Soil Environ. 35(1): 30-34, 2016
www.se.org.pk
Online ISSN: 2075-1141
Print ISSN: 2074-9546

Yield of oil seed Brassica (*napus* and *juncea*) advanced lines as influenced by boron application

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Abstract

Four varieties/advanced lines of brassica species, two from Napus (NIFA-Gold and NH-97-5/2-4) and two from Juncea (NIFA-Raya and 7x1/05-4) were tested in a field experiment at NIFA experimental farm. The experiment was laid out according to split plot design, keeping varieties/lines in main plot and boron (B) levels in sub plot. Basal dose of NPK was applied to the experiment at the time of sowing. Different levels of boron were applied as foliar on crop in three splits at vegetative growth, flowering and pod formation stage. The results showed that maximum increase in seed yield (23.8%) was recorded for NIFA-Gold and NIFA-Raya by the application of 700 g B ha^{-1} followed by an advanced line of juncea 7x1/05-4 yielded (20.8%) more than control at 1000 g B ha^{-1}, while minimum (19.3%) increase over control in seed yield was recorded in NH-97-5/2-4 at 700 g B ha^{-1}. Boron concentration in brassica leaves increased with the increase in boron application dose and 100 ± 5 ppm boron concentration in plants leaves was found ideal/optimal.

Keywords: Brassica, boron, yield, quality

Introduction

The economy of Pakistan is agro-based. However, the country is facing a severe deficit of edible oil and domestic oil production is far below the total demand. The domestic oil production is only about 17% of the total national demand while the remaining 83% is imported at the cost of huge foreign exchange (Anonymous, 2015). Since early 1970s its import increased at the rate of 12.5% (Amjad, 2014) and 13% (Razi, 2004) annually and the trend will further not only continue but will also get worsen with increase in population. Oleiferous Brassica (rapeseed and mustard) are grown as vegetable, oil, fodder, condiment and green manure purposes. It is an important oilseed crop of Pakistan, but its production per unit (238900 ha) area is very low (220300 tons) i.e., 922 kg ha^{-1} (Anonymous, 2013). Rapeseed and mustard are the third largest contributors to the local vegetable oil after cottonseed and sunflower in Pakistan (Anonymous, 2013). There are many factors responsible for its low yield per unit area, but one of them is the non-availability of essential plant nutrients in proper amount.

Boron (B) is one of the sixteen essential nutrient elements, required for proper growth and yield of crop plants (Kakar *et al.,* 2000; Tariq and Mott, 2006). In plants, it plays important role in water relations, cell wall formation; cations and anions absorption, pollen viability and metabolism of N, P, carbohydrates and fats (Stiles, 1961; Oyinlola, 2007). Of all known plant micronutrient deficiencies, that of boron is most widespread (Gupta, 1993). Boron deficiencies occur over a wide range of soils and crops (Mengel and Kirkby, 2001). Boron deficiency in plants results in terminal bud growth inhibition and death of young leaves. Sugar transport, pollen formation, seed germination and development of nodules are also affected by boron deficiency. Seed and grain production are also reduced with low boron supply (Sillanpae, 1982). Deficiency of boron, shown by a positive response to boron application, has been reported in more than 80 countries for 132 crops over the last 60 years (Shorrocks, 1997).

Boron is an essential micro element for plant growth and development (Warington, 1923). On the other hand, toxicity and shortage ranges are very narrow in plants (Gupta, 1993). Boron, one of the essential micronutrients, plays vital role in plant growth. Being required by plants in minute quantities, it is classified as micronutrient; otherwise its role is as important as of any major plant nutrient, like nitrogen, phosphorus or potassium. Boron is required for normal development of reproductive tissues and deficiency results in low grain set or poor seed quality (Dell *et al.,* 2002). Even the cereals (like wheat and rice) with small B requirement, can suffer from impaired seed set due to B deficiency at a critical growth stage (Shorrocks, 1997).

Fertilizer use in Pakistan predominately pertains to nitrogen and phosphorus. While potassium use is confined to a few high-K requiring crops like tobacco and potato. Micronutrient fertilizer use particularly B is negligible.

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Moreover, continual removal of soil B in harvested plant parts and possible B loss through leaching depletes the meager soil and irrigation B supply thus, sooner or later, B must be replenished to sustain soil and crop productivity. Most of the cultivated soils in Pakistan have multiple nutrient deficiencies inclusive of B because of alkaline calcareous nature, low organic matter content, nutrient mining with centuries old cropping pattern and inadequate and imbalanced fertilizer use (Rashid, 2006).

