

Original Research Article

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Boron Content in Different Plant Parts of Soybean as Influenced by Boron Application

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ABSTRACT

The investigation entitled “Boron content in different plant parts of Soybean as influenced by Boron application” was carried out during *Kharif* season (2016) on Soybean variety JS-97-52 to study the partitioning of boron in soybean as affected by periodicity and levels of boron application. Field experiment carried out at Research Farm, JNKVV, Jabalpur with soybean variety JS 97-52 was laid in split plot design with three main treatments of periodicity (single year, alternate year and each of year B application) and five sub treatments of levels of Boron application (0, 0.5, 1.0, 1.5 and 2.0 kg B ha⁻¹) along with recommended dose of NPK. Treatments were replicated thrice under optimum agronomic management practices. Boron content in leaf, stem and root at different days interval was significantly affected by Boron application and found maximum under 2.0 kg B ha⁻¹ treatment. Significant change in content of Boron in pod, seed and stover due to Boron application was found with the highest content under 2.0 kg B ha⁻¹ treatment which was at par with that under 1.5 kg B ha⁻¹ treatment while the interaction effects were found non significant.

Keywords

Partitioning,
Boron,
Periodicity

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Introduction

Balanced and optimal use of inputs, especially nutrients, is the key for agricultural production system. In spite of balanced application of macronutrients, productivity and quality of soybean has been diminishing mainly due to spreading of micronutrients deficiency as a result of intensive cropping, loss of top soil through erosion, loss of

micronutrients by leaching and reduction in use of organic sources of plant nutrients. Micronutrients are usually required in minute quantities, nevertheless are vital to plant growth as they improve general condition of plant and are known to act as catalysts in promoting bio-chemical reactions taking place in plant. Among different micronutrients boron is one of the essential elements and belongs to the metalloid group

of element with intermediate properties between metals and non-metals. In several plant functions, B is implicated directly and indirectly as it involves in cells growth in newly emerging shoot and root. It is also crucial for pod formation, flowering, pollination, seed development, transport of sugar synthesized by different plant components (Miwa *et al.*, 2008) and synthesis of amino acids and root nodulation (Yamagishi and Yamamoto, 1994). Boron deficiency at early growth stage significantly boosts chlorophyll content in leaf, minimizes carbohydrate transport from leaf to fruit and ultimately leaf photosynthetic rate and stomatal conductance is abated. Availability of B in soil regulates the biomass accumulation and partitioning in plant and also influences the productivity of soybean. The increase in plant biomass is also associated by an increase in B concentration in plant parts which is always higher in reproductive than vegetative parts (Asad *et al.* 2002 and Goldberg *et al.* 2003). To assess the content of Boron in different plant parts of soybean the field experiment was conducted to study the concentration of boron in different plant parts i.e. partitioning of boron in soybean as affected by periodicity and levels of boron application.

Materials and Methods

The field experiment was conducted during *khari* season of 2016 at Research Farm, Department of Soil science and Agricultural Chemistry, JNKVV, Jabalpur (MP). The soil of the experimental site was Vertisol belonging to fine Montmorillonite, Hypothermic family of *Typic Haplusterts* popularly known as “Black cotton soil” having neutral soil reaction. The experiment was laid out under the ongoing AICRP on Micro, Secondary Nutrients and Pollutant Elements in Soils and Plants during *khari* season of 2016. The experiment consists of 3

main treatments of periodicity of boron (B) application and 5 sub treatments of B levels which were and replicated 3 times in a Split plot design. The details of treatments of experiment are:

Main plot treatments: 3 (Periodicity of B application)

P₁: Single year (Once in 6 years)

P₂: Alternate year

P₃: Each year.

