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Brassinolide Maximized the Fruit and Oil Yield, Induced the Secondary Metabolites, and Stimulated Linoleic Acid Synthesis of *Opuntia ficus-indica* Oil

Amira K. G. Atteya [1,*], Rasha S. El-Serafy [2], Khaled M. El-Zabalawy [3], Abeer Elhakem [4] and Esmail A. E. Genaidy [5]

[1] Horticulture Department, Faculty of Agriculture, Damanhour University, Damanhour 22516, Egypt
[2] Horticulture Department, Faculty of Agriculture, Tanta University, Tanta 31527, Egypt; rasha.elserafi@agr.tanta.edu.eg
[3] Environment and Bio-Agriculture Department, Faculty of Agriculture, Al-Azhar University, Cairo 11651, Egypt; khaled_mohamed@azhar.edu.eg
[4] Department of Biology, College of Sciences and Humanities, Prince Sattam Bin Abdulaziz University, Al-Kharj 11942, Saudi Arabia; a.elhakem@psau.edu.sa
[5] Pomology Department, National Research Centre, Giza 12622, Egypt; esmail_nrc@yahoo.com
* Correspondence: amira.khames@agr.dmu.edu.eg

Abstract: Prickly pear plant is widely cultivated in arid and semi-arid climates. Its fruits are rich in polyphenols, proteins, vitamin C, minerals, fatty acids, and amino acids. The oil extracted from the seeds also has a significant proportion of linoleic acid (ω6) and might be employed as a therapeutic raw material. The potential of enhancing fruit yield, increasing bioactive compounds of the fruit pulp, and improving the unsaturated fatty acid content of prickly pear oilseed by using the foliar application of brassinolide as a plant growth regulator was the main goal of this study. Prickly pear plants were foliar sprayed with a brassinolide solution at concentrations of 0, 1, 3, and 5 mg L^{-1}. The plant performance was significantly improved following brassinolide applications, as compared with untreated plants. The plants subjected to 5 mg L^{-1} application exhibited 183 and 188% stimulation in the fruit yield, and 167 and 172% in the seed yield for the first and second seasons, respectively. The highest concentration of phenolic, flavonoid, protein, vitamin C, and maximum antioxidant activity in the fruit pulp was observed following 5 mg L^{-1} brassinolide treatment. The oil yield has been increased by 366 and 353% following brassinolide at a 5 mg L^{-1} level over control plants. Linoleic, oleic, and palmitic acids are the major components in prickly pear seed oil. Brassinolide foliar spraying induced an alternation in the fatty acid profile, as linoleic and oleic acids exhibited 5 and 4% higher following 5 mg L^{-1} application as compared with untreated plants. In conclusion, the treatment of 5 mg L^{-1} brassinolide improved the growth and quality of prickly pear plants by boosting fruit and seed yields, increasing active component content in the fruit pulp, improving mineral content, and increasing oil production and linoleic acid proportion.

Keywords: prickly pear; linoleic acid; fatty acid profile; brassinolide; unsaturated fatty acid; vitamin C

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Citation: Atteya, A.K.G.; El-Serafy, R.S.; El-Zabalawy, K.M.; Elhakem, A.; Genaidy, E.A.E. Brassinolide Maximized the Fruit and Oil Yield, Induced the Secondary Metabolites, and Stimulated Linoleic Acid Synthesis of *Opuntia ficus-indica* Oil. *Horticulturae* **2022**, *8*, 452. https://doi.org/10.3390/horticulturae8050452

Academic Editors: Tarun Belwal, Sapna Langyan, Ina Yosifova Aneva, Renu Singh and Pranjal Yadava

Received: 31 March 2022
Accepted: 14 May 2022
Published: 18 May 2022

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1. Introduction

Prickly pear (*Opuntia ficus-indica* L.) is a Cactaceae member that grows normally under arid and semi-arid conditions, as the species have a high level of ecological adaptability. Its fruits and stems have long been used for medicinal and cosmetic applications, as well as for fodder and natural color sources, but so far, the fresh fruits are the only part that is consumed in many countries [1]. Prickly pear fruit consists of pulp, peel, and seeds. Pulp is used in many industrial commodities, e.g., fruit juices, jams, syrups, and salad dressings [2]. The pulp is rich in many active ingredients, including polyphenols, flavonoids, sugars, proteins, vitamins, minerals, fatty acids, antioxidants, fibers, and amino

acids [3]. The seeds, which account for 3 to 15% of the prickly pear fruit mass, are a waste material [4,5], despite their importance as a source of edible oils, where 1 kg of seed contains 98.8 g of oil [6]. The seeds are rich in polyphenols, proteins, polysaccharides, cellulose, hemicelluloses, minerals, and antioxidants [3,7,8]. In addition, they represent a rich source of oleic and linoleic acids (ω6), as well as other important polyunsaturated fatty acids [4]. Linoleic acid has a critical role in supporting heart health and reducing the hazard of coronary heart disease development [9]. The oil is employed in important pharmaceutical industries for the production of antimicrobial and antioxidant substances [10–13]; and cardioprotective, anti-inflammatory, anti-thrombotic, hypolipidemic, anti-arrhythmic, and anti-hyperglycemia materials [14,15]. It a healthy edible oil and one of the natural agents for food preservation [16], as well as for the manufacture of natural-based foods [17] with a long shelf life [18,19].

Prickly pear is regarded as a promising functional food due to global desertification and the ability of *Opuntia* spp. to tolerate drought [2]. However, cultivars; environmental conditions, such as the type of soil minerals; and the growth promoters and plant-growth regulators can affect the growth, productivity, and active ingredients content [20–22].

Brassinosteroids are a steroidal sixth group of phytohormones that are found across the plant kingdom and can regulate growth. It has been discovered that there are 70 analogs of them, including 24-epibrassinolide, brassinolide, and 28-homobrassinolide. Under field circumstances, brassinosteroids are stable [23]. Brassinosteroids activate a wide range of physiological processes, from single cells to the entire plant [24,25]. Hayat et al. [26] and Fathima et al. [27] reported that brassinosteroids have a significant role in increasing vegetable crops, cereals, fruit crop, and oilseed crop performance, as well as secondary metabolite synthesis. These improvements are due to their role in the performance of various physiologic processes, such as plant growth, development, cell division, and elongation; xylem differentiation; gene regulation; enzyme activation; nucleic acid and protein syntheses; photosynthesis; flowering; seed germination; fruit set; and maturation [24,26,28]. In addition, they provide resistance to various stress factors because of their antioxidative characteristics [23,26,29,30]. However, to protect humanity from health risks, all exogenous applications must be environmentally benign [31]. Brassinosteroids decrease cancer cell proliferation in humans [32] and reduce phytotoxic effects induced by pesticides, herbicides, and fungicides in this field, without damaging healthy cells [28,33].

