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DEVELOPMENTAL RESPONSE OF BERSEEM (*Trifolium alexandrinum* L.) TO BORON

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Abstract: The aim of the study was to determine the effect of boron fertilization on agromorphological properties of berseem (*Trifolium alexandrinum* L.). The field experiment was arranged in randomized blocks with divided parcels. It was applied with 3 replications in 2017 and 2018 years in Ankara conditions. Three different berseem varieties (Derya, Erix, Mario) were sown to main parcels and 5 different boron fertilizer doses (0, 100, 200, 400, 800 g da^{-1}) were applied to sub-parcels. According to the research results; plant height was varied between 67.20 and 98.33 cm. Stem diameter was 3.43-4.45 mm, stem numbers were 6.17-11.67 pieces and head numbers were 7.28-15.02 pieces. The highest plant height and stem diameter were exhibited by variety of Mario. Erix displayed the highest development in terms of stem numbers, Derya showed the highest development in terms of head numbers. When boron doses were compared with control parcel, the highest plant height, stem diameter, stem numbers and head numbers were obtained at 100 g da^{-1} boron dose.

Keywords: Agromorphological properties, Berseem varieties, Boron doses

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1. Introduction

The role of the nutrients taken by the plant from the soil in the emergence of yield power is very important. Gezgin and Hamurcu (2006) stated that micronutrients perform important functions, although the amounts taken by plants are very small. To develop healthy plants and obtain a product with good quality, the boron element must be at a sufficient level in the soil. In plants, boron deficiency occurs most often in acidic sandy soils with low organic matter. Boron deficiency can even occur in plants despite of sufficiently high amounts of boron in soils or in fully-expanded leaves which is usually common under conditions where the humidity is high and the transpiration is low (Gunes et al., 2017). The lack of boron in the soil can be solved quickly with new fertilizer types developed today. The amount of boron that plants need to complete their development is very low. Soil boron analysis is important in determining whether plants need boron fertilization. The balance between nutrients in the soil is maintained in the fertilization applied by performing soil boron analysis. Correct fertilization contributes to the balanced nutrition of the plant and increases its resistance to diseases and pests. The amount of boron that causes deficiency symptoms and the amount of toxic effects are very close to each other (Adriano, 1986). There are big differences between field crops in terms of boron requirement. It is important to know the boron requirement of the plant before boron fertilization.

Forage crops agriculture in Türkiye consists of very few plant species which are alfalfa, sainfoin, and vetch and silage corn. Therefore, it is necessary to include new forage plants that may be an alternative considering the climate, soil conditions and agricultural systems of the regions. Also these forage crops are insufficient in terms of sustainable animal husbandry. For this reason, factors affecting yield in forage crop production are extremely important. Forage crops, especially trifoliums require more boron than many plants (Gupta, 2007). In these plants, if the boron amount in the leaves is below 20 mg kg^{-1}, boron fertilization is recommended (Gunes et al., 2017). Correct fertilization of these plants increases yield and quality. On the other hand, alternative species must be included in every period of forage crop production. The inclusion of one-year forage crops, which can be grown as short or second crops in the vegetation period, will contribute to the reduction of the roughage deficit. Berseem clover is one of the alternative species that can adapt to different regions. Berseem (*Trifolium alexandrinum* L.) is a one-year, legume forage plant that adapts well to semi-arid climatic conditions (Putievsky and Katznelson, 1970). The plant develops well in places where annual precipitation is more than 400 mm or where there is sufficient irrigation (Soya, 2009). Genckan (1983) reported that the first product of this forage plant is used for herb production and other products are used for grazing purposes in the vegetation period.
This study was carried out to determine the boron

requirement of berseem clover grown in regions with irrigation facilities in semi-arid climatic conditions. In the study, the yield changes in the agromorphological characteristics of the plant were evaluated by the amounts of boron given to berseem clover at different rates.

2. Materials and Methods

The field experiment was conducted at Ankara University, Faculty of Agriculture, Department of Field Crops parcels in 2017 and 2018. The elevation of the research area from the sea was 860m. Ankara has a semi-arid and less humid climate. The summers are hot and dry, the winters are cool and rainy. Vegetation period of the plant was between April and August. In vegetation period of 2017 and 2018, total precipitation was 161.7 mm and 174.1 mm, average temperature was 19.5 °C and 20.9 °C and average humidity was 49.7% and 48.1%. Precipitation was showed a regular distribution in 2017, but irregular in 2018 (Table 1).

