Effect of foliar spraying with boron and sugar alcohol (mannitol) on vegetative growth traits of pea *Pisum sativum* L.

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ABSTRACT

The experiment was carried out at the Research Station of the Department of Horticulture and Landscaping-College of Agriculture-University of Diyala, during the autumn season 2021–2022 to study the effect of foliar spraying with sugar alcohol **(**mannitol) with Two concentrations in addition to the control treatment of 0, 10, and 15 g. liter^{-1}, and boron with three concentrations in addition to the control treatment of 0, 50, 100, and 150 mg. liter^{-1} on the growth and yield of pea plants. The results showed that spraying with mannitol 15 g L^{-1} gave the highest plant length, number of branches, leaf area, number of pods, number of seeds in a pod, yield per plant, and total yield, which reached 98.49 cm, 5.635 and 322.2 cm^2, 27.99, 7.851, 178.8 g and 9.564 ton respectively. While spraying with boron at a concentration of 150 gm L^{-1} was superior in recording the highest mean in plant length, number of branches, leaf area, chlorophyll content, dry matter in leaves, number of pods, pod length, number of seeds in a pod, yield per plant, and total yield, which reached 103.3 cm, 6.404, 386.8 cm^2, 44.12 spad, 64.36%, 33.34, 12.42 cm, 8.454, 208.5 g, and 11.14 ton, respectively.

Keywords: Pea, mannitol and boro

INTRODUCTION

Peas *Pisum sativum* L. belongs to the Fabaceae family. It is an annual herbaceous plant and some of its varieties are short-lived perennials up to 4 years. They are long-day plants and thrive in cold and humid areas. They do not tolerate high temperatures more than 35 °C, where growth stops, and tolerate low temperatures - 5 °C, and the height of their stems is divided into three types: short 50 cm, medium 51-150 cm, and long151-300cm, Peas are one of the important crops of the leguminous family, as they are cultivated for their fresh green seeds, green pods, and dry seeds. The original home of peas is southwest Asia, India, Pakistan, Afghanistan, and the Mediterranean, especially the Middle East [15]**.** In Iraq, the production of the crop is relatively different compared to the global production, as the cultivated area in Iraq for the year 2020 reached (518.5) hectares, with a production of 70 tons of green crop, despite the importance of this crop, its cultivation is limited to the central regions as well as in some limited parts in the northern region, and the demand for them and their consumption increases annually to enter into diets, whether green, frozen or dry, so frozen and dry seeds are imported from abroad to meet the need for annual consumption [13]**.** Alcohol sugars are one of the most important factors that can change the physiological and biochemical responses in plants [21]. Mannitol is a hexacarbon sugar alcohol and is an antioxidant, and it can be produced by *Lactococcus lactis* bacteria that have an inherent ability to produce mannitol from glucose through their adaptive evolution, also *Lactococcus lactis* can produce mannitol only from fructose, which shows the great potential of using *Lactococcus lactis* as a mannitol product [23]**.** Boron deficiency is one of the main obstacles to plants grown in acidic soils, and foliar spraying with boron has a positive effect on the biological yield of the plant [14]. Because of the importance of foliar fertilization with boron and mannitol sugar for plants, the study aimed to evaluate their effectiveness in the growth and production of pea yield.

MATERIALS AND METHODS

The study was carried out during the autumn season 2021–2022 at the Research Station of the Department of Horticulture and Landscaping-College of Agriculture-University of Diyala, under the open cultivation system, to study the effect of foliar spraying with boron and mannitol on the growth and yield of pea plants. Pea seeds produced by the American Catalyst Seeds Company (cv. Garden pea Onward) were used, whose plants are characterized by medium growth, with thin and creeping stems, produce fruits in the form of green pods containing 3-10 smooth, spherical seeds, are sweet in taste and flavour, with a good yield, and produce pods containing mature seeds after 130 days of sowing seeds.