Certain crops, like cotton, sunflower, legumes clover, lucerne, canola and pine have higher requirements than cereal crops (Shorrocks, 1997); hence, are susceptible to B deficiency and suffer yield losses in low B soils. Deficiency of B in soils of Pakistan is reported to be 50-60% (Rashid *et al.*, 2002). Experimental evidences in the country suggest that the risk of B deficiency for crop production in Pakistan is increasing, prompting a need for careful B diagnosis, delineation of deficient areas, developing effective management strategies and enhancing awareness for its profitable use (Rashid *et al.*, 2002; Rashid, 2006). Keeping in view the importance of B in sustainable crop production, an experiment was conducted to assess the effect of boron on yield and quality of oil seed brassica at NIFA experimental farm. The main aim of the study was to determine specific dose of boron for Brassica.

Materials and Methods

The experiment was conducted at NIFA experimental farm located at (71° 50`) longitude, (34° 01`) latitude, altitude 400 m above sea level. Composite soil samples from 0 to 60 cm depth i.e (0-15, 16-30 and 31-60 cm) were collected from field. The collected soil samples were analyzed for physio-chemical properties.

Two advanced lines from *Brassica napus* (NIFA-Gold and NH-97/2-4) and two advanced lines from *Brassica juncea* (NIFA-Raya and 7x1/05-4) developed at NIFA were used. The experiment was laid out according to split plot design, with three replications, each plot size being 2m × 3m keeping varieties/lines in main plot ant B levels in sub plot. Recommended row to row distance for sowing and other cultural practices were followed. Leaves and soil samples before and after B application were collected and analyzed for boron and other essential nutrients. At sowing time basal doses of other fertilizers was applied as per recommendation (Give values). Boron (Give levels) was applied as foliar spray on crop in three splits i.e. vegetative growth, flowering and pod formation stages. Soil pH and conductivity was determined by glass electrode pH meter and conductivity meter (1:2.5 soil-water suspension). Organic matter was determined by wet oxidation method (Nelson and Sommers, 1982). The K contents of soil were determined by 1M NH_4OAc (pH 7.0) extraction method using flame photometer. Phosphorus concentration was determined by colorimetric method and B concentration by azomethine-H method. The biological yield (grain and stover) were recorded after one week of harvesting before threshing expressed in kg ha^{-1} while grain yield was recorded just after threshing each plot in kg ha^{-1}. The grain samples from each plot were collected and analyzed for quality parameters such as % oil content, % protein, GSL (umol g^{-1}) %Moisture, %Oleic Acid, %Lenolenic Acid, and % Erucic Acid using Near Infrared Spectroscopy (NIRS) system.

Results and Discussion

The pH of the soil was from 7.4 and 7.44 in 0-15 and 16-30 cm depth, respectively. The conductivity of the soil samples was from 380 µs/cm to 400 µs/cm in 0-15 and 16-30 cm depth, organic matter was from 0.69 to 0.89% in 0 to 15 cm depth while 0.07 to 0.52% in lower depth (16- 30 cm), phosphorus (P) ranging from (6.7 - 4.5 ppm), potassium (K) was from 60 ppm to 40 ppm respectively and boron concentration was less or equal to 0.4 ppm when we move from 0-15 cm depth to 16-30 cm depth down word in the soil Table 1.

Table 1: Physio-chemical properties of soil

Depth (cm)	0-15	16-30
K (ppm)	60	40
P (ppm)	6.7	4.5
% OM	0.69-0.89	0.07-0.52
pH	7.4	7.44
EC (µs/cm)	380	400
B (ppm)	0.4	0.4

The results showed that all the treatments of boron applied increased yield over control. But maximum seed/grain yield was observed in an advance line 7x1/05-4, 2765 kg ha^{-1}, while maximum grain yield increase over control was observed in NIFA Raya 2187 kg ha^{-1} over control 1766 kg ha^{-1} and NIFA-Gold 2173 kg ha^{-1} over control 1756 kg ha^{-1} (i.e 23.8% increase over control), at @ 700 g B ha^{-1} followed by 7x1/05-4 2765 kg ha^{-1} over control 2290 kg ha^{-1} (i.e 20.8 % increase over control), at @ 1000 g B ha^{-1}. table-2. While minimum in NH-97/2-4 3143 kg ha^{-1} over control 2636 kg ha^{-1} (i.e 19.3% increase over control), at @ 700 g B ha^{-1} Table 2.

