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Effect of organic manures and boron application on nitrogen, phosphorus, potassium and boron content in soil

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Abstract
The present investigation was conducted with an aim to determine the effect of organic manures and boron application on available nutrient status of soil. The experiment was lay out in factorial randomized block design with three sources of organic manures and two methods of application of boron with four levels of boron replicated thrice at experimental field, Division of Soil Science and Agricultural Chemistry, SKUAST-Jammu, Chatha during *rabi* season in the consecutive years 2018-19 and 2019-20. Three sources 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}) with four levels of boron i.e. B_1 (control), B_2 (soil application 5 kg borax ha^{-1}), B_3 (soil application 10 kg borax ha^{-1}), B_4 (foliar spray 0.1% boric acid solution) and B_5 (foliar spray 0.2% boric acid solution). Results revealed that the significantly higher available nitrogen (243.02 kg ha^{-1}, 245.55 kg ha^{-1} and 244.29 kg ha^{-1}) and available phosphorus 14.95 kg ha^{-1} and 15.99 kg ha^{-1} were observed under OM_3 (FYM 5 t ha^{-1} + VC 2.5 t ha^{-1}) during 2018-19 and 2019-20, respectively and even the same trend was noticed in two year of pooled data. Further, the highest available potassium 120.51 kg ha^{-1} and 121.70 kg ha^{-1} was observed under OM_3 (FYM 5 t ha^{-1} + VC 2.5 t ha^{-1}) during both the years (2018-19 and 2019-20) and also in pooled data. The highest interaction value of available boron at harvest of mustard 0.53 mg kg^{-1} was found under OM_3 (FYM 5 t ha^{-1} + VC 2.5 t ha^{-1}) along with B_{S-10} (Soil application 10 Kg Borax ha^{-1}) during 2018-19 and 0.75 mg kg^{-1} during 2019-20 and 0.64 mg kg^{-1} in pooled data which were significantly higher as compare to control and other application of organic manures and boron application.

Keywords: Organic manures, nitrogen, phosphorus, potassium, and boron

Introduction
India is emerged as one of the largest rapeseed mustard grower worldwide, occupying the first position in area (6.07 million hectare) and third position in production (7.41 million tone), accounting for about 12 per cent of the world's total rapeseed mustard seed and about 8.5 per cent of the world's total rapeseed-mustard oil which often experimental boron deficiency problem. Indian mustard accounts for about 75-80 per cent of the under these crops in the country during 2016-17. In India, average rapeseed-mustard yield is about 1145 kg ha^{-1} as compared to the combined oilseeds crops average of 1135 kg ha^{-1} in temperate and sub-tropical regions.

Rapeseed-mustard is a major oilseed crop of *Rabi* season in temperate and sub-tropical regions of UT of Jammu and Kashmir occupying a total area of 55236 ha with an annual productivity of 6.99 qt ha^{-1} which is 37.72 per cent of global productivity and 67.85 per cent of national productivity.

Boron is considered as a vital micronutrient in crop production, it is unique among all the other essential mineral elements as it is the only element that is normally present in the soil solution and as no ionized molecule over the pH range suitable for the plant growth and development. The total boron content in soils is 7 mg g^{-1} to 80 mg g^{-1}. The concentration of boron in the soil solution is generally controlled by boron adsorption reactions; as is the amount of water soluble boron available for plant uptake. Boron is involved in the synthesis of mustard oil and protein and responsible for the cell division in plants as fruit development and flowering were restricted by the shortage of boron content in the soil. Several workers have been also reported that the requirement of boron by the crop is affected by the several soil and environmental factors *viz.*, pH, organic matter, adsorption capacity, temperature, light and soil moisture conditions.

Organic matter is an active component in the soils, only a few studies of B-organic matter interaction have been conducted. Humus was found to exhibit chemical affinity for boron and it appears to play an important role in the retention of boron by soils (Parks and White, 1952 and Gu and Lowe, 1990) [20, 8]. Several studies revealed that there a large fraction of the total boron in the soil is associated with the organic matter in tightly bound compounds and that this boron fraction can be released to the soil solution in forms available to plants *via* microbial activity (Berger and Pratt, 1963) [3].

Keeping in view the importance of organic manures and boron, efforts has been made to determine the effect of organic manures and boron on available nutrients status and boron content in the mustard grown soil.

Material and Methods

The experiment was conducted in the experimental field of the Division of Soil Science and Agriculture Chemistry, SKUAST Jammu, Main Campus, Chatha (J&K). The site of experimental was located at 32º-40º, North latitude and 74-58º, East longitude with an altitude of 332 meters above means sea level in the Shiwalik foothills of North-Western Himalayas.

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 45º C and minimum temperature goes down to 4-5º 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. [Source: Agrometeorological section, Division of Agronomy, Faculty of Agriculture, SKUAST-Jammu].