Despite the importance of *Opuntia ficus-indica* L. plant and its oil as an important source of linoleic acid, there are no reports about the influence of brassinolide foliar application on the oil yield or oilseed fatty acid profile of *Opuntia ficus-indica*. Therefore, the current study aimed to assess the impact of exogenous application of brassinolide on the development, fruit yield, fruit active-ingredients content, oil yield, and oil fatty acid composition of *Opuntia ficus-indica*.

2. Materials and Methods

2.1. Experimental Location, Plant Source, and Layout

This investigation was performed at a private farm in EL-Behira governorate, Egypt, during the February–May period of the 2020 and 2021 seasons. Nine-year-old plants were used in this study. Uniform plants (vigor and size) were chosen for use in this experiment. The plants were grown at a spacing of 5 × 3 m (between rows × plant spacing). The experiment was arranged in a randomized complete block design (RCBD) in three replications, with each one consisting of five cladodes having the same height, thickness, vigor, number of buds, and orientation. The drip irrigation system was used, and all agricultural practices were performed according to normal agro-management procedures. Physical and chemical analysis of experimental soil was performed according to Jackson [34] and Cottenie et al. [35] methods, and the results are present in Table 1.

Table 1. Physical and chemical analysis of the experimental soil.

Property	Unit	Value
Clay	%	19
Sand	%	38
Silt	%	43
Texture class		Clay loam
OM	%	1.3
pH		7.9
Ece	ds m^{-1}	2.3
$CaCO_3$	%	1.8
Soluble ions (meq L^{-1})		
HCO^{-3}	1.4	
Cl^{-}	13.2	
SO^{-2}	5.21	
Ca^{+2}	8.82	
Mg^{+2}	4.03	
Na^{+}	4.55	
K^{+}	0.32	

2.2. Preparation and Brassinolide Application

Prickly pear plants were foliar sprayed with brassinolide (Titan Biotech Ltd. Company, New Delhi, India) solutions at levels of 0, 1, 3, and 5 mg L^{-1} (4 L $tree^{-1}$). During brassinolide solution preparation, tween-20 at 0.1% (v/v) was applied as a surfactant to ensure optimal penetration into cladodes tissues. Four applications of brassinolide were supplemented (on the 1st of February, March, April, and May). Untreated plants were foliar sprayed with distilled water supplemented with Tween 20 at the same time as brassinolide application.

2.3. Cladodes Parameters and Harvesting Date

Nine plants were randomly collected for each treatment (3 plants $replicate^{-1}$), and the number of flowering cladodes $plant^{-1}$, as well as the number of fruits $cladode^{-1}$, was recorded. Harvesting dates were calculated as the number of days from the beginning of the treatments until the beginning of the fruit harvest.

2.4. Fruit Characteristics

Fruit length and width (cm), fresh fruit weight (g), pulp weight (g), peel weight (g), seeds weight (g), and juice weight (g) were estimated.

2.5. Fruit, Seed, and Oil Yields

Fruit yield $plant^{-1}$ (kg), fruit yield $hectare^{-1}$ (ton ha^{-1}), seed yield $plant^{-1}$ (kg), and seed yield $hectare^{-1}$ (ton ha^{-1}) were estimated. The oil (%) was estimated according to the method mentioned by A.O.A.C. [36], then oil yield $plant^{-1}$ (L) and oil yield $hectare^{-1}$ (L) were calculated.

2.6. GC–MS Analysis of the Seeds Oil

In order to identify the active ingredients of oil samples, GC–MS analysis was carried out using TRACE GC ultra-gas chromatographs (THERMO Scientific Corp., Waltham, MA USA) in combination with a THERMO mass spectrometer detector (ISQ Single Quadrupole Mass Spectrometer, THERMO Scientific Corp., Waltham, MA USA), equipped with a TG-WAX MS column (30 m × 0.25 mm i.d., 0.25 m film thickness). The temperature program was as follows 140 °C was the temperature source; 210 °C was the temperature of the injector and detector. The initial column temperature was 140 °C for 1 min, raised to 160 °C

at 6 °C/min, and was held for 1 min. Finally, it was held at 210 °C for 1 min. Helium was used as a carrier gas at a flow rate of 1.0 mL min^{-1}.

2.7. Chlorophyll Pigments Determination

Chlorophyll levels in cladodes were assessed according to Wintermans and Mats [37] at the harvest stage and presented in μg g^{-1}. A fresh sample of 0.5 g was mixed with 15 mL of acetone (85%) and 0.5 g of calcium carbonate. The mixture was funneled through a glass funnel, and the residue was washed with acetone and diluted to 25 mL. The optical density was measured using a UV–VIS spectrophotometer at 662 nm for chlorophyll a (E.662) and 644 nm for chlorophyll b (E.644). Photosynthetic pigments were calculated using the following equation:

$$\text{Chlorophyll a} = 9.784 \times \text{E.662} - 0.99 \times \text{E.644}$$

$$\text{Chlorophyll b} = 21.426 \times \text{E.644} - 4.65 \times \text{E.662}$$

2.8. Protein and Vitamin C Determination

Total soluble protein (%) in the pulp extract was determined by the Folin and Ciocâlteu reagent, as described by Lowry et al. [38]. The vitamin C concentration (mg g^{-1}) in the fruit pulp was estimated according to the method of Association of Official Analytical Chemists [36].

2.9. Polyphenols Estimation

The fruit pulp was oven-dried at 48 °C until it reached a consistent weight. A total of 10 g of dried samples was crushed and soaked in 50 mL of methanol (80%) and macerated at room temperature for 48 h. After removing the solvent, the extract was kept at 4 °C for polyphenol determination. The total phenolic content (TPC) was evaluated according to Singleton and Rossi [39] and reported in mg Gallic g^{-1}. Total flavonoids were determined by using aluminum chloride colorimetric according to Kim et al. [40] and presented in mg Rutin g^{-1}.

2.10. Antioxidant Activity (IC_{50}) Determinations

The antiradical activity of pulp samples was assessed according to the method of Brand-Williams et al. [41], using 2-Diphenyl-1-picrylhydrazyl radical (DPPH), and presented as μg mL^{-1}.

2.11. Minerals Estimation

Dried samples of 0.5 g were digested by using perchloric and sulfuric acids to evaluate the nutrient concentration. The P, K, Ca, and Mg nutrients were determined according to Jackson [34] and Cottenie et al. [35].

2.12. Statistical Analysis

The experimental design was a randomized complete block design (RCBD) in three replications. The analysis of variance (ANOVA) was conducted by using SAS software [42]. The Duncan test was used to compare the means within treatments at a 5% level of probability.

3. Results

3.1. Cladodes Characteristics and Harvesting Date

Brassinolide applications significantly enhanced the number of flowering cladodes per plant and the number of fruits per cladode of prickly pear plants (Figure 1) as compared with the untreated plants in both seasons. Both the numbers of flowering cladode per plant (261 and 273 for first and second seasons, respectively) and fruits per cladode (9 and 10 for first and second seasons, respectively) of prickly pear plants were significantly boosted by the higher level of brassinolide, as their values gradually increased with increasing

brassinolide level. Subjected plants to brassinolide treatments produced their fruits earlier than untreated plants, as the treatment of 3 mg L^{-1} recorded the lowest harvest date, which reduced the growth period by 13.69 and 11.4 days for the first and second seasons, respectively, as compared with untreated plants (Figure 1).

