/fed

The interactions of irrigation intervals, SA and GA with average weight of 100 seeds/g, average weight of seeds (g/plant) and seed yield (kg/fed) as impacted by two seasons.

Table 3: Interactions of irrigation intervals, SA and GA with average weight of 100 seeds/g, average weight of seeds (g/plant) and seed yield (kg/fed) as impacted by two seasons

Treatments		Weight of 100 seeds/g	Average weight of seeds (g/plant)	Seed yield (kg/fed)
Interval days				
14 days		46.53	138.25	4080.00
21 days		47.54	149.43	4408.67
28 days		44.64	116.37	3450.33
LSD at 5%		0.03	0.26	92.66
Foliar application				
S1		42.80	99.77	2953.33
S2		46.74	138.67	4107.67
S3		48.44	157.40	4639.33
G1		47.02	143.50	4258.33
G2		48.55	158.28	4646.00
G3		43.36	105.27	3119.00
LSD at 5%		0.04	0.41	65.19
Interactions				
Treatments		Weight of 100 seeds/g	Average weight of seeds (g/plant)	Seed yield (kg/fed)
14 days	S1	42.79	99.80	2944.00
	S2	47.48	142.70	4209.00
	S3	48.92	164.30	4844.00
	G1	47.05	147.80	4365.00
	G2	49.54	169.70	5009.00
	G3	43.38	105.20	3109.00
21 days	S1	43.97	111.30	3257.00
	S2	47.64	152.50	4541.00
	S3	50.10	176.40	5187.00
	G1	48.33	156.10	4691.00
	G2	50.72	183.40	5326.00
	G3	44.50	116.90	3450.00
28 days	S1	41.65	88.20	2659.00
	S2	45.09	120.80	3573.00
	S3	46.30	131.50	3887.00
	G1	45.68	126.60	3719.00
	G2	46.92	137.40	4066.00
	G3	42.21	93.70	2798.00
LSD at 5%		0.07	0.72	112.92
F. test		*	*	*

Results in Table 3 show that 1.0 ppm of SA significantly increased the weight of 100 seeds/g, average weight and kg/fed seed yield compared with other levels (0.01 and 0.1 ppm). The maximum increment in all parameters was (48.44 g, 157.40 g/ plant and 4639.33 kg/ fed) with a weight of 100 seed (S)/ g. These outcomes, accompanied by 0.1 ppm and 0.01 ppm of SA and GA, showed to be increased by 150 and 100 ppm. However, by 200 ppm, the average weight of the seeds g/plant and the seed yield kg/fed have decreased significantly. Reduced irrigation cycles to 21 days dramatically increased the plant's growth parameters (47.54 g, 116.37 g/ plant, 3450.33 kg/ fed). In comparison, irrigation in all variables decreased at 28 days. Table 3 demonstrates that the weight of 100 seeds/ g, average seed weight, and seed yields interacts with SA and Interaction GA evidence shows the highest possible increase in weight of 100 seeds (50.72 g) during 21 days followed by irrigation at 150 ppm in case of GA for 14 days. Seed yield kg/ food with GA addition at150ppm (183.40 g/ plant, 5326.00 kg/ food) is recorded at the average weight. In addition to being handled, faba bean with SA (1.0 ppm) irrigated each 21 days, all parameters of 100 grains/g of average weight of seeds g/plant, were significantly increased in seed yield (50.10 g, 183.40 g/ plant, 5187.00 kg/ fed, respectively, followed by 14 days irrigation of SA (1.0 ppm). Therefore, the weight of 100 seeds, the average weight of the seeds, and seed yield with SA or GA decreased every 28 days of irrigation. The increase in yield parameters due to SA observed in the present investigation can be attributed to increased photosynthetic activity in leaves and the translocation of more photo-assimilated fruits. The result in the olive industry (El-Dakkak *et al.*, 2020) are consistent with this study. SA could increase the dry mass of plants and mitigate the adverse effects of DI stress. These can improve plant growth and overcome the production barrier caused by limited water availability conditions. Gibberellic acid (GA3) is a plant hormone that regulates signaling pathways, seed germination, and plant growth (Cavusoglu and Sulusoglu 2015).

