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Raj Singh Choudhary
Division of Soil Science and Agriculture Chemistry, SKUAST-Jammu, Jammu and Kashmir, India

AK Mondal
Division of Soil Science and Agriculture Chemistry, SKUAST-Jammu, Jammu and Kashmir, India

Vikas Sharma
Division of Soil Science and Agriculture Chemistry, SKUAST-Jammu, Jammu and Kashmir, India

R Puniya
Division of Agronomy, SKUAST-Jammu, Jammu and Kashmir, India

Naresh Kumar Yadav
Division of Soil Science and Agriculture Chemistry, SKUAST-Jammu, Jammu and Kashmir, India

Sunita Jhajhra
Collage of Horticulture and Forestry-Jhalawar, Rajasthan, India

Ramesh Chand Bana
Krishi Vigyan Kendra, Delhi, India

Ranjeet Singh Bochalya
Division of Agronomy, SKUAST-Jammu, Jammu and Kashmir, India

Rakesh Kumar Choudhary
Division of Agronomy, SKUAST-Jammu, Jammu and Kashmir, India

Shesh Narayan Kumawat
Division of Agronomy, SKUAST-Jammu, Jammu and Kashmir, India

Corresponding Author:
Raj Singh Choudhary
Division of Soil Science and Agriculture Chemistry, SKUAST-Jammu, Jammu and Kashmir, India

Effect of organic manures and boron application on growth parameter of mustard (*Brassica juncea* L.)

Raj Singh Choudhary, AK Mondal, Vikas Sharma, R Puniya, Naresh Kumar Yadav, Sunita Jhajhra, Ramesh Chand Bana, Ranjeet Singh Bochalya, Rakesh Kumar Choudhary and Shesh Narayan Kumawat

Abstract
A field experiment was conducted at research farm of Sher-e-Kashmir University of Agriculture Sciences and Technology of Jammu to study the effect of organic manures and boron application on soil properties and yield of mustard (*Brassica juncea* L.) during the two successive *Rabi* seasons 2018-19 and 2019-20. The treatment comprises of three levels of organic manures *viz.*, OM_0 (control), OM_2 (10 t ha^{-1} FYM), OM_3 (5 t ha^{-1} FYM + VC 2.5 t ha^{-1}) and four levels of boron i.e. B_0 (control), B_{S-5} (soil application 5 kg borax ha^{-1}), B_{S-10} (soil application 10 kg borax ha^{-1}), $B_{F-0.1}$ (foliar spray 0.1% Boric acid solution), $B_{F-0.2}$ (foliar spray 0.2% Boric acid solution) constituting 15 treatment combinations replicated thrice in factorial randomized block design. Results indicated that higher plant height (24.78 cm, 125.03 cm and 221.61 cm of pooled mean, at 30, 60, and at harvest) was recorded under OM_3 (5 t ha^{-1} FYM + VC 2.5 t ha^{-1}) + B_{S-10} (soil application 10 kg borax ha^{-1}).

Keywords: Mustard, organic manures, boron and plant height

1. Introduction
Oilseeds have prestigious place in Indian agriculture next to cereals. Mustard occupies an important position among oilseed crops grown in India. Mustard (*Brassica spp*.) belongs to family *Brassicaceae* occupies about 23% area and 14.6% production in India (Kumar *et al*., 2016) [4]. Rapeseed mustard is a major oilseed crop of *Rabi* season in temperate and sub-tropical parts of Jammu and Kashmir. It is grown on area of 55236 ha with an annual productivity of 699 kg ha^{-1}, which is less than 37.72 percent of world productivity and 67.85 per cent of national productivity, while in Jammu province, the total area under rapeseed-mustard crop is about 11241 ha. Boron is an essential micronutrient responsible for growth and development of crop plants, including mustard. Boron plays a vital role in the cell division, synthesis of mustard oil and protein. The lack of boron in the soil hampered fruit development and flowering. Apart from major plant nutrients, boron plays a significant role in the phenology of mustard production and this crop responds to boron applications (Karthikeyan and Shukla, 2011) [3]. Boron deficiency in soils is major problem in cultivation of oil seed crops and about one million ha of land has boron deficiency problem causing low yield of oil seeds (Islam *et al*., 1999) [2].