Soil of the research area was clayey with moderately alkaline. It was insufficient in terms of total nitrogen and organic matter. Soil had enough phosphorus and potassium. The salt level of the soil was harmless. The amount of boron of the soil was measured as 1.13 mg kg^{-1} for 2017 and 0.96 mg kg^{-1} for 2018 (Table 2). The amount of available boron in the soil changes every year depending on the precipitation situation.

Three different varieties were used in the study. These were Derya, Erix and Mario. Derya was developed by Eastern Mediterranean Agricultural Research Institute. Erix and Mario were certified foreign varieties. 3 kg of seeds were sown per decare by hand to a depth of 1-1.5 cm. The field experiment was set up in a randomized complete block design with a split plot arrangement having 3 replications in 2017 and 2018 in Ankara conditions. Berseem varieties were sown to main parcels and 5 different boron fertilizer doses (D1: Control, D2:100, D3:200, D4:400, D5:800 g da^{-1}) were applied to sub-parcels. In the study, each parcel area had 4.5 m^2 in 5 rows and each row is 3 m in length. 20 kg da^{-1} of 18-46-0 (Diammonium Phosphate) was applied to all parcels. Etidot-67 (Disodium Octaborate Tetrahydrate) with 20% pure boron content was preferred for boron fertilization. Boron fertilizer was melted in water and applied to the soil. The parcels were irrigated 2 times and weed struggle took place during the growing period.

In the study, agromorphological properties which are plant height, stem diameter, stem numbers per plant and head numbers per plant were investigated. The study of Erac (1982) was used for the plant height and stem diameter calculations. While the plants were in the flowering phase, the length between the soil surface and the far end of the plant was measured with a ruler. In each parcel, 5 plants were randomly selected from the middle rows and the average of them was accepted as the average plant length of the parcel. Stem diameter was found by measuring the distance between the 2nd and 3rd knots of the main stem of 5 plants in the flowering phase. In the measurements, 0.1 mm split compass was used. The study of Guncan (1992) was used for the stem numbers and head numbers. The stems and heads of 5 plants randomly selected from the parcels that have reached harvest maturity were counted and calculated the average of these for the stem numbers and head numbers.

Table 1. Climate factors of 2017, 2018 and long years at Ankara location (Anonymous, 2019)

Climate Factors	Years	Months												
		Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Avg.
Average Temperature (°C)	2017	-1.3	2.9	8.1	11.0	15.8	20.4	25.6	24.7	22.6	12.6	7.1	4.7	12.9
	2018	3.1	6.5	10.0	15.3	18.0	21.4	24.5	25.1	20.1	14.9	9.0	3.3	14.3
	Long Years	0.1	1.7	5.7	11.2	16.0	19.9	23.4	23.3	18.8	13.1	7.2	2.4	11.9
Average Humidity (%)	2017	76.8	66.7	60.2	50.6	55.9	58.0	38.1	45.8	34.2	56.3	69.7	78.3	57.6
	2018	77.0	73.1	63.3	44.9	59.6	53.4	45.4	37.4	45.3	58.9	64.4	81.4	58.6
	Long Years	77.3	73.0	64.6	58.8	57.3	52.0	44.5	43.6	48.2	58.9	70.0	77.6	60.5
														Tot.
Total Precipitation (mm)	2017	36.3	8.7	49.4	22.8	53.8	56.3	11.6	17.2	4.4	31.5	41.3	46.3	379.6
	2018	54.8	37.3	84.6	3.8	102.7	45.0	11.0	11.6	4.3	55.1	25.1	70.5	505.8
	Long Years	40.4	35.2	39.2	43.3	51.8	34.7	14.1	12.5	18.8	28.0	31.7	44.3	394.0

Table 2. Soil factors of 2017 and 2018 of the research area (Anonymous, 2018)

	Year	pH	Salt (%)	Total N (%)	Organic Matter (%)	P_2O_5 (kgda^{-1})	K_2O (kgda^{-1})	B (mgkg^{-1})
Soil Factors (0-30cm)	2017	8.08	0.04	0.09	1.06	7.96	119.99	1.13
	2018	7.88	0.03	0.07	0.91	6.64	96.02	0.96

The statistical analysis of variance for all the measured properties was performed by using the Mstat-C package program. Duncan multiple comparison test was applied to compare the means.