Soil preparation

The field soil was prepared by cleaning it of plant residues and weeds, immersing the soil with water and leaving it for five days, then conducting the plowing process by the plow, at a depth of 0.30 m and perpendicularly, and smoothing and leveling the soil. The experiment area was divided into three sectors, each with 12 experimental units, and the experimental units were then divided into three equal lines for planting. The distance between lines was 0.75 m and between plants 0.25 m, and the total cultivated area was 75 m^2 with a length of 15 m and a width of 5 m. The plants were planted beside the irrigation pipes, and a T-Tape drip irrigation system was used. Samples of field soil were taken from different locations randomly at a depth of 0.30 m to estimate the properties of the physical and chemical soil before planting, and the analyses were carried out in the soil laboratory of the Diyala Agriculture Directorate as shown in (Table 1).

Planting of seeds

The seeds of the pea plants were sown directly into the soil on 15/10/2021, at a rate of two seeds per hole, and the plants were thinned to one plant, and all service operations were conducted that included irrigation, weeding, weed and insect control for all experimental units.

Alcoholic sugar (mannitol) and boron were sprayed a month after planting, and the second spraying was carried out 15 days after the first spray, then the spraying process was carried out every 15 days between one spray and another in the morning by using a back sprayer, taking into consideration the spraying of boron after spraying the alcoholic sugar on the next day.

Table 1. The physical and chemical properties of soil

Measurements	Value	Unit of measurement
Clay	122	g. kg^{-1}
Silt	591.7	g. kg^{-1}
Sand	286.3	g. kg^{-1}
pH	7.05	-
EC 1:1	7.43	ds.m^{-1}
N	54.02	mg. kg^{-1} or ppm
P	8.045	mg. kg^{-1} or ppm
K	81.788	mg. kg^{-1} or ppm
Boron	5.25	mg. kg^{-1} or ppm
Organic matter	6.9	g. kg^{-1}
CaCo3	260.2	g. kg^{-1}
Field capacity	25	%
The density	1.35	g. cm^{-3}
Texture of soil	Silty loam	-

Study factors

The experiment included a study of two factors. The first factor involved spraying boron element at Three concentrations in addition to the treatment of the control (0, 50, 100, and 150 mg L^{-1}); the second factor involved spraying mannitol sugar alcohol at Two concentrations in addition to the treatment of the control (0, 10, and 15 g L^{-1}).

Studied traits

Five plants were randomly selected from each experimental unit and each replicate for the following traits: plant length (cm), number of branches (branch. plant-1), leaf area (cm^2.$plant^{-1}$), chlorophyll content in leaves (SPAD), dry matter in the leaves (%), number of pods (pod. $plant^{-1}$), pod length (cm.$plant^{-1}$), number of seeds in a pod (seed.pod^{-1}), yield per plant (g.$plant^{-1}$), and total yield of the crop (ton. ha^{-1}).

Experimental design

A factorial experiment was carried out using the Randomized Complete Block Design (RCBD) with two factors and three replicates, and the averages were compared according to the Duncan polynomial test at a probability level of 0.05 by using the SAS program to analyze the studied traits statistically and according to the design mentioned [16]**.**

RESULTS

The results in Table (2) indicated that the spraying with mannitol 15 g. L^{-1} recorded the highest mean in plant length (98.49 cm), number of branches (5.635), and leaf area (321.3 cm^2), whereas spraying with boron 150 mg. L^{-1} gave the highest mean with significant differences from other concentrations in previous traits 103.3 cm,6.404 and 386.8 cm2 respectively, while the treatments of mannitol 15 g. L^{-1} and boron 150 mg. L^{-1} were superior in giving the highest rate in plant length (105.43 cm), number of branches (6.553), and leaf area (404.2 cm^2) at the interaction, whereas the treatments of mannitol 0 g. L^{-1} and boron 0 mg. L^{-1} recorded the lowest rate in plant length (78.80 cm), number of branches (3.610), and leaf area (231.5 cm^2). There were no significant differences in chlorophyll content between the mannitol concentrations (0, 10, and 15 g.L^{-1}) while the concentrations of 10 and 15 g.L^{-1} had the highest mean in dry matter, reaching 59.56 and 58.93%, respectively, compared to the control 0 g.L^{-1}, which had the lowest dry matter of 55.05%, whereas spraying with boron 150 mg. L^{-1} gave the highest mean in chlorophyll content 44.12 spad, and dry matter 64.36%, as for the interaction between spraying with mannitol and boron , the treatment of mannitol 10 g.L^{-1} with boron 150 mg.L^{-1} was superior in giving the highest rate in chlorophyll content of 44.40 spad and dry matter of 67.47% compared to the treatment of mannitol 0 g.L^{-1} and boron 0 mg. L^{-1}, which gave the lowest rate in chlorophyll content of 36.56 spad and dry matter of 41.12%.