Sub plot treatments: 5 (Levels of B application)

B₀: 0.0 kg B ha⁻¹

B_{0.5}: 0.5 kg B ha⁻¹

B_{1.0}: 1.0 kg B ha⁻¹

B_{1.5}: 1.5 kg B ha⁻¹

B_{2.0}: 2.0 kg B ha⁻¹

To obtain the desirable seedbed for sowing the field was ploughed once in summer with disc plough followed by two cross harrowing and a final harrowing followed by planking to level the field. Good quality seeds of soybean variety JS-9752 was used @ 80 kg ha⁻¹ and were placed in soil at 3-4 cm depth in rows having spacing of 40 cm. Basal application of recommended dose of N, P₂O₅ and K₂O (20, 80 and 20 kg ha⁻¹) was done in all the plots before sowing through urea (46 %N), single super phosphate (16%P₂O₅) and muriate of potash (60%K₂O) respectively and Boron was applied through borax (10.6%B) according to the treatment at the time of sowing as soil application. During the crop growth period a manual thinning was done at 15 days after sowing to maintain the optimum plant population and two manual hand weeding at 15 DAS and 45 DAS were done in order to remove the weeds. The crop was harvested after maturity when 90% leaves become yellow and grain become hard.

Three randomly selected plants from each plot were sampled at 30, 45, 60 and 90 DAS,

and at harvest of the crop and brought to the laboratory for the determination of boron content in different plant parts (B partitioning) of soybean. In the laboratory, collected samples were washed under tap water for 2 to 3 times to remove the foreign impurities and adhering soil particles over the plant surface if any. After that plant samples were washed with the 0.1 N HCl carefully. After precise washing the plant parts (leaf, stem, root from the collar region and pod) were separated and oven dried at 60 °C till the constant dry weight obtained. After proper drying, leaf, stem, root and pod samples were grind separately. After processing of plant samples Boron content in plant samples was determined spectrophotometrically by Azomethine H method as described by Berger and Truog (1939). The data obtained during estimation of Boron content in plant was statistically analyzed by the method of analysis of variance technique (Panse and Sukhatme, 1967).

Results and Discussion

The concentration of boron in different plant parts of soybean estimated during the experiment showed its maximum concentration in leaves followed by stem and minimum in root till the vegetative phase. Higher concentration of B in leaf may be attributed to role of B as one of the important structural components for cell wall and passive movement of boron within the plant along with the transpiration stream. While, higher B concentration in stem as compared to roots might be supported by the reason that B involves in various meristematic activities. Further it was also found that concentration of boron in reproductive plant part was higher than vegetative part which might be because of translocation of B from leaves and other vegetative parts towards the reproductive part. Marentes *et al.*, (1997) also reported that B was transported through the phloem, as

phloem transport is independent of transpiration and supplies the major proportion of nutrient requirements for actively growing organs, such as young leaves, pods, and seeds.

Temporal variation in boron concentration in different parts (leaf, stem, root, pod, seed and stover) of soybean was estimated to find out the boron partitioning behaviour in plant and the results thus obtained are presented in under the following sub-heads:

Boron concentration in leaf

Data pertaining to the boron concentration in leaf as affected by periodicity and levels of boron at 30, 45, 60 and 90 days after sowing (DAS) presented in table 1.1 clearly indicates that boron concentration in leaf increased due to periodicity of boron application from single year to each year but difference was found statistically non- significant. It is also evident that maximum concentration (25.87, 28.67, 29.06 and 29.75 mg kg⁻¹) of B in leaf at 30, 45, 60 and 90 DAS, respectively was obtained in each year B application treatment followed by alternate and single year B application treatments. The data further showed that the increasing levels of boron application progressively increased its concentration in leaves at all the intervals of crop growth under study and highest B concentration in leaf was obtained with the application of 2.0 kg B ha⁻¹(26.76, 29.65, 30.53, 30.27 mg kg⁻¹ at 30, 45, 60 and 90 DAS, respectively) which was significantly higher than control but statistically at par with other treatments of B levels.

This finding was in good agreement with those reported by Moreira *et al.*, (2011) and Reinbott *et al.*, (1997). Concentration of B in leaf increased up to 60 DAS and thereafter decreased till 90 DAS which may be attributed to increased dry matter

accumulation from 60 DAS to 90 DAS but decreased uptake of B in plant.