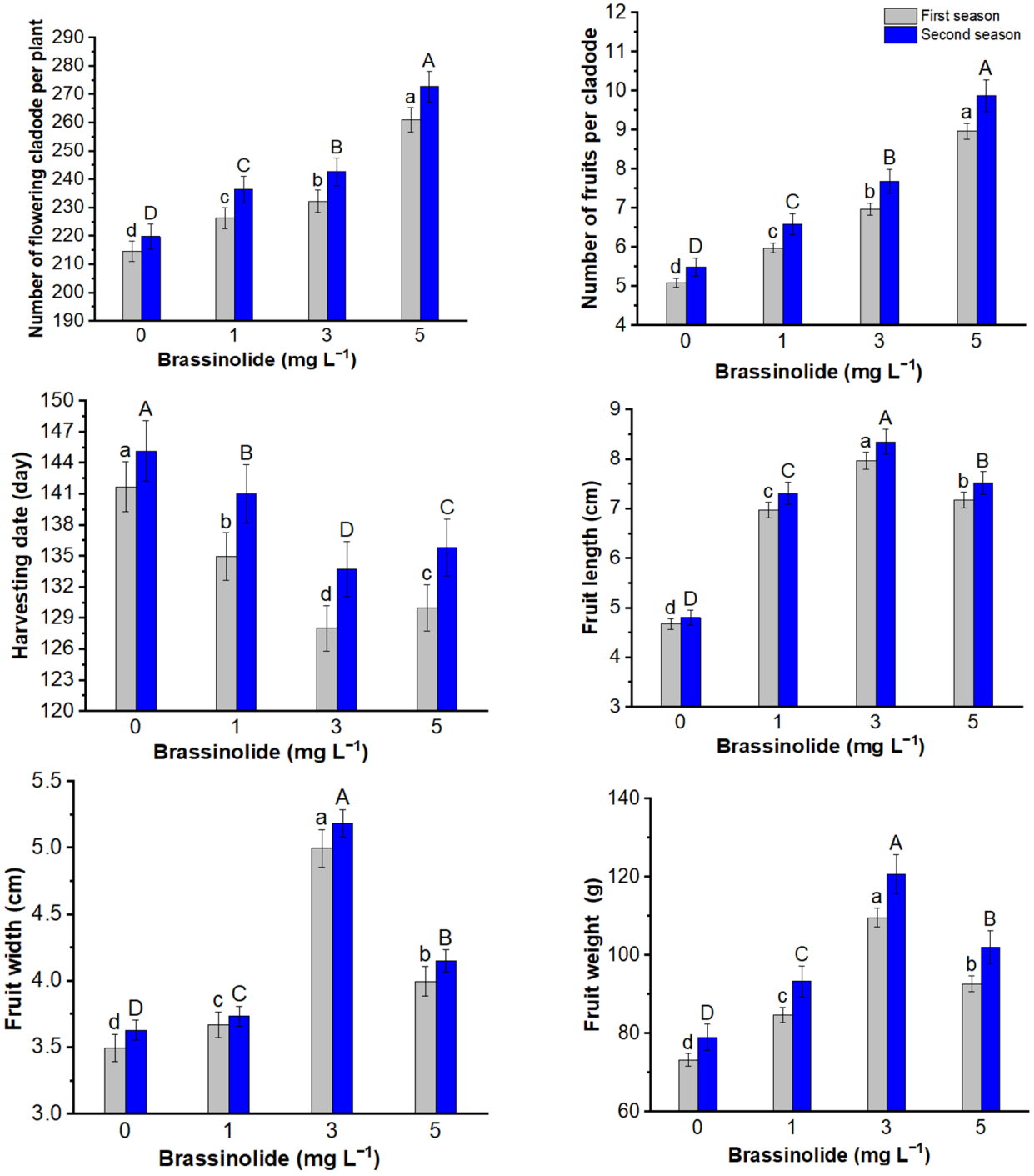


Figure 1. Number of flowering cladodes $plant^{-1}$, number of fruits $cladode^{-1}$, harvesting date, fruit length (cm), fruit width (cm), and fruit fresh weight (g) of prickly pear plant subjected to brassinolide foliar spray. Data are mean value ± SE. Bars with the same letters (lowercase for the first season and uppercase for the second season) are not significant at $p \leq 0.05$ level.

3.2. Fruit Characteristics

Foliar application with brassinolide exhibited a significant improvement in fruit characteristics as compared with the control plants (Figures 1 and 2). For both seasons, the traits of fruit length and width, fruit fresh weight, pulp, seed, and juice per fruit exhibited a significant increase with increasing the brassinolide level reaching the highest values when plants were received 3 mg L^{-1} treatment and decreasing after that, where fruit fresh weight was increased by 49.78 and 52.78% for both seasons, respectively. On the other hand, the 5 mg L^{-1} application presented the highest peel weight, as it recorded 36 and 40 g for the first and second seasons, respectively, against 34 and 36 g, which were obtained by control plants for both seasons.