Moreover, excessive or lower water decreased most faba bean yield characteristics, which is implied with reported studies (Sallam *et al.*, 2014; Khalifa 2019). GA3 stimulates growth by lengthening stems, increasing dry weight, and improving yield. It could be attributed to increased cell division and stem elongation (longer plants), photosynthetic pigments, plant biomass (fresh weights of leaves, stems, and roots), and grain N content. Plant growth improves due to cell division and expansion in a similar way(Islam *et al.*, 2021). GA3 promotes rapid growth by stimulating the creation of mRNA molecules in cells, which activates hydrolytic enzymes. Greater dry matter production and distribution have long been known to contribute greatly to crop plant yield potential, and this appears to account for the majority of the higher crop yields (Miceli *et al.*, 2019).

Number of flower/plant, number of pods/plant, fruit setting

Table 4 showed the effect of irrigation periods, SA and GA on average flower no./ plant, no. of pods/ plant and fruit setting percentage in two seasons.

Table 4: Effect of irrigation periods, SA and GA on average flower no./ plant, no. of pods/ plant and fruit setting % in two seasons

Treatments		No. of flower/plant	No of pods /plant	fruit setting%
Interval days				
14 days		12.93	8.51	65.04
21 days		13.40	9.06	66.99
28 days		12.02	7.12	58.82
LSD $_{at\ 5\%}$		0.06	0.23	1.67
Foliar application				
S1		10.92	5.97	54.57
S2		13.16	8.59	65.07
S3		13.88	9.75	69.96
G1		13.35	8.64	64.63
G2		13.82	9.77	70.23
G3		11.30	6.32	55.81
LSD $_{at\ 5\%}$		0.04	0.19	1.34
F. test		*	*	*
Interactions				
Treatments		No. of flower/plant	No of pods /plant	fruit setting%
14 days	S1	10.91	5.97	54.72
	S2	13.35	8.84	66.22
	S3	14.24	10.21	71.70
	G1	13.57	9.20	67.80
	G2	14.29	10.52	73.62
	G3	11.19	6.29	56.21
21 days	S1	11.55	6.64	57.49
	S2	13.73	9.53	69.41
	S3	14.44	10.87	75.28
	G1	13.84	8.97	64.81
	G2	14.75	11.33	76.81
	G3	12.08	7.02	58.11
28 days	S1	10.29	5.30	51.51
	S2	12.40	7.39	59.60
	S3	12.97	8.16	62.91
	G1	12.63	7.74	61.28
	G2	13.18	8.50	64.49
	G3	10.64	5.65	53.10
LSD $_{at\ 5\%}$		0.06	0.33	2.32
F .test		*	*	*

Data revealed that 1.0 ppm of SA could cause an increase in the number of flowers/plants, the number of pods/plants and the fruit setting % compared to the levels (0.01 and 0.1 ppm). At 150 ppm, GA produced a high rise, followed by 100 ppm, but not 200 ppm. The growth parameters (13.40 flower/ plant, 9.06 pods/ plant, 66.99 %) have been improved by decreasing irrigation periods to 21 days. On the other hand, 28 days of irrigation gave a decline in all parameters. Data also illustrated the effect of SA, GA and irrigation intervals. Their interactions showed an increase in all parameters. The maximum mean values of vegetative parameters were obtained from irrigation every 21 days with GA at 150 ppm on number of flowers /plant (14.75 flower/ plant) followed by irrigation every14 days, but the lowest values recorded by irrigation every 28 days. Irrigation every 21 days with the addition of 0.1 ppm SA gave the highest level (11.55 flower/ plant) followed by 14 days irrigation at the same level of SA. The number of pods/ plant showed the highest irrigation value at 21 days with 150 ppm GA (11.33 pods/ plant). Fruit setting percentage also provides the highest increase for irrigation at the same GA level every 21 days. On the other hand, the addition of 0.1 ppm SA with irrigation at the fruit setting percentage after 21 days (75.28 %) gave the highest value. These treatments are followed by irrigation at the same level of SA every 14 days. The obtained results are in accordance with that reported describing the role of SA in the regulation of physiological processes in plants, encouraging the blooming of a number of plants, enhancing floral life and controlling the root uptake of ions and stomach conductivity (Mahdi *et al.*, 2020) This outcome was consistent with what was previously stated (El-Shafey *et al.*, 2019).

Chemical contents

Chlorophyll a and b content and total chlorophyll

The effect of irrigation periods, SA and GA on the average of chlorophyll a& b and total chlorophyll in two seasons is shown in Table 5.