Soil characteristics

Surface soil samples from 0-15 cm depth were collected randomly from four spots of the field prior to start of an experiment. The collected soil samples were mixed together to form respective composite samples and were analyzed by standard procedure given below:

The composite soil sample so obtained was air dried, grinded to pass through 2 mm stainless steel sieve to remove gravel and crop residues. 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 the physico-chemical characteristics of the soil during experimentations. The results showed that the soil was sandy clay loam in texture, slightly alkaline in reaction, poor in carbon with low available nitrogen, phosphorus and potassium content.

Method of Analysis

Available Nitrogen

Available nitrogen was determined by alkaline $KMnO_4$ method (Subbaiah and Asija, 1956) [24] which is based on the extraction of inorganic and readily oxidizable N from organic compounds. The N was extracted with 0.32 per cent $KMnO_4$ and distilled by 2.5 per cent NaOH. The distillation process was carried out by nitrogen analyzer and manual titration was done. The liberated ammonia was absorbed in 2 per cent boric acid, containing bromocresol green and methyl red mixed indicator. The amount of ammonia absorbed was determined titrimetrically using standard H_2SO_4 (0.02 N) till the color flashed from green to pink.

Available phosphorus

Available phosphorus content in soil after mustard harvest was extracted by the method as suggested by Olsen (1954) [16]. The $NaHCO_3$ solution extracts P from Calcium phosphates, some P from Al and Fe phosphates. The soluble phosphate forms heteropoly complexes with molybdate ions librated from ammonium molybdate. The hetero polycomplexes gives faint yellow colour, which on reduction with ascorbic acid gives blue colour. The intensity of blue colour is directly proportional to the concentration of phosphate and read on colorimeter at wavelength of 760 nm using red filter. The concentration of P in soil extract is calculated from the standard curve prepared at same time.

Available potassium

Available potassium content of soil was determined by the method described by Jackson, (1967) [10]. Five gram soil was taken in a 150 ml conical flask and extracted with 25 ml of neutral 1 N ammonium acetate solution. The filtrate was aspirated into the automizer of the calibrated flame photometer and reading was noted. The concentration of potassium in the solution was proportional to the galvanometer reading.

Available boron

The hot water soluble B was extracted using procedure of Berger and Truog (1939) [4] with slight modification of adding dilute electrolyte (0.01M $CaCl_2$) instead of water for B extraction.

Determination of available boron in soil Principle

Azomethine H forms colored complex with H_3BO_3 in aqueous media over a concentration range of 0.5 to 10 mg B ml^{-1}. The complex is stable at pH 5.1. Maximum absorbance occurs at 420 nm with little or no interference from a wide variety of salts. This technique is accurate, rapid, reliable and more convenient to use in comparison to the traditional procedures employing carmine, curcumine or quinalizarin (John *et al.*1975; Parker and Gardner, 1981) [12, 19].

Results and Discussion

Available nitrogen

The data presented in table 1 highlighted that different levels of organic manures recorded significantly higher available nitrogen during both the years 2018-19 and 2019-20 and in pooled data as well compared to control. However, the interaction effect between organic manures and boron application was found to be non-significant during both the years of study and in pooled data. The highest available nitrogen 243.02 kg ha^{-1}, 245.55 kg ha^{-1} and 244.29 kg ha^{-1} was recorded under OM_3 (FYM 5 t ha^{-1} + VC 2.5 t ha^{-1}) as compare to control (219.45 kg ha^{-1}, 221.75 kg ha^{-1} and 220.60 kg ha^{-1}) during 2018-19 and 2019-20, respectively and in pooled data as well and no significant effect was recorded with different levels and method of boron application. The data also showed that the source of boron did not exhibit any substantial change in the accessible nitrogen content of the soil, but did register comparatively higher than the starting values (Kumar *et al*. 2019) [13]. The interaction between boron and nitrogen was also recorded to be positive, although it was statistically non-significant. The significant increase in nitrogen content with the addition of FYM and vermicompost may be attributed to the reason that direct contribution of FYM and vermicompost to the available nitrogen pool and breakdown of organic nitrogenous material, which boosted the microbial population and improved mineralization (Bonde *et al*. 2005) [5]. Furthermore, there have been several instances of soil N levels being greater in FYM-treated soils (Agbenin and Goladi, 1997) [1]. Our results are in conformity with the results of Saviozzi *et al*. (1999) [22] and Murwira and Kirchrnann (1993) [15]. They also reported that application of some organic fertilizers results in a net mobilization of nitrogen in the soil.