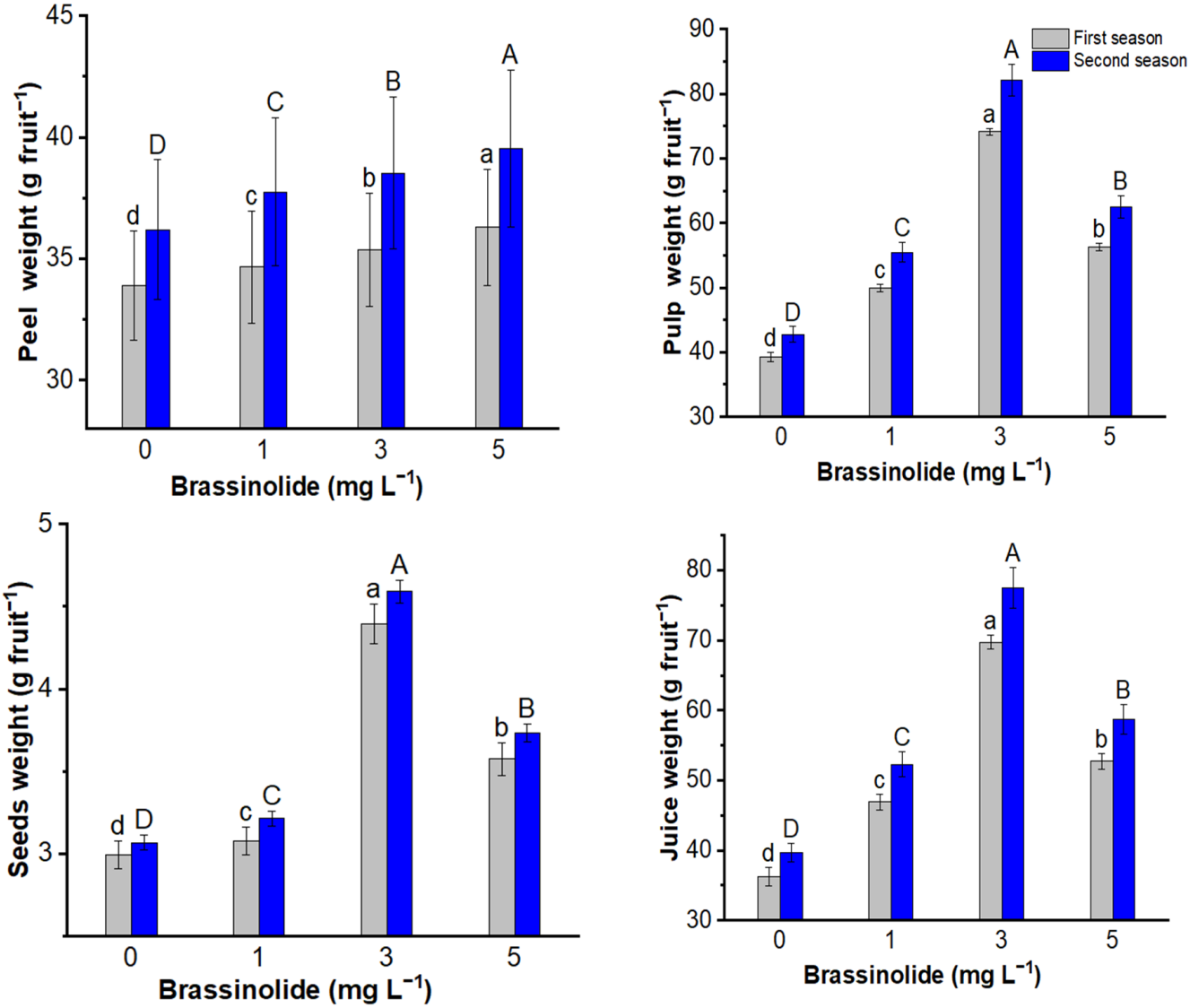


Figure 2. Peel weight fruit^{-1} (g), pulp weight fruit^{-1} (g), seeds weight fruit^{-1} (g), and juice weight fruit^{-1} (g) of *Opuntia ficus-indica* L. plant subjected to brassinolide foliar spray. Data are mean value ± SE. Bars with the same letters (lowercase for the first season and uppercase for the second season) are not significant at $p \leq 0.05$ level.

3.3. Seed, Fruit, and Oil Yields

Seed, fruit, and oil yield values presented in Figures 3 and 4 revealed that the outputs of prickly pear plants gradually increased when increasing brassinolide levels. In comparison to the control plants, the fruit yield plant^{-1} was increased by using 5 mg L^{-1} by 182.78

and 188.43% for the first and second seasons, respectively, resulting in a greater seed yield plant^{-1} production (166.58 and 171.91% for the first and second seasons, respectively) and oil plant^{-1} (366.08 and 353.19% for the first and second seasons, respectively). Consequently, significant increments were recorded for fruit yield ha^{-1}, seed yield ha^{-1}, and oil yield ha^{-1} traits. On the other hand, the lowest values were given by untreated plants in this regard.

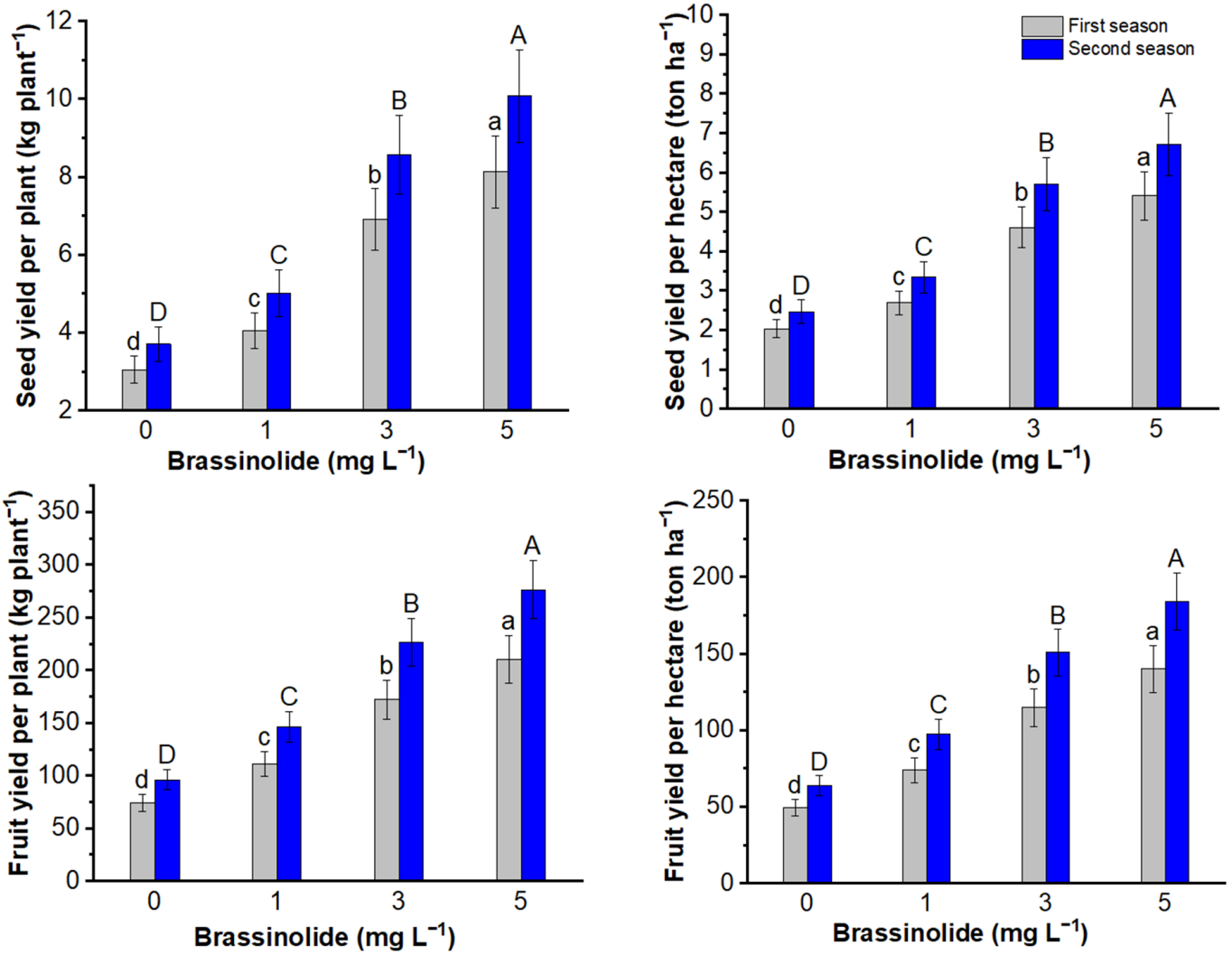


Figure 3. Seed yield plant^{-1} (kg), seed yield ha^{-1} (ton ha^{-1}), fruit yield plant^{-1} (kg), and fruit yield ha^{-1} (ton ha^{-1}) of *Opuntia ficus-indica* L. plant subjected to brassinolide foliar spray. Data are mean value ± SE. Bars with the same letters (lowercase for the first season and uppercase for the second season) are not significant at $p \leq 0.05$ level.