Table 5: Effect of irrigation periods, SA and GA on the average of chlorophyll a& b and total chlorophyll in two seasons

Treatments		Chlorophyll a (mg/g FW)	Chlorophyll b (mg/g FW)	Total chlorophyll (mg/g FW)
Interval days				
14 days		0.678	0.480	1.158
21 days		0.696	0.495	1.191
28 days		0.638	0.450	1.088
LSD at 5%		0.007	0.003	0.010
Foliar application				
S1 (0.01 ppm)		0.607	0.425	1.032
S2 (0.1 ppm)		0.680	0.482	1.161
S3 (1 ppm)		0.710	0.506	1.216
G1 (100 ppm)		0.689	0.490	1.049
G2 (150 ppm)		0.711	0.507	1.218
G3 (200 ppm)		0.616	0.433	1.049
LSD at 5%		0.005	0.004	0.006
Interaction				
Treatments		chlorophyll a (mg/g FW)	chlorophyll b (mg/g FW)	Total chlorophyll (mg/g FW)
14 days	S1	0.608	0.425	1.033
	S2	0.688	0.487	1.175
	S3	0.723	0.516	1.239
	G1	0.696	0.495	1.191
	G2	0.734	0.524	1.258
	G3	0.617	0.433	1.050
21 days	S1	0.625	0.440	1.065
	S2	0.705	0.502	1.208
	S3	0.743	0.531	1.274
	G1	0.715	0.510	1.225
	G2	0.751	0.539	1.290
	G3	0.636	0.448	1.084
28 days	S1	0.587	0.411	0.998
	S2	0.645	0.456	1.101
	S3	0.664	0.471	1.135
	G1	0.657	0.464	1.121
	G2	0.676	0.480	1.156
	G3	0.596	0.418	1.014
LSD at 5%		0.009	0.007	0.007
F. test		*	*	*

The recorded data showed the impact of SA, GA concentration and irrigation intervals on the content of chlorophyll. It's found that chlorophyll a& b and total chlorophyll with irrigation every 14 days and 21 days had the highest increase. The addition of 1 ppm SA afford the highest mean value in chlorophyll a& b and total chlorophyll (0.710, 0.506 and 1.216 mg/ g FW, respectively) compared to other concentrations of SA (0.01and 0.1 ppm). The highest value (0.711, 0.507 and 1.218 mg/g FW, respectively) is given by GA at 150 ppm, followed by SA (100 and 200 ppm). An increase between drying time from 14 to 21 days resulted in a relative increase of chlorophyll, b and total chlorophyll with SA and GA. The interaction effects values of irrigation periods, SA and GA on chlorophyll a& b and total chlorophyll showed that 21-day irrigation with foliar application of SA (S3 1.0 ppm) followed by 14-day irrigation is the most effective interaction to increase chlorophyll a& b and also total chlorophyll (0.743, 0.531 and 1.274 mg/g Fw, respectively). However, the lowest result with the same doses of SA was by irrigation every 28 days. GA has recorded higher irrigation rates every 21 days with the addition at 150 ppm (0.751, 0.539 and 1.290 mg/g F w, respectively) followed by irrigation every 14 days. However, irrigation reduces chlorophyll a, b and total chlorophyll to (0.625, 0.440 and 1.065 mg/g FW, respectively) per 28 days in combination with SA (S1). Chlorophyll a, b and total chlorophyll plant duration also decreased to (0.596, 0.418 and 1.014 mg/G Fw, respectively) by adding 200 ppm GA (G3) with 28 days irrigation period. The use of GA3 reveals the effects on seed germination, fresh and dry weight of root and shoot, chlorophyll and carotenoid contents of wheat and saline stress (Turkyilmaz 2012). Spraying SA let photosynthetic pigments has a beneficial effect on endogenous cytokine levels, which accelerate growth and chloroplast differentiation, this could explain the good effect (Rady *et al.,* 2019). Salicylic acid (SA) regulates plant growth and development by controlling pigment content, photosynthesis and transpiration rate, ion uptake and transport, seed germination, fruit yield, glycolysis, and inducing changes in leaf anatomy and chloroplast ultrastructure (Jayakannan *et al.,* 2015). GA3 increases the number and size of chloroplasts and the activity of plastids by increasing the content of photosynthetic pigments (chlorophylls and carotenoids (Islam *et al.,* 2021). This observation has been supported by literature findings (Saini and Keum 2018). Additional chlorophyll and carotene isomers were discovered in leaves treated with high doses of SA and with increased SA activity N, P and K% in grains of faba bean. The percentage values of N, P and K in faba beans grains were measured and tabulated in Table 6.