2. Material and Methods
2.1 Description of experimental site
The experiment of this investigation was conducted in the experimental field of the Division of Soil Science and Agriculture Chemistry, SKUAST-Jammu, Chatha. The experimental site located at 32^0- 40^0, North latitude and 74-58^0, East longitude with an altitude of 332 meters above means sea level in the Shiwalik foothills of North-Western Himalayas.

2.2 Climate and weather conditions
The experimental site falls under low altitude sub tropical zone and has hot dry summer and cold winter. The maximum temperature rises up to 45^0 C and minimum temperature goes down to 4-5^0 C. The mean annual rainfall ranges between 1000-1200 mm and large part of it was received during rainy season (July-September). Meteorological observations were recorded at weekly maximum and minimum temperature, rainfall, relative humidity from October to March, in 2018-19 and 2019-20 from Agrometerological section, Division of Agronomy, Faculty of Agriculture, SKUAST-Jammu.

2.3 Soil characteristics

The processed samples thoroughly mixed and brought to the laboratory for analysis in the Division of Soil Science and Agricultural Chemistry, SKUAST-Jammu to evaluate physio-chemical characteristics of the soil during experimentations. The results has been presented in table 1. showed that the soil was sandy clay loam in texture, slightly alkaline in reaction, poor in carbon with low available nitrogen, phosphorus, potassium and boron content.

Table 1: Physico-chemical properties of the experimental soil

S. No.	Soil properties	Value
1	pH(1:2.5)	7.85
2	EC (1:2.5) dS m^{-1}	0.40
3	Bulk density (Mg m^{-3})	1.44
4	Organic Carbon (g kg^{-1})	3.5
5	Cation exchange capacity (cmol(p^{+}) kg^{-1})	18.62
6	Available nitrogen (kg ha^{-1})	218.00
7	Available phosphorus (kg ha^{-1}), P_2O_5	12.73
8	Available potassium (kg ha^{-1}), K_2O	213.60
9	Available boron (mg kg^{-1})	0.30
10	Mechanical composition (per cent)	
a)	Sand	72.69
b)	Silt	6.88
c)	Clay	20.43
d)	Textural class	Sandy clay loam

2.4 Experiment detail

An experiment was laid out to assess the response of mustard *cv*. "RSPR-01" to graded levels of B along with organic manures. The treatment comprises of 4 levels of B kg ha^{-1} applied through borax and boric acid, 2 levels of organic manures (FYM @10 t ha^{-1} and FYM + Vermicompost 5 t ha^{-1} + 2.5 t ha^{-1}) constituting 15 treatment combinations replicated thrice in Factorial RBD. Experiment was carried out for the two consecutive years of 2018-19 and 2019-20.

Table 2: Experiment detail

1	Test crop	Mustard (*cv*.RSPR-01)
2	Seed rate	4 kg ha^{-1}
3	Spacing	45 x 15 cm
4	Organic manures	Two levels:(FYM @10 t ha^{-1} and FYM + Vermicompost 5 t ha^{-1} + 2.5 t ha^{-1})
5	Boron	Four levels in the form of borax and boric acid: (5,10 borax kg ha^{-1} and 0.1%, 0.2% boric acid solution)
6	Soil	Light textured soil (sandy clay loam)
7	Source of Fertilizers	Organic manures and B-Borax and Boric acid
8	Statistical design	Factorial Randomized Block Design (FRBD)
9	Replications	Three
10	Treatments	15
11	Total no. of Plots	45
12	Irrigation	As and when required
13	Harvesting	At maturity

2.5 Treatment details

Apart from different levels of B, the other nutrients of N, P, and K were added in accordance with the recommended doses of fertilizers for mustard, as per package of practices SKUAST Jammu.