3.4. GC–MS Analysis of the Seeds Oil

The total identified fatty acids percent in the oil of prickly pear seeds ranged from 96.10 to 98.98%. The unsaturated fatty acids percentage ranged from 80.05 to 84.03% (Table 2). The total saturated fatty acids percentage ranged between 13.60 and 14.92%. Linoleic, oleic, and palmitic acid are the major fatty acids detected by GC–MS analysis. Their respective percentages ranged from 59.09 to 62.05%, 20.49 to 21.37%, and 10.26 to 11.12%. The results also showed that linoleic acid was the most oil component. All brassinolide treatments increased linoleic acid content. The most pronounced effect was recorded with 5 mg L^{-1} brassinolide treatment, which recorded the maximum proportion of linoleic acid.

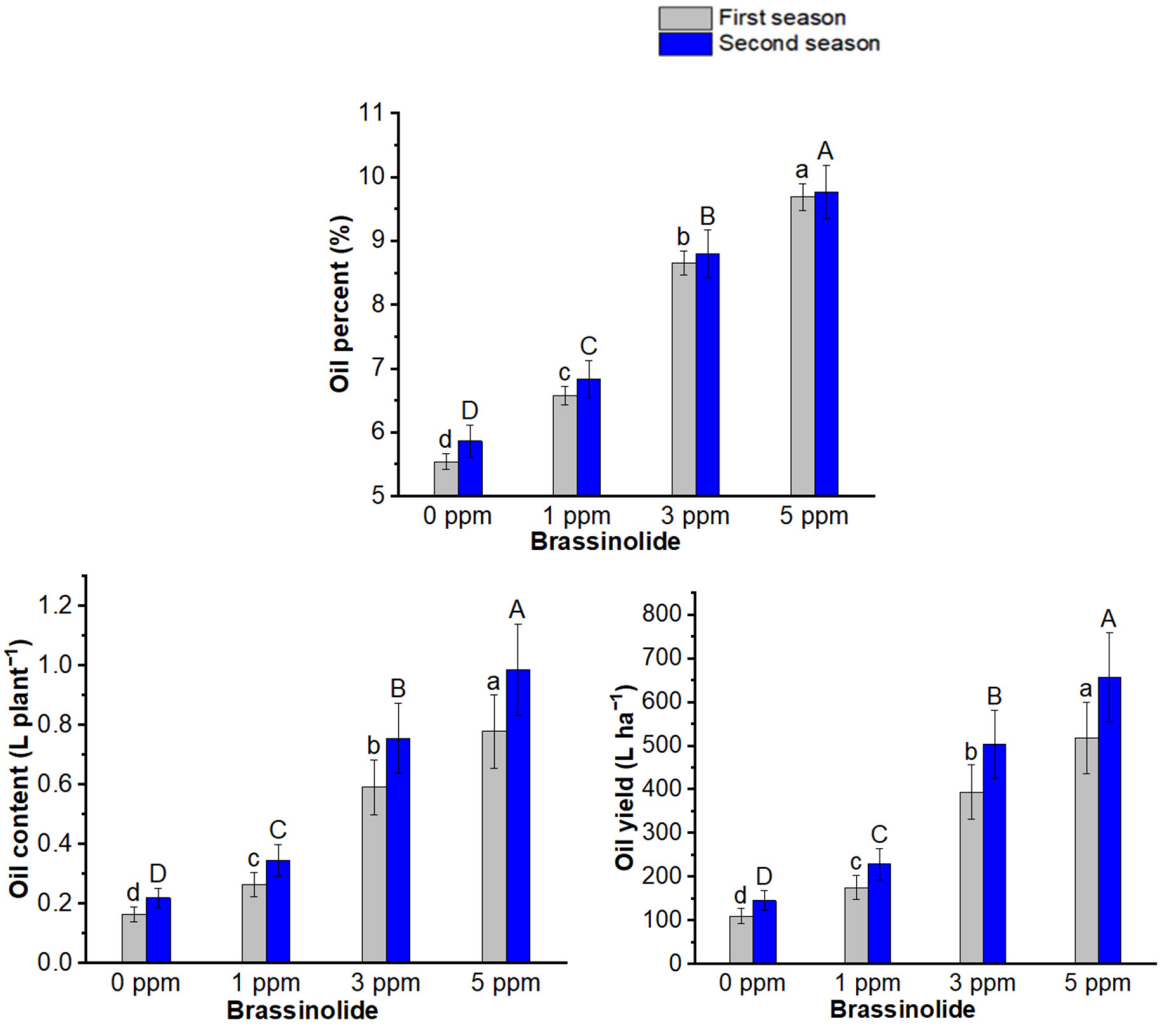


Figure 4. Oil (%), oil yield content (L plant^{-1}), and oil yield (L ha^{-1}) of *Opuntia ficus-indica* L. plant subjected to brassinolide foliar spray. Data are mean value ± SE. Bars with the same letters (lowercase for the first season and uppercase for the second season) are not significant at $p \leq 0.05$ level.

Table 2. GC–mass spectrometry analysis of *Opuntia ficus-indica* L. oil as affected by brassinolide foliar application.

Fatty Acids	Brassinolide Concentration			
	Untreated	**1 mg L^{-1}**	**3 mg L^{-1}**	**5 mg L^{-1}**
Stearic acid (C18:0)	3.09 ± 0.14	3.13 ± 0.13	3.22 ± 0.14	3.28 ± 0.16
Linoleic acid (C18:2)	59.09 ± 2.52	60.37 ± 2.63	61.86 ± 2.62	62.05 ± 2.62
α-Linolenic acid (C18:3)	0.20 ± 0.01	0.18 ± 0.01	0.14 ± 0.01	0.12 ± 0.01
Oleic acid (C18:1)	20.49 ± 0.92	20.88 ± 0.93	21.1 ± 0.9	21.37 ± 0.85
Palmitic acid (C16:0)	10.26 ± 0.44	10.55 ± 0.45	10.94 ± 0.47	11.12 ± 0.50
Palmitoleic acid (C16:1)	0.34 ± 0.01	0.37 ± 0.02	0.39 ± 0.02	0.32 ± 0.03
Arachidic acid (C20:0)	0.10 ± 0.004	0.20 ± 0.008	0.29 ± 0.012	0.31 ± 0.01
Paullinic acid (C20:1)	0.26 ± 0.011	0.25 ± 0.011	0.23± 0.010	0.17 ± 0.01
Behenic acid (C22:0)	0.08 ± 0.003	0.09 ± 0.004	0.11 ± 0.005	0.12 ± 0.005
Lignoceric acid (C24:0)	0.07 ± 0.003	0.08 ± 0.003	0.09 ± 0.004	0.09 ± 0.004
Total identified fatty acids	98.98	96.10	98.37	98.95
Total unsaturated fatty acids	80.83	82.05	83.72	84.03
Total saturated fatty acids	13.60	14.05	14.65	14.92

The data are mean values ± SE (n = 3).