Table 6: Average of N, P and K (%) in faba bean grains and their interactions as influenced by irrigation periods, SA and GA in two seasons

Treatments		N%	P%	K%
Interval days				
14 days		2.64	0.332	2.31
21 days		2.99	0.338	2.50
28 days		2.30	0.269	1.89
LSD at 5%		0.07	0.004	0.02
Foliar application				
S1		2.03	0.234	1.57
S2		2.65	0.314	2.32
S3		2.95	0.355	2.66
G1		2.73	0.326	2.43
G2		2.97	0.358	2.65
G3		2.44	0.280	1.66
LSD at 5%		0.06	0.005	0.03
Interaction				
Treatments		N%	P%	K%
14 days	S1	2.03	0.237	1.57
	S2	2.71	0.323	2.39
	S3	3.04	0.365	2.81
	G1	2.79	0.346	2.50
	G2	3.15	0.387	2.90
	G3	2.11	0.334	1.66
21 days	S1	2.19	0.255	1.75
	S2	2.87	0.343	2.61
	S3	3.26	0.389	2.99
	G1	3.27	0.354	2.72
	G2	3.38	0.408	3.08
	G3	2.95	0.267	1.84
28 days	S1	1.87	0.209	1.39
	S2	2.36	0.277	1.95
	S3	2.54	0.301	2.17
	G1	2.45	0.289	2.06
	G2	2.63	0.312	2.28
	G3	1.95	0.228	1.48
LSD at 5%		0.10	0.008	0.05
F. test		*	*	*

The largest increase in all parameters, followed by 0.1 ppm and 0.01, 2 ppm of SA was (N= 2.95, P= 0.355 and K= 2.66 %) in the faba bean grains. The GA was shown to be a very substantial increase in the range of 150 ppm (N= 2.97, P= 0.358 and K= 2.65 %) followed by 100 ppm. The reduced 21 days of irrigation led to a substantial increase in N, P and K (2.99, 0.338 and 2.5 %, respectively). However, irrigation caused all parameters to decrease in 28 days. An increase in the duration of drought between 14 days and 21 days resulted in a relative increase of N, P and K % in the presence of SA and GA, due to the interaction of irrigation, SA and GA to N, P, and K. Irrigation at 21 days with SA foliar application (S3) at 1.0 ppm showed the highest increase in N, P and K % (3.26, 0.398 and 2.99 %, respectively) followed by irrigation at 14 days, while irrigation every 28 days was the lowest with the same doses of SA. Addition of GA up to 150 ppm led to N = 3.38, P= 0.408 and K= 3.08 % every 21 days with irrigation increases. These data were supported by the same SA and GA treatment each for 14 days irrigated, while N, P, and K % (1.87, 0.209 and1.39, respectively) were decreased each 28 days in combination with SA (S2). And with the same 28-day irrigation period, the addition of GA (G3) at level of 200 ppm decreased the N, P and K% to (1.95, 0.228, and 1.48 %, respectively). The role of SA in increasing the N, P, K and Ca content has been reported (Maity and Bera 2009). When faba bean plants were sprayed with salicylic acid, the shoot system's dry weight increased significantly compared to non-sprayed (control) plants. Spraying sugar beet and pea plants with salicylic acid or garlic extract had a significant positive effect on plant growth in this regard (Khan *et al.*, 2018). Salicylic acid's promoting effect may be attributed to its bio regulator effects on physiological and biochemical processes in plants, such as ion uptake, cell elongation, cell division, and cell differentiation (El-Shafey *et al.*, 2020).

Effect of irrigation periods, SA and GA on C. protein %, total carbohydrates % and D. fibber % in grains of faba bean.

The effect of irrigation periods, SA and GA on C. protein %, T. carbohydrates % and D. fibber % in grains of faba bean was studied and data was collected in Table 7.

Table 7: Average of C. protein %, T. carbohydrates %, D. fibber % in grains of faba bean as affected by irrigation periods, SA and GA in two seasons

Treatments		C. protein%	T. carbohydrates %	D. fiber%
Interval days				
14 days		14.53	45.57	10.09
21 days		15.39	46.70	10.32
28 days		12.79	43.50	4.48
LSD at 5%		0.05	0.23	0.13
Foliar application				
S1		11.37	40.93	8.97
S2		14.63	46.20	10.13
S3		16.07	47.67	10.53
G1		15.04	46.63	10.28
G2		16.09	47.62	10.59
G3		11.81	41.87	9.13
LSD at 5%		0.03	0.49	0.12
Interactions				
Treatments		C .protein%	T. carbohydrates %	D. fibber%
14 days	S1	11.38	40.80	8.97
	S2	14.96	46.70	10.23
	S3	16.63	48.30	10.85
	G1	15.33	47.20	10.39
	G2	17.07	48.80	10.98
	G3	11.82	41.60	9.13
21 days	S1	12.25	42.10	9.28
	S2	15.76	47.60	10.54
	S3	17.50	49.20	10.83
	G1	16.18	47.90	10.70
	G2	17.98	49.80	11.13
	G3	12.69	43.6	9.43
28 days	S1	10.47	39.90	8.66
	S2	13.16	44.30	9.61
	S3	14.09	45.50	9.92
	G1	13.62	44.80	9.76
	G2	14.51	46.10	10.08
	G3	10.91	40.40	8.82
LSD at 5%		0.08	0.85	0.21
F. test		*	*	*