Table 3: Treatment combinations with notation

Notation	Symbol	Treatment Details
T_1	OM_0B_1	Control
T_2	OM_0B_2	Soil application 5 kg ha^{-1} (Borax)
T_3	OM_0B_3	Soil application 10 kg ha^{-1} (Borax)
T_4	OM_0B_4	Foliar spray 0.1% (Boric acid)
T_5	OM_0B_5	Foliar spray 0.2% (Boric acid)
T_6	OM_2B_1	FYM 10 t ha^{-1}
T_7	OM_2B_2	FYM 10 t ha^{-1}+ soil application 5 kg ha^{-1} (Borax)
T_8	OM_2B_3	FYM 10 t ha^{-1}+ soil application 10 kg ha^{-1} (Borax)
T_9	OM_2B_4	FYM 10 t ha^{-1}+ Foliar spray 0.1% (Boric acid)
T_{10}	OM_2B_5	FYM 10 t ha^{-1}+ Foliar spray 0.2% (Boric acid)
T_{11}	OM_3B_1	FYM 5 t ha^{-1}+ VC 2.5 t ha^{-1}
T_{12}	OM_3B_2	FYM 5 t ha^{-1} + VC 2.5 t ha^{-1}+ Soil application 5 kg ha^{-1} (Borax)
T_{13}	OM_3B_3	FYM 5 t ha^{-1}+ VC 2.5 t ha^{-1}+ Soil application 10 kg ha^{-1} (Borax)
T_{14}	OM_3B_4	FYM 5 t ha^{-1}+ VC 2.5 t ha^{-1}+ Foliar spray 0.1%(Boric acid)
T_{15}	OM_3B_5	FYM 5 t ha^{-1}+ VC 2.5 t ha^{-1}+ Foliar spray 0.2%(Boric acid)

2.6 Seed treatment and sowing
Crop seeds were treated with SAAF (Carbendazim + Mancozeb) @ 2 g kg^{-1} seed before sowing to protect the crops from seed borne diseases. Thus the healthy and clean mustard seeds were used for sowing. Furrows were opened with the help of kudal maintaining 45 cm row spacing and seeds were sown at about 4-5 cm depth. The seed rate was 4 kg ha^{-1}.

2.7 Treatment application
2.7.1 Organic manures
Well rotten FYM @ 10 t ha^{-1} and vermicompost 2.5 t ha^{-1} was added 15 days ahead of treatment application. The quantity of farmyard manure and vermicompost was uniformly spread at the time of bed preparation in manner of treatment-wise and then thoroughly mixed.

2.7.2 Boron (B)
Boron was applied through Borax (10.81% B) in soil application and foliar application of Boric acid (17%) in accordance with the treatment. Requisite quantity of borax was mixed with some amount of soil to make it more voluminous and then applied in respective plots through broadcasting.

2.8 Thinning
Desired plant population in mustard was maintained by thinning of extra plants in two steps at 14 and 21 DAS during both the year of experiments.

2.9 Weed management
Hand weeding was done at an interval of two weeks during both the years of experimentation. This practice was sufficient to keep weeds under control.

2.10 Plant height
The plant height was measured at 30, 60 DAS and at harvest with a meter scale from the ground level to the top of the plants and the mean height was expressed in cm. Plant height were recorded as the average of 5 plants selected at random from the inner rows of each plot.

2.11 Statistical analysis
Descriptive statistical analysis, includes mean value, maximum and minimum values, for the data were used. And, the analysis was done through statistical software SPSS 14.0. For presenting the study results, tables and graphs (bar and line) are the important tools were also used to make the data intuitively understand and graphical representations in the succeeding chapter. The data recorded for experimental area was tabulated and analysed statistically in factorial RBD as per the procedure.