Data presented in Table (3) revealed that spraying with mannitol 15 g. L^{-1} recorded the highest mean in number of pods (27.99), number of seeds in a pod (7.851), yield per plant (178.8 g), and total yield (9.564 ton), whereas mannitol 10 g. L^{-1} recorded the highest mean in pod length (11.64 cm). Spraying with boron 150 mg. L^{-1} gave the highest mean with significant differences from other concentrations in number of pods (33.34),pod length (12.42 cm), number of seeds in a pod (8.454), yield per plant (208.5 g), and total yield (11.14 ton). As for the interaction between spraying with mannitol and boron , the treatment of mannitol 10 g/L^{-1} with boron 150 mg/L^{-1} was superior in giving the highest rate in number of pods (34.37), pod length (13.05 cm), number of seeds in a pod (8.416), yield per plant (218.9 g), and total yield (11.70 ton) compared to the treatment of mannitol 0 g. L^{-1} and boron 0 mg. L^{-1}, which gave the lowest rate in previous traits (18.66, 9.400 cm, 4.440, 99.79 g, and 5.335 ton) respectively**.**

Table 2. Effect of foliar spraying with alcoholic sugar (mannitol) and boron on plant height, branches number, leaf area, chlorophyll content and percentage of dry matter in the leaves of pea plants

Plant length (cm)					
Concentrations of Mannitol (g L^{-1})	Concentrations of Boron (mg L^{-1})				Mean
	0	50	100	150	
0	78.80 f	97.12 cd	99.12 bcd	107.0 ab	94.20 B
10	92.20 e	92.72 e	99.95 bc	105.43 a	96.84 B
15	95.33 de	95.88 cde	97.33 cd	105.43 a	98.49 A
Mean	88.70 D	95.27 C	98.70 B	103.3 A	
Number of branches (branch. plant-1)					
0	3.610 g	5.110 cdef	5.555 bcd	6.330 a	5.150 B
10	4.555 f	4.886 ef	6.110 ab	6.330 a	5.470 A
15	4.996 def	5.330 cde	5.663 bc	6.553 a	5.635 A
Mean	4.386 D	5.108 C	5.77 B	6.404 A	
Leaf area (cm^2.$plant^{-1}$)					
0	231.5 f	299.7 cd	307.0 c	352.2 b	310.8 B
10	256.1 e	287.7 d	307.0 c	392.8 a	322.2 A
15	296.8 e	307.0 c	304.3 cd	404.2 a	321.3 A
Mean	252.5 D	298.1 C	335.1 B	386.8 A	
The relative content of chlorophyll in the leaves (SPAD)					
0	36.56 e	40.86 bc	42.33 ab	43.70 a	40.70 A
10	38.43 de	39.86 cd	44.03 a	44.40 a	41.68 A
15	39.63 cd	41.36 bc	41.56 bc	44.26 a	41.708 A
Mean	38.21 D	40.70 C	42.64 B	44.12 A	
Percentage of dry matter in leaves %					
0	41.12 e	54.67 cd	64.22 ab	60.20 bc	55.05 B
10	51.77 d	53.81 d	65.20 ab	67.47 a	59.56 A
15	52.63 d	61.93 ab	55.76 bc	65.40 ab	58.93 A
Mean	48.50 C	56.80 B	61.73 A	64.36 A	

Table 3. Effect of foliar spraying with alcoholic sugar (mannitol) and boron on the number of pods, pod length, number of seeds in a pod, yield per plant, and total yield of the crop