Boron concentration in stem

The concentration of boron in stem at 30, 45, 60 and 90 DAS as affected by periodicity and levels of B application in soybean presented in table 1.2 clearly indicated highest concentration of boron in stem (14.37, 17.06, 18.89, 18.17 mg kg⁻¹ respectively) in each year B application treatment followed by alternate and single year B application. At 30 and 60 DAS the effect of periodicity on boron concentration in stem was found non-significant but at 45 and 90 DAS concentration of B in stem under each year application treatment was significantly higher than single year and at par with alternate year application of boron. The data further indicated B concentration in stem increased with increasing level of boron at various intervals under study. However, significant higher B concentration in stem over control was found in 1.5 and 2.0 kg B ha⁻¹ application treatments but the difference in B concentration in stem between these two treatments was statistically at par.

These findings are well supported by those reported by Choi *et al.*, (2015) which also stated that increasing levels of boron application significantly increased the boron concentration in stem of the plant.

Boron concentration in root

Effect of periodicity and levels of boron application on B concentration in root was also studied at 30, 45, 60 and 90 DAS and data given in table 1.3 revealed that the boron concentration in root of soybean increased up to 45 DAS and then further decreases. At 30, 60 and 90 DAS the concentration of B in root of soybean in each year B application treatment was significantly higher than single

year B application but statistically at par with alternate year. But at 45 DAS concentration of B in root under alternate and each year B application treatments was significantly higher than single year B application treatment. Data further revealed that increasing levels of boron application increased the B concentration in roots at different DAS. Boron concentration in root at 30 DAS was significantly higher under 1.0, 1.5 and 2.0 kg B ha⁻¹ treatments as compared to control but the difference in B concentration in root under 1.5 and 2.0 kg ha⁻¹ B application was statistically at par. However, at 45, 60 and 90 DAS the concentration of boron in root under 1.5 and 2.0 kg B ha⁻¹ treatments was significantly higher than control but statistically at par in both.

Maximum B concentration in root at 45 DAS and then its decreased concentration till 90 DAS might be attributed to highest root nodulation at 45 DAS that decreased afterward and B is directly involved in the development of root nodules. Also it might be due to translocation of boron from root towards reproductive parts of the plant as after 45 DAS the reproductive stage of soybean crop started and accumulation of B in root was decreased and root biomass increased that resulted in lower concentration due to dilution factor. Similarly, Yamagishi and Yamamoto (1994) also found that B deficiency resulted in underdeveloped nodules in soybean. Reduction in boron content in root towards reproductive phase was also found by Zhang *et al.*, (2012) which closely support the findings of the present investigation.

Boron concentration in pod

Data pertaining to the concentration of boron in pod of soybean as affected by periodicity and increasing B levels at 60 and 90 DAS are

presented in table 1.4. The data revealed that the periodicity of boron application had a significant effect on B concentration in pod of soybean. Data also showed that B concentration in pod at 60 and 90 DAS under each and alternate year B application treatments was statistically at par but significantly higher than single year B application. The data further revealed that B concentration in pod increased with increasing B application in soybean and highest concentration (32.74 and 35.09 mg kg⁻¹) was obtained at 60 and 90 DAS, respectively under 2.0 kg B ha⁻¹ application treatment. At 60 DAS the concentration of B in pods was significantly higher under 1.5 and 2.0 kg B ha⁻¹ application treatments as compared to control, while at 90 DAS under 1.0, 1.5 and 2.0 kg B ha⁻¹ treatments it was found significantly higher than control. But the B concentration in pod under 1.5 and 2.0 kg B ha⁻¹ application treatments was found statistically at par.

The significant increase in concentration of B in pods of soybean increased due to periodicity and increasing levels of B application were well supported by the finding of Moreira *et al.*, (2011) and Rathod *et al.*, (2016) which also showed significantly higher B concentration in pod, seed and stover due to higher level of boron either as soil or foliar applied B through soil and foliar application.

Boron concentration in seed and stover

It is clearly evident from the data given in table 1.5 that a significant effect of periodicity and levels of boron application on boron concentration in seed and straw of soybean was observed with a significantly high concentration of B in seed under alternate (32.93 mg kg⁻¹) and each year (34.29 mg kg⁻¹) as compared to single year (30.04 mg kg⁻¹) B application treatment, but statistically alternate and each year B application treatments were at par.