3. Results

3.1. The Analysis of Variance

The analysis of variance for three berseem varieties and five boron doses in 2017, 2018 and both years was given in Table 3. In terms of plant height, variety was significant at 5% and 1% level in 2017 and 2018. Boron dose was significant at 1% level in both years. The means of 2017 and 2018 were grouped because of year factor was insignificant. When stem diameter was examined, variety was significant at 5% level in 2018. The boron dose was significant at 1% level in both years. The means of 2017 and 2018 were grouped separately because of year factor was significant at 5% level.

In terms of stem numbers per plant, variety was significant at 5% and 1% level in 2017 and 2018. The boron dose was significant at 1% level in both years. The means of 2017 and 2018 were grouped together because of year factor was insignificant. When head numbers per plant was examined, variety was significant at 5% level in 2017. The boron dose was significant at 1% level in both years. The means of 2017 and 2018 were grouped because of year factor was insignificant (Table 3).

3.2. Plant Height

Plant height means for 2017, 2018 and both years were given separately in Table 4. Erix had 89.24 cm as two-year means. The lowest plant height means were obtained from Derya with 74.85 cm. The highest plant height mean of two years was observed in Mario with 92.44 cm.

Plant height means for different boron doses were ranged between 80.78 and 91.58 cm according to the average of the two years. Compared to the control parcels, the highest plant height mean was reached at 91.58 cm at 100 g da^{-1} boron dose (Table 4).

3.3. Stem Diameter

Stem diameter means for 2017, 2018 and both years were given separately in Table 5. Erix had 4.05 mm as two-year means. The lowest stem diameter means were obtained from Derya with 3.74 mm. The highest stem diameter mean of two years was observed in Mario with 4.06 mm.

Stem diameter means for different boron doses were ranged between 3.78-4.26 mm according to the average of the two years. Compared to the control parcels, the highest stem diameter mean was reached with 4.26 mm at 100 g da^{-1} boron dose (Table 5).

Table 3. Analysis of variance for varieties and boron doses in 2017, 2018 and both years

Source of Variation	Plant Height	Stem Diameter	Stem Numbers/Plant	Head Numbers/Plant
		2017		
Variety	1533.91*	0.35	37.31*	82.86*
Error	125.80	0.09	2.22	6.87
Dose	165.86**	0.51**	4.56**	12.77**
Variety x Dose	6.16	0.02	0.07	0.40
Error	5.59	0.02	0.34	0.28
		2018		
Variety	1119.36**	0.73*	50.44**	6.40
Error	5.85	0.07	0.73	2.76
Dose	145.66**	0.45**	4.32**	7.08**
Variety x Dose	2.76	0.01	0.19	0.13
Error	1.72	0.01	0.60	0.11
		2017 and 2018		
Year	64.52	0.11*	3.44	1.07
Replicate	100.91	0.59	13.73	21.21
Error	96.5	0.01	0.69	8.09
Variety	2634.67**	1.04**	82.56**	67.63**
Year x Variety	18.60	0.04	5.19	21.64
Error	65.82	0.08	1.47	4.81
Dose	304.63**	0.95**	8.71**	19.23**
Year x Dose	6.89	0.01	0.16	0.62
Variety x Dose	7.39	0.01	0.16	0.34
YearxVarietyxDose	1.52	0.01	0.10	0.19
Error	3.65	0.01	0.20	0.20

*= 0.05, **= 0.01 shows significant probability level.

Table 4. Plant height means of different varieties and boron doses in 2017, 2018 and both years (cm)

	2017				
Dose	Derya	Erix	Mario	Means	
D1	73.60±5.74	86.60±6.71	91.28±6.79	83.82±6.55	
D2	81.00±6.32	94.87±7.41	97.28±7.57	91.04±6.76	
D3	74.93±5.77	91.33±6.79	93.00±7.26	86.42±6.68	
D4	68.80±5.31	86.80±6.70	90.80±7.09	82.13±6.43	
D5	67.20±5.29	85.33±6.69	87.13±6.77	79.89±6.29	
Means	73.11±5.69	88.99±6.73	91.89±6.83		
	2018				
Dose	Derya	Erix	Mario	Means	
D1	74.27±5.96	87.27±6.77	90.53±6.68	84.02±6.59	
D2	83.53±6.51	94.47±7.96	98.33±7.83	92.11±7.11	
D3	79.40±6.26	91.08±7.14	94.40±7.87	88.29±6.63	
D4	75.07±5.79	88.87±6.70	93.13±7.35	85.69±6.79	
D5	70.67±5.38	85.80±6.73	88.53±6.62	81.67±6.42	
Means	76.59±5.93	89.49±6.99	92.99±7.25		
2017-2018 Variety Means	Derya	Erix	Mario		
	74.85±6.69c	89.24±6.96b	92.44±7.13a		
2017-2018 Dose Means	D1	D2	D3	D4	D5
	83.92±6.58c	91.58±7.34a	87.36±6.85b	83.91±6.57c	80.78±6.29d

* Means with the same letter are not significantly different at 5% probability level.