3. Result
3.1 Plant height at 30 DAS
The data pertaining to the effect of organic manure and boron applications on plant height at 30 DAS is presented in table 4. The data indicated that, higher plant height at 30 DAS (23.55 cm) was recorded under B_{S-10} during 2018-19 which was significantly higher as compared to B_0 (19.17 cm), B_{S-5} (21.60 cm) and $B_{F-0.1}$ (22.15 cm), while it was statistically at par with $B_{F-0.2}$ (22.44 cm). Treatment B_0 recorded (21.26 cm) plant height, which was statistically at par with B_{S-5} (24.00 cm), $B_{F-0.1}$ (24.16 cm) and $B_{F-0.2}$ (24.70 cm).
In pooled data, the higher plant height (24.78 cm) was recorded under B_{S-10}, which was significantly higher as compared to B_0 (20.22 cm), B_{S-5} (22.80 cm) and $B_{F-0.1}$ (23.16 cm) but statistically at par with $B_{F-0.2}$ (23.57 cm).
Among organic manures, the higher plant height was recorded under OM_3 (23.13 cm) during 2018-19, 25.77 cm during 2019-20 and 24.45 cm in pooled data, which was significantly higher as compared to OM_0 (20.49 cm), OM_2 (21.73 cm) during 2018-19, OM_0 (22.37 cm), OM_2 (23.81 cm) during 2019-20 and OM_0 (21.43 cm) and OM_2 (22.84 cm) in pooled data. There was 12.88% (2018-19), 15.19% (2019-20) and 14.09% increase in pooled data over OM_0 treatment.
The interaction effect between organic manures and boron application on plant height at 30 DAS of mustard was found non-significant during both the years 2018-19 and 2019-2020 and same trend was noticed in pooled data.

3.2 Plant height at 60 DAS
The data pertaining to the effect of organic manures and boron applications on plant height at 60 DAS were summarized in table 5. The data indicated that, the higher plant height (123.84 cm) was recorded under B_{S-10} during 2018-19 which was significantly higher as compared to B_0 (117.40 cm) but statistically at par with B_{S-5} (120.53 cm), $B_{F-0.1}$ (121.87 cm) and $B_{F-0.2}$ (122.78 cm). During 2019-20, the higher value recorded under B_{S-10} (126.22 cm) which was significantly higher as compared to B_0 (121.22 cm) but statistically at par with B_{S-5} (123.22 cm), $B_{F-0.1}$ (124.22 cm) and $B_{F-0.2}$ (124.78 cm).
The pooled data revealed that higher plant height (125.03 cm) was recorded under B_{S-10}, which was significantly higher as compared to B_0 (119.31 cm) and B_{S-5} (121.88 cm) but statistically at par with $B_{F-0.1}$ (123.04 cm) and $B_{F-0.2}$ (123.78 cm).
In organic manures, the higher plant height was recorded under OM_3 (123.76 cm) during 2018-19, (125.60 cm) during 2019-20 and (124.68 cm) in pooled data which was significantly higher as compared to OM_0 (118.51 cm) during 2018-19, OM_0 (122.27 cm) during 2019-20 and OM_0 (120.39 cm) in pooled data which was statistically at par with OM_2 (121.59, 123.93 and 122.76 cm) during 2018-19, 2019-20 and in pooled data, respectively. The interaction effect between organic manures and boron application on plant height of mustard at 60 DAS was found non-significant during both the years and same trend was observed in pooled data of two years as well.

3.3 Plant height at harvest
The data pertaining to the effect of organic manures and boron applications on plant height at harvest were summarized in table 6. The higher plant height (219.56 cm) was recorded under B_{S-10} during 2018-19 which was significantly higher as compared to B_0 (208.91 cm) but statistically at par with B_{S-5} (213.73 cm), $B_{F-0.1}$ (218.07 cm) and $B_{F-0.2}$ (218.84 cm) and during 2019-20, the highest value recorded under B_{S-10} (232.67 cm) which was significantly higher as compared to B_0 (220.56 cm) but statistically at par with B_{S-5} (226.56 cm), $B_{F-0.1}$ (228.11 cm) and $B_{F-0.2}$ (229.67 cm). There was 22.84% (2018-19), 22.34% (2019-20) and 22.55% (pooled data) increase in B_{S-10} over B_0 treatment.
In pooled data, the highest value (226.11 cm) was recorded under B_{S-10}, which was significantly higher as compared to B_0 (214.73 cm) but statistically at par with B_{S-5} (220.14 cm), $B_{F-0.1}$ (223.09 cm) and $B_{F-0.2}$ (224.26 cm).
In case of organic manures treatments, the highest value was

recorded under OM_3 (219.03 cm) during 2018-19, 232.13 cm during 2019-20 and 225.58 cm in pooled data which was significantly higher as compared to OM_0 (211.95 cm) during 2018-19, OM_0 (222.27 cm) during 2019-20 and OM_0 (217.11 cm) in pooled data, but statistically at par with OM_2 (216.49, 228.13 cm and 222.31 cm) during 2018-19, 2019-20 and in pooled data, respectively.