Table.1 Effect of periodicity and levels of boron application on boron concentration in leaves of soybean

Treatment	Boron concentration in leaf (mg kg ⁻¹)			
	30 DAS	45 DAS	60 DAS	90 DAS
Periodicity of B application				
Single Year	24.77	27.55	28.57	27.05
Alternate Year	25.05	28.01	29.05	29.26
Each Year	25.87	28.67	29.06	29.75
SEm ±	0.60	0.44	0.77	0.84
CD(p=0.05)	2.34	1.73	3.03	3.31
Levels of B application (kg ha⁻¹)				
B ₀	23.45	26.88	27.81	27.71
B _{0.5}	24.22	27.66	28.03	27.96
B _{1.0}	25.57	27.80	28.85	28.48
B _{1.5}	26.05	28.41	29.27	29.02
B _{2.0}	26.76	29.65	30.53	30.27
SEm±	0.92	0.89	0.84	0.88
CD(p=0.05)	2.63	2.55	2.41	2.53

Table.2 Effect of periodicity and levels of boron application on boron concentration in stem of soybean

Treatment	Boron concentration in stem (mg ka ⁻¹)			
	30 DAS	45 DAS	60 DAS	90 DAS
Periodicity of B application				
Single Year	12.98	14.13	17.07	16.74
Alternate Year	13.81	16.73	18.03	17.74
Each Year	14.37	17.06	18.89	18.17
SEm ±	0.39	0.64	0.65	0.35
CD(<i>p</i> =0.05)	1.54	2.50	2.55	1.37
Levels of B application (kg ha⁻¹)				
B ₀	12.31	14.47	16.56	16.06
B _{0.5}	13.27	15.27	17.20	17.07
B _{1.0}	13.68	15.87	17.87	17.23
B _{1.5}	14.36	16.57	18.98	18.13
B _{2.0}	14.98	17.68	19.36	19.27
SEm±	0.52	0.57	0.54	0.65
CD(<i>p</i> =0.05)	1.48	1.62	1.54	1.87

Table.3 Effect of periodicity and levels of boron application on boron concentration in roots of soybean

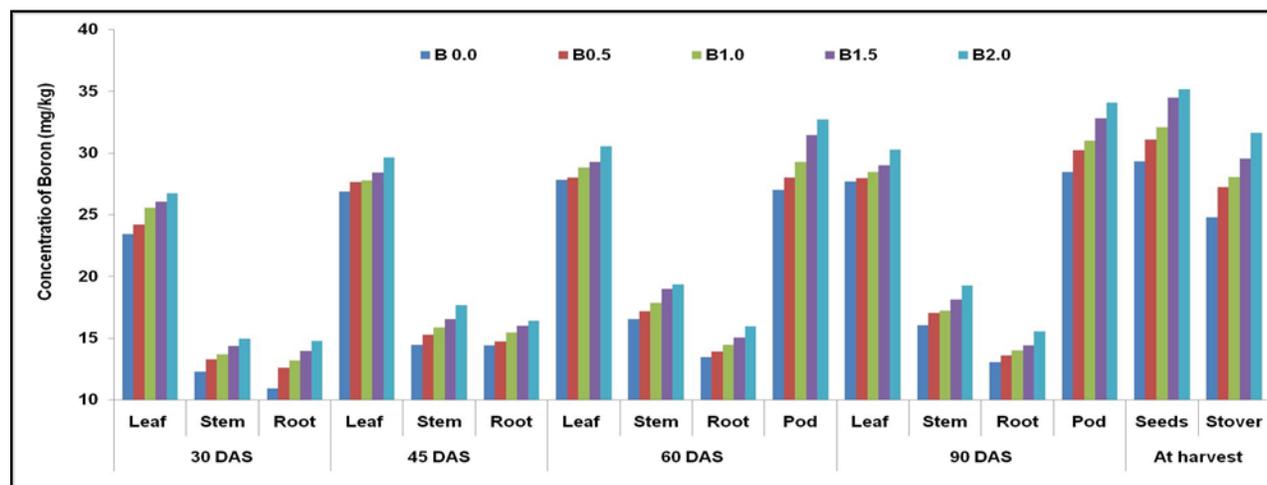
Treatment	Boron concentration in root (mg kg ⁻¹)			
	30 DAS	45 DAS	60 DAS	90 DAS
Periodicity of B application				
Single Year	12.47	14.68	13.47	13.14
Alternate Year	12.89	15.53	14.51	14.07
Each Year	13.93	16.00	15.76	15.20
SEm ±	0.29	0.17	0.42	0.28
CD(<i>p</i> =0.05)	1.12	0.66	1.64	1.09
Levels of B application (kg ha⁻¹)				
B ₀	10.91	14.40	13.49	13.08
B _{0.5}	12.61	14.75	13.94	13.62
B _{1.0}	13.19	15.45	14.45	14.00
B _{1.5}	13.97	15.99	15.04	14.44
B _{2.0}	14.80	16.42	15.97	15.56
SEm±	0.69	0.49	0.51	0.43
CD(<i>p</i> =0.05)	1.96	1.40	1.46	1.23