Table 5. Stem diameter means of different varieties and boron doses in 2017, 2018 and both years (mm)

	2017				
Dose	Derya	Erix	Mario	Means	
D1	3.71±0.25	3.81±0.26	3.90±0.27	3.81±0.26cd	
D2	4.04±0.28	4.45±0.31	4.37±0.31	4.29±0.30a	
D3	3.97±0.27	4.23±0.30	4.19±0.29	4.13±0.29ab	
D4	3.84±0.26	4.10±0.29	3.99±0.27	3.98±0.27bc	
D5	3.47±0.23	3.78±0.26	3.86±0.26	3.70±0.26d	
Means	3.81±0.26	4.07±0.29	4.06±0.28		
2018					
Dose	Derya	Erix	Mario	Means	
D1	3.52±0.24	3.82±0.26	3.90±0.27	3.75±0.26c	
D2	3.93±0.27	4.35±0.30	4.43±0.31	4.24±0.30a	
D3	3.77±0.26	4.10±0.29	4.14±0.29	4.01±0.28b	
D4	3.66±0.25	4.06±0.29	4.04±0.28	3.92±0.27b	
D5	3.43±0.24	3.78±0.26	3.78±0.26	3.66±0.25c	
Means	3.66±0.25b	4.02±0.28a	4.06±0.29a		
2017-2018 Variety Means	Derya	Erix	Mario		
	3.74±0.26	4.05±0.28	4.06±0.28		
2017-2018 Dose Means	D1	D2	D3	D4	D5
	3.78±0.26	4.26±0.29	4.07±0.28	3.95±0.27	3.78±0.26

* Means with the same letter are not significantly different at 5% probability level.

3.4. Number of Stem

Stem means for 2017, 2018 and both years were given separately in Table 6. Mario had 9.66 pieces as two-year means. The lowest stem means were obtained from Derya with 6.96 pieces in both years. The highest stem mean of two years was observed in Mario and Erix with 9.66 and 9.98 pieces. Stem means for different boron doses were ranged between 8.06-9.89 pieces according to the average of the two years. Compared to the control parcels, the highest stem mean was reached with 9.89 pieces at 100 g da^{-1} boron dose (Table 6).

3.5. Number of Head

Head means for 2017, 2018 and both years were given separately in Table 7. Erix had 12.08 pieces as two-year means. The lowest head means were obtained from Mario with 9.94 pieces in both years. The highest head mean of two years was observed in Derya with 12.89 pieces. Head means for different boron doses were ranged between 10.43-13.04 pieces according to the average of the two years. Compared to the control parcels, the highest head mean was reached with 13.04 pieces at 100 g da^{-1} boron dose (Table 7).

Table 6. Stem numbers/plant means of different varieties and boron doses in 2017, 2018 and both years (piece)

	2017				
Dose	Derya	Erix	Mario	Means	
D1	6.93±0.90	9.85±1.27	8.87±1.15	8.55±1.11	
D2	7.95±1.03	11.13±1.43	10.06±1.31	9.71±1.26	
D3	7.41±0.96	10.27±1.32	9.17±1.18	8.95±1.16	
D4	6.33±0.82	9.84±1.27	8.72±1.13	8.30±1.08	
D5	6.17±0.80	9.21±1.19	8.06±1.05	7.81±1.01	
Means	6.96±0.91	10.06±1.31	8.98±1.16		
		2018			
Dose	Derya	Erix	Mario	Means	
D1	6.67±0.86	9.62±1.25	9.66±1.26	8.65±1.11	
D2	7.79±1.01	10.73±1.39	11.67±1.51	10.06±1.31	
D3	7.26±0.97	10.13±1.31	10.83±1.42	9.41±1.22	
D4	6.74±0.89	9.70±1.27	10.35±1.36	8.93±1.16	
D5	6.36±0.82	9.33±1.21	9.20±1.18	8.30±1.08	
Means	6.96±0.89	9.90±1.28	10.34±1.35		
2017-2018 Variety Means	Derya	Erix	Mario		
	6.96±0.89[b]	9.98±1.27[a]	9.66±1.25[a]		
2017-2018 Dose Means	D1	D2	D3	D4	D5
	8.60±1.12[c]	9.89±1.29[a]	9.18±1.18[b]	8.62±1.12[c]	8.06±1.05[d]

* Means with the same letter are not significantly different at 5% probability level.