Table 1: Effect of organic manures and boron application on available nitrogen (kg ha^{-1}) of mustard soil

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	218.16	223.67	241.86	227.90	220.68	225.85	244.14	230.22	219.42	224.76	243.00	229.06
B_{S-5}	219.33	237.46	244.10	233.63	221.42	238.61	246.55	235.53	220.38	238.04	245.33	234.58
B_{S-10}	220.76	239.00	245.34	235.04	221.95	241.49	248.17	237.20	221.36	240.25	246.76	236.12
$B_{F-0.1}$	219.65	223.72	241.89	228.42	222.10	225.92	244.31	230.77	220.87	224.82	243.10	229.60
$B_{F-0.2}$	219.34	224.04	241.92	228.43	222.61	225.98	244.58	231.06	220.98	225.04	243.25	229.75
Mean	219.45	229.58	243.02		221.75	231.57	245.55		220.60	230.58	244.29	
Factors	CD (5%)				CD (5%)				CD (5%)			
OM	7.10				4.96				4.52			
B	NS				NS				NS			
OM × 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.

Available phosphorus

The data presented in table 2 revealed that the interaction effect between organic manures and boron application on available phosphorus was found non-significant during both the years 2018-19 and 2019-2020 and the same trend was observed in pooled data of the two years of study. The different levels of organic manures recorded significantly higher available phosphorus during both the years 2018-19 and 2019-20 and in pooled data of experimentations as compared to control. Higher available phosphorus 14.95 kg ha^{-1} and 15.99 kg ha^{-1} was recorded with OM_3 (FYM 5 t ha^{-1} + VC 2.5 t ha^{-1}) during 2018-19 and 2019-20, respectively. The same trend was noticed in two year of pooled data. No significant difference was recorded with different levels and methods of boron application. The data on available phosphorus in soil also showed that the sources of boron did not showed significant effect on available phosphorus content in the soil but registered relatively higher than initial values (Kumar *et al*., 2019) [13] but the status of available phosphorus, significantly influenced by the different treatments of organic manures OM_3 (FYM 5 t ha^{-1} + VC 2.5 t ha^{-1}) and OM_2 (FYM 10 t ha^{-1}). The increase in available phosphorus content was attributed to the mineralization of organic phosphorus, which has contributed its accumulation in the soil (Vig and Bhumla, (1990) [25]. The similar results were also reported by Basak *et al*. (1990) [2] who reported that an increase in the available phosphorous might be attributed to organic manure, which might have helped in releasing of higher amount of phosphorous from the soil. Manure also helps in producing intermediate compounds that interact with phosphorus-fixing cations thereby reducing phosphorous adsorption capacity. Our results are in conformity with results of Palm *et al*. (1997), Hati *et al*. (2006) and Das *et al*. (2010) [18, 9, 6].

Table 2: Effect of organic manures and boron application on available phosphorus (kg ha^{-1}) of mustard soil

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	12.75	13.21	14.94	13.63	13.52	13.98	15.97	14.49	13.13	13.60	15.46	14.06
B_{S-5}	12.88	13.33	15.00	13.74	13.56	14.16	16.23	14.65	13.22	13.75	15.62	14.20
B_{S-10}	12.92	13.19	15.04	13.72	13.70	13.97	16.43	14.70	13.31	13.58	15.73	14.21
$B_{F-0.1}$	12.85	13.32	14.81	13.66	13.63	14.11	15.58	14.44	13.24	13.72	15.19	14.05
$B_{F-0.2}$	12.74	13.18	14.97	13.63	13.53	13.96	15.74	14.41	13.14	13.57	15.35	14.02
Mean	12.83	13.25	14.95		13.59	14.04	15.99		13.21	13.64	15.47	
Factors	CD (5%)				CD (5%)				CD (5%)			
OM	0.78				0.72				0.73			
B	NS				NS				NS			
OM × 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.

Available potassium

As evident from the data presented in table 3 that the interaction effect between organic manures and boron application on available potassium was found to be non-significant during both the years 2018-19 and 2019-2020 and the same trend was recorded in pooled data of two years of the study. However, the highest available potassium was observed ranging from 115.86 kg ha^{-1} to 120.51 kg ha^{-1} during 2018-19 and 117.59 kg ha^{-1} to 121.70 kg ha^{-1} during 2019-20 and 116.72 kg ha^{-1} to 121.10 kg ha^{-1} in pooled data under organic manure treatments as compared to control (114.06 kg ha^{-1}, 115.10 kg ha^{-1} and 114.58 kg ha^{-1}, respectively and no significant difference was recorded under different levels and method of boron application. However, there was increase in soil available potassium over the initial values under B_{S-10} (soil application 10 kg borax ha^{-1}). The value of potassium content in soil enhanced with increasing boron doses (Kumar *et al*., 2019) [13]. Non-significant effects of organic manures on available potassium content also corroborate with the findings of Dhaker *et al*. (2013) [7].