The seed yield increased markedly due to B application (Hossain *et al.*, 2011). The highest seed yield was obtained from 1 kg B ha^{-1} and the lowest yield from the B control plots. Showing a 30-35% yield increase over control. Averaged over three years, the seed yield was found to vary from 1389 to 1879 kg ha^{-1} for 0, 1, and 2 kg ha^{-1} B treatments (Hossain *et al.*, 2011). Lu *et al.* (2000) found that B fertilizer contributed 611 kg ha^{-1} (48.5%) yield advantage of rapeseed. Positive effect of B application on mustard yield has been reported in Bangladesh by Hossain *et al*. (1995), Haque *et al*. (2000) and Islam (2005). As reported by Wang *et al*. (1996), both deficiency and excess level of B showed abnormal growth of rapeseed plants, and use of borax fertilizer did not cause B toxicity when it was used 4 to 8 times higher than the recommendation (Wang *et al*., 1999). Mengel and Kirkby (1987) stated that Brassica crop has high B requirement. Sinha *et al*. (1991) and Sen and Farid (2005) observed 1.5 kg B ha^{-1} as the optimum dose for mustard cultivation.

selected for plant height. *Brassica juncea* both lines (7x1/05-4 and NIFA Raya) were taller than *Brassica napus* (NH-97/2-4 and NIFA Gold). 7x1/05-4 advance line of juncea is comparatively taller than NIFA-Raya. The minimum height is recorded mostly in NIFA-Gold. The averages of which varies from minimum 204.9 cm to maximum 241.9 cm, in *Brassica juncea* lines and from minimum 130.8 cm to maximum 228.8 cm in *Brassica napus* lines (Table 4), but cannot show clear differences among the B treatments. This means that the plant height was not influenced by B treatments. This type of results are also given by (Hossain *et al*., 2011), that plant height was not influenced remarkably by B treatments.

Table 2: Effect of boron application on averages grain yield (kg ha^{-1}) and percent increase over control in grain yield of *Brassica napus* and *juncea* advance lines

Grain yield (kg ha^{-1})					% increase over control in grain yield			
7x1/05-4	**NIFA Raya**	**NH-97/2-4**	**NIFA Gold**	**Treatment**	**7x1/05-4**	**NIFA Raya**	**NH-97/2-4**	**NIFA Gold**
2290	1766	2636	1756	T1	0.0	0.0	0.0	0.0
2504	1829	2901	1859	T2	9.4	3.5	10.1	5.9
2554	2130	3114	2126	T3	11.6	20.6	18.1	21.1
2688	2187	3143	2173	T4	17.4	23.8	19.3	23.8
2765	1881	3040	2067	T5	20.8	6.5	15.3	17.7
2473	1809	2965	1953	T6	8.0	2.4	12.5	11.3
2398	1803	2868	1911	T7	4.7	2.1	8.8	8.8

Table 3: Effect of boron application on biological yield (kg ha^{-1}) and percent increase over control in biological yield of *Brassica napus* and *juncea* advance lines

Biological yield (kg ha^{-1})					% increase over control in biological yield			
7x1/05-4	**NIFA Raya**	**NH-97/2-4**	**NIFA Gold**	**Treatment**	**7x1/05-4**	**NIFA Raya**	**NH-97/2-4**	**NIFA Gold**
19500	17833	20000	12833	T1	0.0	0.0	0.0	0.0
24500	18833	20500	13000	T2	25.6	5.6	2.5	1.3
25333	19500	21167	14500	T3	29.9	9.3	5.8	13.0
26167	20000	22500	14667	T4	34.2	12.1	12.5	14.3
25500	20500	21333	14167	T5	30.8	15.0	6.7	10.4
24167	20500	20833	13833	T6	23.9	15.0	4.2	7.8
22000	20000	20500	12833	T7	12.8	12.1	2.5	0.0

The effect of B application on the total produce from field before threshing (biological yield) of brassica species 7x1/05-4, NIFA Raya, NH-97/2-4 and NIFA Gold ranges from minimum12833 kg ha^{-1} to maximum 26167 kg ha^{-1} but after 1000 g B application the biological yield is reducing with increase of boron application. However, B control treatment produced the lowest yield and application of 700 g B ha^{-1} got the highest (34.2% increase over control) (Table 3). Saha *et al.* (2003) also reported that the use of B did not influence the yield of mustard. While Dear and Lipsett (1987) stated that reproductive growth is more sensitive to B deficiency than vegetative growth. Ten plants from each treatment and each replicate were randomly

Due to B application there were no significant change in the other qualitative parameters such as % oil content, % protein, GSL (umol g^{-1}), % moisture, % oleic acid, % lenolenic acid, and % erucic acid of all the four advanced lines Figure 1.