Table.4 Effect of periodicity and levels of boron application on B concentration in pod

Treatment	Boron concentration in pod (mg kg ⁻¹)	
	60 DAS	90 DAS
Periodicity of B application		
Single Year	28.24	29.06
Alternate Year	29.87	31.73
Each Year	31.01	33.15
SEm ±	0.364	0.618
CD(<i>p</i> =0.05)	1.430	2.429
Levels of B application (kg ha⁻¹)		
B ₀	27.00	28.46
B _{0.5}	28.03	30.22
B _{1.0}	29.29	31.00
B _{1.5}	31.46	32.81
B _{2.0}	32.74	34.09
SEm±	0.877	0.682
CD(<i>p</i> =0.05)	2.505	1.948

Table.5 Effect of periodicity and levels of boron application on B concentration in seeds and stover of soybean

Treatment	Boron concentration (mg kg ⁻¹)	
	Seeds	Stover
Periodicity of B application		
Single Year	30.04	26.81
Alternate Year	32.93	28.41
Each Year	34.29	29.57
SEm ±	0.295	0.473
CD(<i>p</i> =0.05)	1.159	1.860
Levels of B application (kg ha⁻¹)		
B ₀	29.31	24.81
B _{0.5}	31.08	27.25
B _{1.0}	32.07	28.08
B _{1.5}	34.47	29.56
B _{2.0}	35.16	31.63
SEm±	0.806	0.875
CD(<i>p</i> =0.05)	2.303	2.498

Figure.1 Effect of levels of boron application on partitioning of boron in soybean

However, the concentration of B in straw under each year B application (29.57 mg kg^{-1}) was significantly higher than single year application (26.81 mg kg^{-1}) and statistically at par with alternate year B application (28.41 mg kg^{-1}) treatment.

Data further indicated that B concentration of seeds in control (29.31 mg kg^{-1}) was found significantly lower than 32.07 , 34.47 and 35.16 mg kg^{-1} recorded under the treatments of boron levels of 1.0 , 1.5 and 2.0 kg B ha^{-1} , respectively. Similarly, the B concentration (28.08 , 29.56 and 31.63 mg kg^{-1}) in straw under the application of 1.0 , 1.5 and 2.0 kg B ha^{-1} treatments, respectively was found significantly higher than control (24.81 mg kg^{-1}). Data also revealed that concentration of B in seeds and straw of soybean under 1.5 and 2.0 kg B ha^{-1} application treatments was found statistically at par. The results are closely supported by the findings of Eguchi (2000) and Rathod *et al.*, (2016) which stated that B content in seed and straw increased with increasing levels of boron application.

It is concluded from the data that application of Boron as a nutrient source to Soybean crop significantly influence its concentration in

leaf, stem, root, pod, seed as well as in stover also. It was found maximum under the application of 2.0 kg B ha^{-1} which was statistically at par with that found in 1.5 kg B ha^{-1} treatment and minimum was reported in control. Among the different plant parts of soybean maximum content of Boron was reported in leaves during vegetative stage while during reproductive stage pods were having the maximum content and at harvest seeds are reported with the maximum and roots were having the minimum Boron content.

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