The interaction effect between organic manures and boron applications on plant height of mustard at harvest was found non-significant during both the years and same trend was observed in pooled data of two years.

Table 4: Effect of organic manures and boron application on plant height (cm) at 30 DAS of mustard

Micro-nutrient (Boron)	2018-19				2019-20				Pooled mean			
	OM_0	**OM_2**	**OM_3**	**Mean**	**OM_0**	**OM_2**	**OM_3**	**Mean**	**OM_0**	**OM_2**	**OM_3**	**Mean**
B_0	16.89	19.46	21.17	19.17	19.23	21.06	23.51	21.26	18.06	20.26	22.34	20.22
B_{S-5}	20.99	21.26	22.55	21.60	22.35	24.56	25.08	24.00	21.67	22.91	23.82	22.80
B_{S-10}	22.30	23.08	25.27	23.55	24.07	25.26	28.69	26.01	23.19	24.17	26.98	24.78
$B_{F-0.1}$	21.01	22.30	23.15	22.15	23.04	24.27	25.16	24.16	22.03	23.29	24.16	23.16
$B_{F-0.2}$	21.26	22.54	23.51	22.44	23.15	24.57	26.39	24.70	22.20	23.56	24.95	23.57
Mean	20.49	21.73	23.13		22.37	23.94	25.77		21.43	22.84	24.45	
Factors	CD (5%)				CD (5%)				CD (5%)			
OM	1.05				1.94				1.25			
B	1.36				2.50				1.62			
OM x B	NS				NS				NS			

* OM_0-Control, OM_2-FYM 10 t ha^{-1}, OM_3-FYM 5 t ha^{-1}+VC 2.5 t ha^{-1}, B_0-Control, B_{S-5}-Soil application 5 kg borax ha^{-1}, B_{S-10}-Soil application 10 kg borax ha^{-1}, $B_{F-0.1}$-Foliar spray 0.1% boric acid solution, $B_{F-0.2}$-Foliar spray 0.2% boric acid solution.

Table 5: Effect of organic manures and boron application on plant height (cm) at 60 DAS of mustard

Micro-nutrient (Boron)	2018-19				2019-20				Pooled mean			
	OM_0	**OM_2**	**OM_3**	**Mean**	**OM_0**	**OM_2**	**OM_3**	**Mean**	**OM_0**	**OM_2**	**OM_3**	**Mean**
B_0	115.13	117.47	119.60	117.40	119.67	121.67	122.33	121.22	117.40	119.57	120.97	119.31
B_{S-5}	118.20	120.73	122.67	120.53	122.00	123.67	124.00	123.22	120.10	122.20	123.33	121.88
B_{S-10}	120.27	124.27	127.00	123.84	123.67	125.67	129.33	126.22	121.97	124.97	128.17	125.03
$B_{F-0.1}$	119.00	122.33	124.27	121.87	123.33	124.00	125.33	124.22	121.17	123.17	124.80	123.04
$B_{F-0.2}$	119.93	123.13	125.27	122.78	122.67	124.67	127.00	124.78	121.30	123.90	126.13	123.78
Mean	118.51	121.59	123.76		122.27	123.93	125.60		120.39	122.76	124.68	
Factors	CD (5%)				CD (5%)				CD (5%)			
OM	3.35				2.54				2.25			
B	4.33				3.27				2.90			
OM x B	NS				NS				NS			

* OM_0-Control, OM_2-FYM 10 t ha^{-1}, OM_3-FYM 5 t ha^{-1}+VC 2.5 t ha^{-1}, B_0-Control, B_{S-5}-Soil application 5 kg borax ha^{-1}, B_{S-10}-Soil application 10 kg borax ha^{-1}, $B_{F-0.1}$-Foliar spray 0.1% boric acid solution, $B_{F-0.2}$-Foliar spray 0.2% boric acid solution.