The studied parameters were highly affected every 21 days. The highest increase recorded was (C. protein= 15.39, T. carbohydrates= 46.10 and D. fibber= 10.32 %) at 1.0 ppm. The maximum increase in C. protein, T. carbohydrate, D. fiber and 1.0 ppm of SA was (11.37, 40. 93 and 8.97 %, respectively). The addition of GA at 100 and 150 ppm results in proximity, but the highest increase is found with GA (150 ppm) in all parameters (16.09, 47.62, and 10.59 %, respectively). The statistical test results showed the SA interaction with GA on tested parameters in bean grains at the mean time. Interaction data have shown that irrigation with GA at 150 ppm is the greatest increase at 21 days in C. protein (17.98 %) followed by irrigation every 14 days (16.18 %). The most significant increase in C. protein is at the irrigation period for 21 days with SA at 1.0 ppm (17.50 %). These were followed by 14-day SA irrigation at 1.0 ppm.

Consequently, C. protein with all SA and GA levels decreased every 28 days. In combination with SA and GA, the effect of irrigation intervals showed over total carbohydrate present, where the initial highest irrigation effect every 21 days with SA at 1.0pm (49.20 and 10.83 %) and irrigation at the maximum values every 21 days with150 ppm of G2 (49.80 and11.13 %) followed by irrigation every 14 days. Protein breakdown causes the growth of amino acids in plant organs in saline circumstances, resulting in a decrease in protein and growth. (Ahmad *et al.*, 2019). Therefore, increased irrigation level resulted in a significant drop in soluble carbohydrate and protein content. These findings matched those previously published (Mohamed 2018), which indicated that reduction in soil moisture content was achieved as an effect of irrigation interval on the percentage of black cumin carbohydrates due to an increase of irrigation periods from 2 to 7 days. So that SA caused the protein content to increase by enhancing the activation of nitrate content and nitrate re-educates. The essence of the SA influence on hormone secretion tends to contribute to plant defensive reactions and activation of reparative processes and effects on total protein levels. (Haynes 2017).

Consequently, the percentage of carbohydrates increased through treatment for deficit irrigation (Hassan and Ali 2014), whereas as a result of irrigation water decline, the carbohydrate content decreased to the minimum (Yousef *et al.*, 2013). Data showed that carbohydrate and protein content increased substantially at irrigation intervals in grains of treated plants every 14 and 28 days with SA or Zn treatment. These results are compatible with the reported studies(Yadavi *et al.*, 2014). The addition of salicylic acid to sunflower plants increased total carbohydrate production (El-Saadony *et al.*, 2017). Spraying pea plants with SA (100 ppm) and GE (5%) had a considerable favourable effect on photosynthetic pigments (chlorophyll a, chlorophyll b, and chlorophyll a+b). Spraying SA on photosynthetic pigments may have a favourable effect by increasing endogenous cytokine levels, encouraging growth and chloroplast differentiation. (Bashir *et al.*, 2014).SA application increased carbohydrates content, which might be related to the activation of nitrite transport and translocation in internal plant tissues and increased chlorophyll synthesis to increase the photosynthesis mechanism, which could lead to greater carbs production (El-Shafey *et al.*, 2020).

CONCLUSIONS

Salicylic acid (SA) is a growth regulator that participates in the regulatory oversight of physiological processes in plants. It stimulates the flowering of plants, encourages the blooming of a number of plants, enhances floral life and controls the root uptake of ions and stomach conductivity. The effect of foliar SA applications, gibberellic acid (GA) and irrigation intervals on faba bean growth and productivity are studied. A significant interaction was observed between varieties and SA levels. Increased irrigation intervals from 14 days to 21 day and application of SA (1.0 ppm) and GA (150 ppm) to faba bean were motivated in this experiment. Growth parameters and yield components of faba bean can be improved by suitable water irrigation periods, the addition of SA and GA at suitable levels, and considering the interaction effect of these factors on seed yield, yield parameters, and productivity of the studied crop.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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