Number of pods (pod. plant^{-1})					
Concentrations of Mannitol (g L^{-1})	Concentrations of Boron (mg L^{-1})				Mean
	0	50	100	150	
0	18.66 l	25.33 f	27.22 de	31.88 b	25.77 B
10	20.88 h	25.77 ef	29.99 c	34.37 a	27.75 A
15	23.44 g	26.44 ef	28.33 d	33.77 a	27.99 A
Mean	20.99 D	25.84 C	28.51 B	33.34 A	
Pod length (cm.plant^{-1})					
0	9.400 l	11.66 def	11.94 cd	11.88 cde	11.22 B
10	10.44 h	10.51 h	12.55 ab	13.05 a	11.64 A
15	11.22 f	11.33 efg	11.00 gh	12.33 bc	11.47 B
Mean	10.35 D	11.16 C	11.83 B	12.42 A	
Number of seeds in a pod (seed.pod^{-1})					
0	4.440 f	7.073 de	7.600 bcde	8.316 ab	7.091 B
10	7.073 de	6.887 e	8.166 abc	8.416 ab	7.634 A
15	7.553 cde	7.500 cde	7.723 cde	8.630 a	7.851 A
Mean	6.355 C	7.465 B	7.827 B	8.454 A	
Yield per plant (g.plant^{-1})					
0	99.79 j	159.1 g	169.8 e	193.5 c	155.5 C
10	128.7 i	163.6 f	191.9 c	218.9 a	175.7 B
15	150.9 h	170.7 d	180.8 c	213.1 b	178.8 A
Mean	126.4 D	164.4 B	180.8 C	208.5 A	
Total yield of the crop (ton. ha^{-1})					
0	5.335 j	8.506 f	9.081 e	10.34 c	8.315 C
10	6.881 i	8.794 f	10.25 c	11.70 a	9.406 B
15	8.070 h	9.131 e	9.667 d	11.39 b	9.564 A
Mean	6.762 D	8.810 C	9.666 B	11.14 A	

DISCUSSION

It is clear from the results presented in Tables (2 and 3), there was a significant effect of spraying with mannitol and boron on most of the vegetative growth characteristics, The reason for this increase may be due to the main role of boron in transporting the manufactured materials for products of the carbon metabolism process to the active growth areas in the plant, especially the meristematic tissues, which contribute to increasing cell division and elongation [5,3]. In addition to its contribution to the construction of nucleic acids, DNA and RNA, necessary for cell division, which contributes to encouraging growth, which is represented by increasing the number of leaves that the plant bears [18]. Boron has an effective role through its effect on the effectiveness of the cell membrane in the absorption of nutrients such as nitrogen, phosphorous, and potassium, and its great role in growth and regulation of the vital activities of the plant [19,20]. The plant's need for the element boron leads to the fertility of flowers and the production of fruits and seeds more than to the production of green matter in the plant [17]. It may be attributed to the role of boron in building a radical group, which is highly efficient in absorbing macro and micro nutrients and increasing their concentration within the plant [10,11]. Boron has an important role in the formation of proteins in plants through the formation of RNA, the work of membranes, nitrogen metabolism, and photosynthesis; and the increase in the amount of carbohydrates and proteins manufactured in leaves for building plant tissues and vegetative weight [1]. The reason for the superiority in plant height is due to the role of boron in transporting metabolic compounds to active growth areas such as meristematic tissues, which contribute to increasing cell division and elongation, which is positively reflected in increasing plant height, and these results agree with what was obtained by [6] when spraying boron on soybean plants. The reason for the significant superiority in the number of branches may also be due to the positive and effective role of boron in transferring carbohydrates from the source to the rest of the plant and providing them at the right time for modern and effective growth centers, which gave an opportunity for the formation and growth of branches of the plant [2], these results are in agreement with the findings of [4 and 7] regarding the presence of a significant effect of boron spraying concentrations on the number of branches of soybean plants, as well as the findings of [8] when spraying boron on the bean plant.

The reason for this increase in vegetative growth characteristics could be that the alcoholic sugar Mannitol works to easily transfer boron because of the small size of its molecules, which facilitates its absorption through the stomata of leaves and the direct transfer of boron element through the bark [22]. The mannitol sugar is also based on the transfer of boron in the leaves to the active areas of the plant and other minor and major elements found inside the bark, such as potassium, calcium, magnesium, iron, boron, copper, nickel, silicon, etc. [12]**,** these findings agree with what [9] discovered when spraying the alcoholic sugar mannitol on the pepper plant.

CONCLUSION

Spraying with mannitol at a concentration of 10 or 15 $g.L^{-1}$ and boron at a concentration of 150 mg. L^{-1} resulted in a significant increase in most of the vegetative and yield traits.

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