3.5. Chlorophyll Pigments

Foliar application with brassinolide positively stimulated photosynthetic pigment production in prickly pear cladode, as 5 mg L^{-1} plants exhibited a raise of 37.25 and 39.83% for chlorophyll a and approximately 40% for chlorophyll b than untreated plants for both seasons, respectively (Figure 5).

3.6. Protein and Vitamin C Content

Foliar application with brassinolide enhanced protein and vitamin C content in prickly pear fruit pulp (Figure 5). In comparison with untreated plants, plants treated with 5 mg L^{-1} produced higher protein (33.9 and 36.7%) and vitamin C (32.35 and 35%) content for both seasons, as the untreated plants produced the lowest values in these regards.

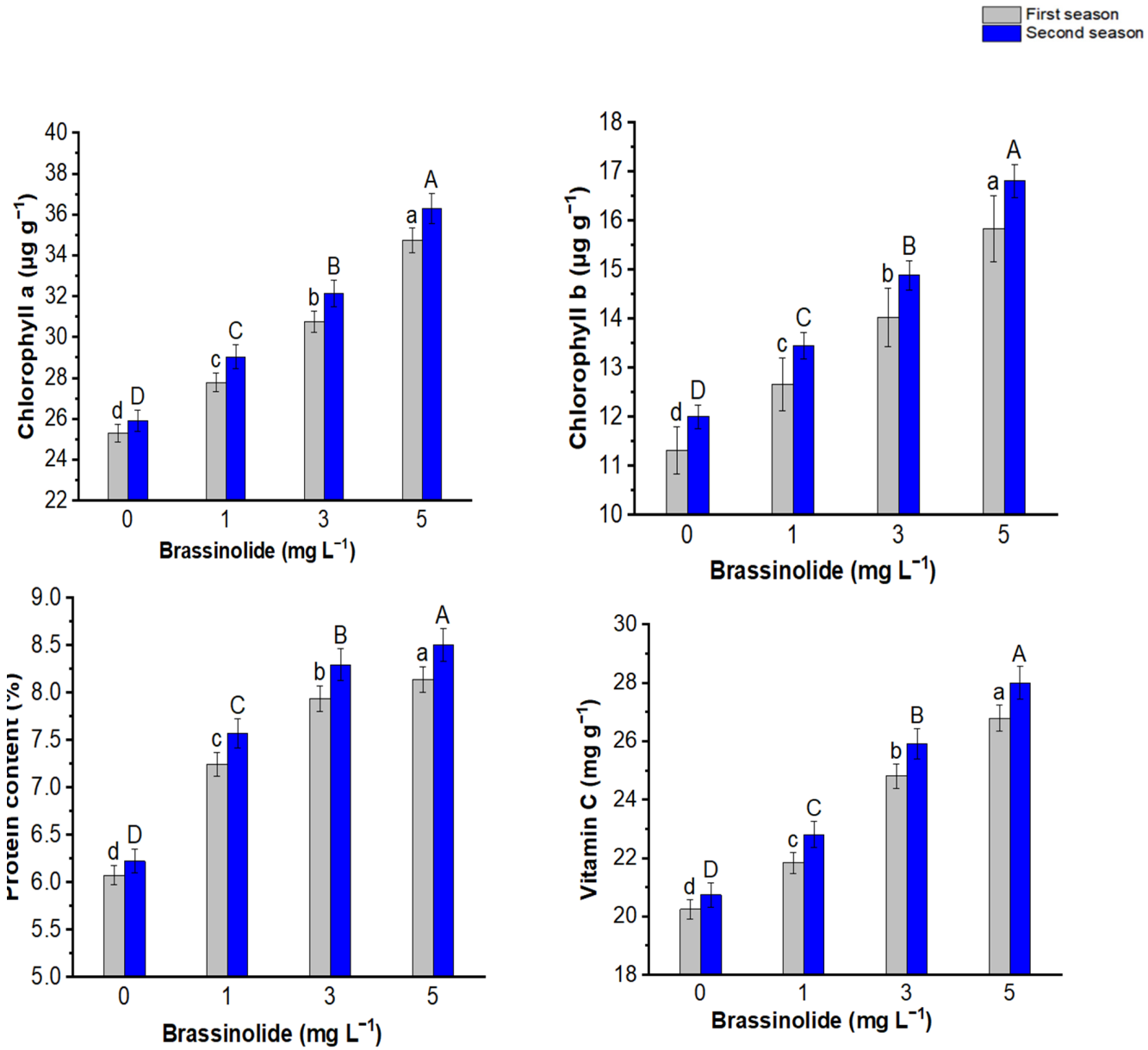


Figure 5. Chlorophyll a (µg g^{-1}), chlorophyll b (µg g^{-1}), protein content (%), and vitamin C (mg g^{-1}) of *Opuntia ficus-indica* L. plants subjected to brassinolide foliar spray. Data are mean value ± SE. Bars with the same letters (lowercase for the first season and uppercase for the second season) are not significant at $p \leq 0.05$ level.

3.7. Phenolic, Flavonoid, and Antioxidant Activity (IC_{50})

The results in Figure 6 indicate that all brassinolide applications modified the proportion of total polyphenols and flavonoids in the fruit pulp. The maximum levels of polyphenols (85.33 and 89.15 mg gallic g^{-1}) and flavonoids (41.98 and 43.86 mg rutin g^{-1}) were obtained by treating plants with 5 mg L^{-1} brassinolide for both seasons. Foliar application with brassinolide significantly increased the antioxidant activity of fruit pulp, and the best treatment that maximized the antioxidant activity was the high level of brassinolide, i.e., 34.73 and 36.28 µg mL^{-1} against 49.6 and 50.8 µg mL^{-1}, which obtained by control plants.