Table 3: Effect of organic manures and boron application on available potassium (kg ha^{-1}) of mustard soil

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	113.63	115.96	118.41	116.00	114.95	116.61	119.60	117.05	114.19	116.28	119.00	116.53
B_{S-5}	114.23	116.05	122.66	117.65	115.13	118.31	124.04	119.16	114.68	117.18	123.35	118.41
B_{S-10}	114.31	116.77	123.93	118.34	115.84	118.96	125.46	120.09	115.07	117.87	124.70	119.21
$B_{F-0.1}$	113.96	115.15	118.72	115.94	114.72	116.42	119.51	116.88	114.34	115.79	119.11	116.41
$B_{F-0.2}$	114.16	115.35	118.82	116.11	114.83	117.66	119.90	117.46	114.50	116.50	119.36	116.79
Mean	114.06	115.86	120.51		115.10	117.59	121.70		114.58	116.72	121.10	
Factors	CD (5%)				CD (5%)				CD (5%)			
OM	NS				NS				NS			
B	NS				NS				NS			
OM × 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.

Available boron

The presented data in table 4 that the interaction effect between organic manures and boron application on available boron in soil at harvest was found significant during both the years (2018-19 & 2019-2020) and the same trend was observed in pooled data of two years. In case of organic manures application the highest mean value 0.42 mg kg^{-1} during 2018-19, 0.63 mg kg^{-1} during 2019-20 and 0.52 mg kg^{-1} in pooled data under OM_3 (FYM 5 t ha^{-1}+ VC 2.5 t ha^{-1}) which was significantly higher as compare to OM_0 (Control) and OM_2 (FYM 10 t ha^{-1}). However, in case of boron application, the highest mean value 0.46 mg kg^{-1} during 2018-19, 0.65 mg kg^{-1} during 2019-20 and 0.56 mg kg^{-1} in pooled data under B_{S-10} (Soil application 10 Kg Borax ha^{-1}) which was significantly higher as compare to B_0 (Control), B_{S-5} (Soil application 5 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), respectively.

Table 4: Effect of organic manures and boron application on boron content in soil at harvest (mg kg^{-1})

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	0.29	0.32	0.36	0.32	0.31	0.37	0.41	0.36	0.30	0.34	0.38	0.34
B_{S-5}	0.34	0.40	0.48	0.41	0.40	0.51	0.59	0.50	0.37	0.45	0.54	0.45
B_{S-10}	0.40	0.45	0.53	0.46	0.57	0.64	0.75	0.65	0.49	0.54	0.64	0.56
$B_{F-0.1}$	0.30	0.33	0.36	0.33	0.36	0.38	0.40	0.38	0.33	0.32	0.35	0.34
$B_{F-0.2}$	0.30	0.35	0.37	0.34	0.36	0.39	0.42	0.39	0.33	0.34	0.37	0.35
Mean	0.33	0.37	0.42		0.40	0.46	0.52		0.36	0.40	0.46	
Factors	CD (5%)				CD (5%)				CD (5%)			
OM	0.023				0.025				0.017			
B	0.030				0.032				0.022			
OM x B	0.052				0.055				0.038			

* 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.

The highest interaction value of available boron 0.53 mg kg^{-1} was found under OM_3 (FYM 5 t ha^{-1}+ VC 2.5 t ha^{-1}) along with Bs-10 (Soil application 10 Kg Borax ha^{-1}) during 2018-19 and 0.75 mg kg^{-1} during 2019-20 and 0.64 mg kg^{-1} in pooled data which were significantly higher as compare to control and other application of organic manures and boron application. This might be explained partly by the use of organic manures, exhibiting a positive role in releasing boron content in the soil solution (Bose *et al*. 2002) and the application of different doses of boron fertilizer which easily comes into the available boron pool (Kumar *et al*. 2019) [13] or may be attributed to increase availability in soil as a results of boron sources addition (Singh *et al*. 2017, Jaiswal *et al*. 2015) [23, 11]. The applied organic manures may help towards minimizing loss of boron from the soil and the same times maintain boron in a reasonably extractable form (Mandal and Das 2011). Pakrashi and Haldar (1992) and Sakal (2001) [14, 17, 21] also reported that the application of organic matter to B deficient soil increased the utilization and recovery of applied B by maintaining relatively higher proportion of B in the soils and the extent of increase was more with increasing levels of organic matter.

Conclusion

On the basis of results obtained in the present investigation it can be concluded that 5 t ha^{-1} FYM + 2.5 t ha^{-1} vermicompost recorded to be best treatment for enhancing the available nitrogen, available phosphorus and available potassium at the harvest of mustard. However, 5 t ha^{-1} FYM + 2.5 t ha^{-1} vermicompost along with 10 kg borax ha^{-1} showed a significant influence on the available boron at the harvest of mustard crop.

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