Conclusion

The results revealed that all the treatments of boron applied increased yield over control. Maximum seed yield was observed in an advance line 7x1/05-4 2765 kg ha^{-1}, while maximum seed yield increase over control was

Table 4: Effect of boron application on averages of plant height (cm) and percent increase over control in plant height of *Brassica napus* and *juncea* advanced lines

Averages of plant height (cm)					% increase over control in plant height			
7x1/05-4	NIFA Raya	NH-97/2-4	NIFA Gold	Treatment	7x1/05-4	NIFA Raya	NH-97/2-4	NIFA Gold
224.5	204.9	184.6	130.8	T1	0	0	0	0
228.6	228.6	201.7	141.5	T2	1.8	11.5	9.3	8.2
241.9	230.4	212.8	149.2	T3	7.8	12.4	15.3	14
238.9	238.3	214.5	156.7	T4	6.4	16.3	16.2	19.7
237.3	224.3	228.8	146.3	T5	5.7	9.4	23.9	11.8
227.7	213.3	227.8	146.3	T6	1.4	4.1	23.4	11.8
220	211.8	223.2	142	T7	-2	3.3	20.9	8.5

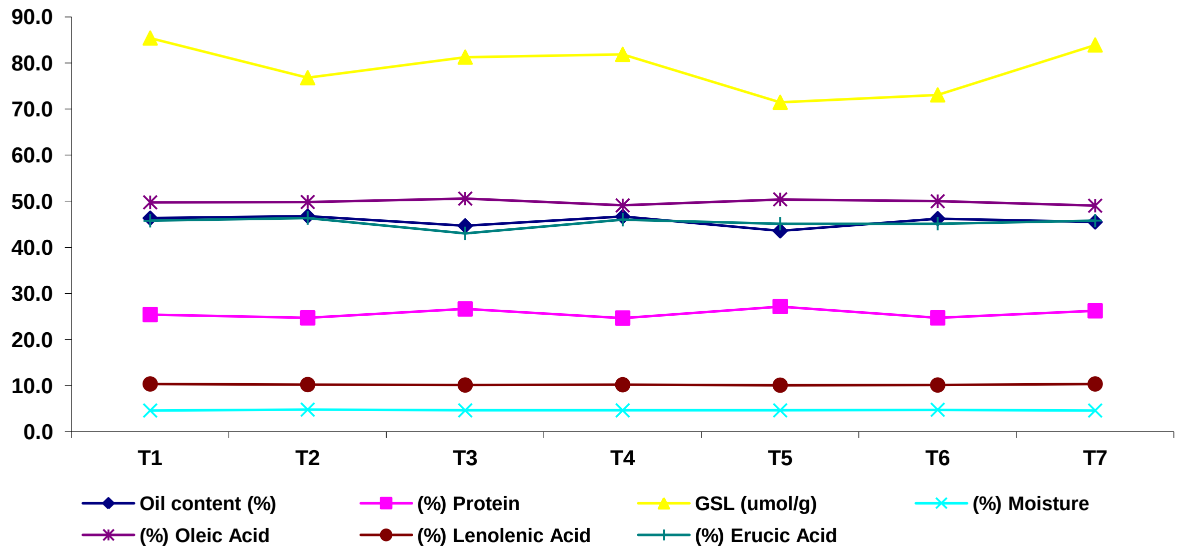

Figure 1: Effect of B treatments on qualitative parameters such as oil, protein, GSL, moisture, oleic acid, lenolenic acid and erucic acid contents, of brassica advanced lines seed

observed in NIFA- Gold and NIFA- Raya (23.8% increase over control), at @ 700 g boron ha^{-1} followed by an

advanced lines of juncea 7x1/05-4 yielded (20.8 %) more than control at 1000 g B ha^{-1}, while minimum (19.3 %) increase over control in seed yield was recorded in napus NH-97-5/2-4 at 700 g B ha^{-1}.) Further studies will be required for confirmation and time of application of nutrient.

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