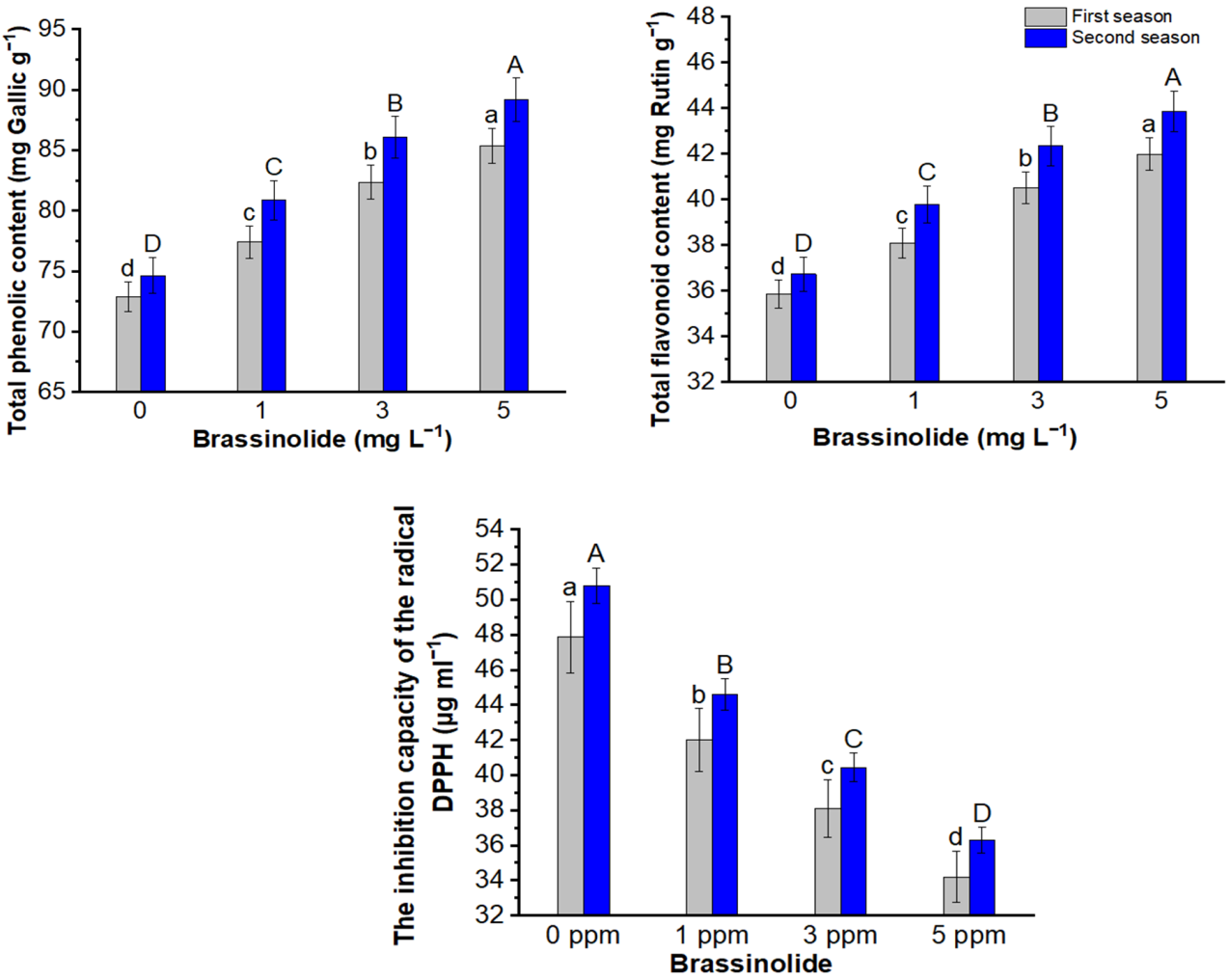


Figure 6. Total phenolic (mg Gallic g^{-1}), flavonoids (mg Rutin g^{-1}), and the inhibition capacity of the radical DPPH (µg mL^{-1}) of *Opuntia ficus-indica* L. plant subjected to brassinolide foliar spray. Data are mean value ± SE. Bars with the same letters (lowercase for the first season and uppercase for the second season) are not significant at $p \leq 0.05$ level.

3.8. Minerals Content

The enhancement obtained in growth and yield characteristics was referred to as an increase in the nutrient content of pulp (Figure 7). Foliar spray with all brassinolide levels exhibited a significant effect on the Ca, Mg, P, and K contents of the fruit pulp. In this regard, the most pronounced effect was related to 5 mg L^{-1} brassinolide application, which recorded the maximum values of Ca (0.264 and 0.280 ppm), Mg (0.273 and 0.290 ppm), P (0.155 and 0.165%), and K (0.952 and 0.995%) for first and second seasons, respectively.