Table 6: Effect of organic manures and boron application on plant height (cm) at harvest of mustard

Micro-nutrient (Boron)	2018-19				2019-20				Pooled mean			
	OM_0	**OM_2**	**OM_3**	**Mean**	**OM_0**	**OM_2**	**OM_3**	**Mean**	**OM_0**	**OM_2**	**OM_3**	**Mean**
B_0	204.73	209.33	212.67	208.91	209.33	211.67	213.67	211.56	207.03	210.50	213.17	210.23
B_{S-5}	210.00	214.67	216.53	213.73	213.33	218.33	221.00	217.56	211.67	216.50	218.77	215.64
B_{S-10}	215.60	220.40	222.67	219.56	216.00	226.33	228.67	223.67	215.80	223.37	225.67	221.61
$B_{F-0.1}$	214.40	218.53	221.27	218.07	213.67	218.67	225.00	219.11	214.03	218.60	223.13	218.59
$B_{F-0.2}$	215.00	219.53	222.00	218.84	214.00	220.67	227.33	220.67	214.50	220.10	224.67	219.76
Mean	211.95	216.49	219.03		213.27	219.13	223.13		212.61	217.81	221.08	
Factors	CD (5%)				CD (5%)				CD (5%)			
OM	5.68				6.12				5.17			
B	7.34				7.90				6.67			
OM x B	NS				NS				NS			

* OM_0-Control, OM_2-FYM 10 t ha^{-1}, OM_3-FYM 5 t ha^{-1}+VC 2.5 t ha^{-1}, B_0-Control, B_{S-5}-Soil application 5 kg borax ha^{-1}, B_{S-10}-Soil application 10 kg borax ha^{-1}, $B_{F-0.1}$-Foliar spray 0.1% boric acid solution, $B_{F-0.2}$-Foliar spray 0.2% boric acid solution.

4. Discussion

Plant height was significantly affected at 30, 60 DAS at harvest of mustard by the application of organic manure and boron levels. The highest plant height at 30, 60 DAS at harvest obtained with B_{S-10} (soil application 10 Kg Borax ha^{-1}) and OM_3 (FYM 5 t ha^{-1} + VC 2.5 t ha^{-1}). Our result are in agreement with the results of Verma *et al*. (2012) [9] who reported application of boron increased the activity of merismetic tissue resulting in increase in plant height and cell elongation, however boron also helps in cell elongation, photosynthesis and translocation of photosynthates in plants. Sharma *et al*. (2020) [7] revealed that application of FYM and vermicompost along with boron increased the plant height, as boron will enhance the uptake of nutrients as compared to the other manures application. Increase in plant height with organic sources might be due to higher nutrient supply, rapid conversion of carbohydrates in to protein which in turn elaborated in to protoplasm and nitrogen increased in size of cell, which expressed morphologically increased in plant height (Kumar *et al*. 2018) [5]. The balanced application of organic manures made higher nutrients available to the plants that resulted in maximum plant height (Murali *et al*. 2018,

Yadav *et al*., 2013 and Tomar *et al*., 2007) [6, 8, 10]. Hussion *et al*. (2008) also reported that boron treated plants resulted in maximum height.

5. Conclusion

On the basis of the experimental findings, it may be concluded that application of organic manures and boron increase the plant height of mustard. Boron is important elements in sustaining growth of mustard. The best treatment combination was application of OM_3 (5 t ha^{-1} FYM + 2.5 t ha^{-1} vermicompost) along with B_{S-10} (Soil application 10 kg borax ha^{-1}) which recorded best results with respect to plant height at 30, 60 DAS and at harvest. Thus the application of these treatments in deficient areas is recommended to increase the growth of mustard in the region.

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