Table 7. Head numbers/plant means of different varieties and boron doses in 2017, 2018 and both years (piece)

	2017				
Dose	Derya	Erix	Mario	Means	
D1	12.73±3.68	11.79±3.39	8.27±2.38	10.93±3.16	
D2	15.02±4.35	13.61±3.94	11.07±3.21	13.23±3.83	
D3	14.02±4.06	12.72±3.68	9.73±2.81	12.16±3.54	
D4	13.24±3.83	12.16±3.51	8.04±2.34	11.15±3.25	
D5	12.46±3.62	11.11±3.22	7.28±2.12	10.28±2.98	
Means	13.49±3.91	12.28±3.57	8.88±2.55		
		2018			
Dose	Derya	Erix	Mario	Means	
D1	11.87±3.42	11.15±3.22	10.93±3.16	11.32±3.28	
D2	13.38±3.88	13.05±3.77	12.13±3.51	12.85±3.71	
D3	12.81±3.71	12.62±3.65	11.47±3.34	12.30±3.57	
D4	12.10±3.51	11.84±3.42	10.69±3.10	11.54±3.34	
D5	11.27±3.68	10.69±3.10	9.78±2.84	10.58±3.07	
Means	12.29±3.27	11.87±3.42	11.00±3.19		
2017-2018 Variety Means	Derya	Erix	Mario		
	12.89±3.74[a]	12.08±3.51[b]	9.94±2.87[c]		
2017-2018 Dose Means	D1	D2	D3	D4	D5
	11.13±3.22[c]	13.04±3.77[a]	12.23±3.54[b]	11.35±3.31[c]	10.43±3.02[d]

* Means with the same letter are not significantly different at 5% probability level.

4. Discussion

4.1. Plant Height

Plant height means of the varieties were varied between 74.85-92.44 cm in 2017 and 2018 (Table 4). Celen (1998) reported that plant height varied between 64.23 and 80.42 cm in a study on seed yield characteristics of some berseem clover varieties under Izmir conditions. The means obtained from varieties in the study were higher than the reported values.

4.2. Stem Diameter

Stem diameter means of the varieties were varied between 3.74-4.06 mm in 2017 and 2018 (Table 5). Demirok (1993) reported that stem diameter varied between 4.09 and 4.47 mm in a study on weed yield characteristics of some berseem clover varieties under Ankara conditions. The means obtained from varieties in the study were consistent with reported values.

4.3. Number of Stem

Stem means of the varieties were varied between 6.96-10.34 pieces in 2017 and 2018 (Table 6). Celen (1998) reported that number of stem varied between 2.50 and 4.30 pieces in a study on some seed yield and yield characteristics of some berseem clover varieties under Izmir conditions. The means obtained from varieties in the study were higher than the reported values.

4.4. Number of Head

Head means of the varieties were varied between 9.94-12.89 pieces in 2017 and 2018 (Table 7). Guncan (1992) reported that number of head varied between 5.90 and 12.00 pieces in a study on seed yield characteristics of some berseem clover varieties under Ankara conditions. The means obtained from varieties in the study were consistent with reported values.

5. Conclusion

Considering the different boron doses applied in berseem clover varieties; Mario has reached the highest plant height and stem diameter means. The highest development in terms of stem numbers per plant was observed in Erix. Derya was showed the highest development in terms of head numbers per plant. When boron doses were compared with control parcels, the highest plant height, stem diameter, stem numbers and head numbers were obtained at 100 g da^{-1} boron dose. It was determined as the best boron dose for high yield and quality**.**

Author Contributions

The percentage of the author(s) contributions is presented below. All authors reviewed and approved the final version of the manuscript.

	H.B.
C	100
D	100
S	100
DCP	100
DAI	100
L	100
W	100
CR	100
SR	100
PM	100
FA	100

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

Conflict of Interest

The author declared that there is no conflict of interest.

Ethical Consideration

Ethics committee approval was not required for this study because there was no study on animals or humans.

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