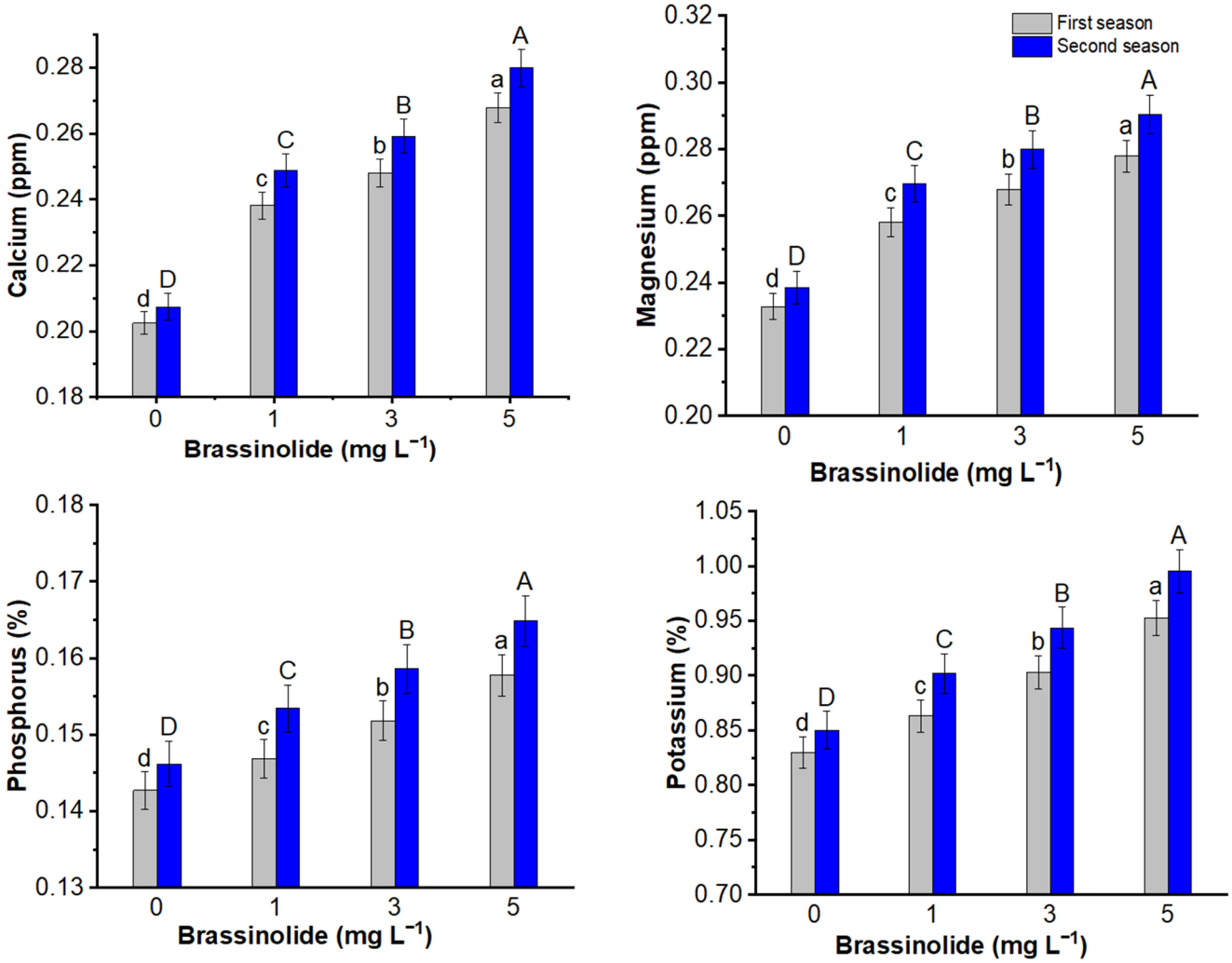


Figure 7. Ca (ppm), Mg (ppm), P (%), and K (%) of *Opuntia ficus-indica* L., as affected by brassinolide foliar spray. Data are mean value ± SE. Bars with the same letters (lowercase for the first season and uppercase for the second season) are not significant at $p \leq 0.05$ level.

4. Discussion

Opuntia ficus-indica plays an important role in providing food for both humans and animals in the arid and semi-arid regions of South Africa [43], as well as worldwide; thus, its fruit and fodder production has increased [44].

The plants subjected to 3 mg L^{-1} brassinolide had the highest fruit fresh weight and characteristics, while 5 mg L^{-1} brassinolide minimized the number of days from treatment until the beginning of harvest and achieved the maximum number of flowering cladodes and fruits per cladode; fruit, seed, and oil yield; photosynthetic pigments; protein content; and vitamin C and element content. Brassinosteroids are involved in various processes in plant growth and development, such as differentiation, nucleic acid, and protein synthesis [45]; reproductive and vascular development; membrane polarization and proton pumping [46]; source/sink relationships; and modulation of stress [47]. Brassinolide, a brassinosteroid, stimulates cell division and growth in plants [48,49]. The fundamental mechanism of plant growth and development is cell elongation, which is influenced by a variety of environmental factors and phytohormones [50–54]. Brassinosteroid, as a plant hormone, regulates cell elongation, resulting in an increase in plant height. Brassinosteroids have been discovered to promote cell elongation by increasing gibberellin levels [55]. Moreover, brassinosteroids promote plant growth by activating the BRU1 and TCH4 genes,

which encode the proteins xyloglucan and expansions, which cause cell-wall slackening [56,57]. These findings are consistent with those of Yu et al. [58] and Anuradha and Rao [59]. In this study, prickly pear plants exposed to brassinolide treatments revealed an increase in the chlorophyll content. Such results were obtained by Hayat et al. [26] on *Lycopersicon esculentum*, Bajguz and Czerpak [60] on *Chlorella vulgaris* Beijerinck, Swamy and Rao [61] on *Pelargonium graveolens*, Houimli et al. [62] on *Capsicum annuum*, and Shahid et al. [63] on *Pisum sativum*.

Brassinolide enhances plant growth, pollen germination, and pollen tube growth [64–66], which all contribute to the improvements in fruit traits, fruits, seeds, and oil yields of the prickly pear plant (Figures 3 and 4). Brassinosteroids have an important role in reproductive growth regulation [67]. In addition, they stimulate the source/sink relationship via improving the mobilization and accumulation of assimilates in fruits [68]. Furthermore, brassinolide boosts the potential for sugar unloading from the phloem, modifies the sink strength by increasing its growth, and stimulates nutrient transport via the phloem [69]. The oil extracted from prickly pear seeds was increased by 375% following brassinolide at 5 mg L^{-1} level, compared to the oil obtained by control plants. The highest level of brassinolide significantly maximized the essential-oil content in geranium plants [61]. Brassinolide application doubled the amount of Mentha essential oil, as result that may be due to the plants' innate genetic ability to produce higher essential oil yields being triggered [70]. Previous reports have proven that brassinosteroids boost the content of essential oils in a variety of plants [61,71,72]. Farooqi and Sharma [73] and Santoro et al. [74] reported that brassinosteroids can improve oil content and quality by affecting source/sink connections, as well as biochemical pathways and physiological processes that affect plant metabolism. Furthermore, as a result of the treatment, the oil analysis of prickly pear seeds was altered. Linoleic acid is the major fatty acid in the seeds and pulp of the prickly pear oil, followed by palmitic and oleic acids [6]. According to Ennouri et al. [75], the primary fatty acids found in prickly pear seed oil are C16:0, C18:0, C18:1, and C18:2. The unsaturated fatty acids concentration was 88.5% and 88.0% for *Opuntia ficus-indica* and *Opuntia stricta*, respectively, with an outstanding level of linoleic acid, up to 70%. Taoufik et al. [76] stated that oleic acid (20.5 g 100 g^{-1}) and linoleic acid (62.3 g 100 g^{-1}) make up 80–84% of the total fatty acids in cactus seed oil. Other fatty acids identified in tiny levels included palmitoleic (C16:1), arachidic (C20:0), and behenic (C22:0) acids.

5. Conclusions

The current report was performed to shed more light on the possibility of the positive influence of brassinolide foliar spray to enhance the growth; fruit, seed, and oil yields; and phytochemical content in the fruit of *Opuntia ficus-indica* L. plants. Foliar spray with brassinolide produced a significant ($p \leq 0.05$) impact on the yields obtained from *Opuntia ficus-indica* L. plants. The higher level of brassinolide outperformed the other levels in terms of the aforesaid traits. Brassinolide at 5 mg L^{-1} was the more effective treatment in minimizing the harvesting date, increasing the oil yield, inducing the active ingredients in the fruit juice (total polyphenols, flavonoids, protein, and vitamin C, and nutrient content), and stimulating linoleic acid generation in the oil of *Opuntia ficus-indica* L. seeds.

Author Contributions: Conceptualization, A.K.G.A., R.S.E.-S. and E.A.E.G.; methodology, A.K.G.A., R.S.E.-S., K.M.E.-Z., A.E. and E.A.E.G.; software, A.K.G.A., R.S.E.-S., K.M.E.-Z., A.E. and E.A.E.G.; validation, A.K.G.A., R.S.E.-S., K.M.E.-Z., A.E. and E.A.E.G.; formal analysis, A.K.G.A., R.S.E.-S. and E.A.E.G.; investigation, A.K.G.A., R.S.E.-S. and E.A.E.G.; resources, A.K.G.A., R.S.E.-S., K.M.E.-Z., A.E. and E.A.E.G.; data curation, A.K.G.A., R.S.E.-S. and E.A.E.G.; writing—original draft preparation, A.K.G.A., R.S.E.-S. and E.A.E.G.; writing—review and editing, A.K.G.A., R.S.E.-S. and E.A.E.G.; visualization, A.K.G.A., R.S.E.-S. and E.A.E.G.; supervision, A.K.G.A., R.S.E.-S. and E.A.E.G. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available within the article.

Conflicts of Interest: The authors declare no conflict of interest.

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