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Effect of nutrient management on yield and nutrient uptake by Indian mustard (*Brassica juncea* L)

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Abstract
A field experiment was conducted during *rabi* season, 2015-16 to study the Effect of nutrient management on yield and nutrient uptake by Indian mustard (*Brassica juncea* L.) varietyPusa Bold at Crop Research Centre Chirori, Meerut. The soil of experimental field was sandy loam texture, alkaline in nature with pH (8.2), low in organic carbon, available nitrogen, phosphorus, potassium,sulphur, zincand boron.Twelve treatments in different nutrient management practices consisting Control,100% NPK, 100% NPK+20 kg S ha^{-1}, 100% NPK+40 kg S ha^{-1}, 100% NPK+1.5 kg B ha^{-1}, 100% NPK+20 kg Zn ha^{-1}, 100% NPK+20 kg S ha^{-1}+1.5kg B ha^{-1}, 100% NPK+20 kg S ha^{-1}+20 kg Zn ha^{-1}, 100% NPK+40 Kg S ha^{-1}+1.5 kg B ha^{-1}, 100% NPK+40 kg S ha^{-1}+20 kg Zn ha^{-1}, 100% NPK+20 kg S ha^{-1}+1.5 kg B ha^{-1}+20 kg Zn $ha^{-1}$and 100% NPK+40 kg S ha^{-1}+1.5 kg B ha^{-1}+20 kg Zn ha^{-1} were tested in randomized block design with three replication.The experimental results revealed that significantly higher yield (grain and stover),nutrient uptake(N,P, K, S, Zn and B) by grain and stoverwere noticed with the application of 100% NPK+40 kg S+1.5 B+20 kg Zn ha^{-1} as compared to rest of the treatments.

Keywords: Mustard, Nutrient uptake

Introduction
Mustard (*Brassica juncea* L.) belonging to the family cruciferae is one of the important oilseed crops and currently ranked as the world's third important oil seed crop in terms of production and area. Among the seven edible oilseed cultivated in India, mustard contributes 28.6% towards the total oilseed production, being the second most important edible oilseed after groundnut. The share of oilseeds is 14.1% in the total cropped area of India and mustard accounts for 3% of it. The global production of mustard and its oil is around 38-42 and 12-14 mt, respectively. India contributes 28.3 and 19.8% in world acreage and production. India produces around 6.9 mt of rapeseed-mustard next to China (11-12 mt) and EU (10-13 mt) with significant contribution in world mustard industry (Anonymous, 2014) [1]. By 2050, India needs to produce 17.84 million tonnes of vegetable oils for its nutritional fat requirement of projected 1685 millions population. Thus, enhancing the productivity of oilseeds is imperative for self-reliance.

The productivity of mustard and other oilseed crops is low. Oil seed production often suffers from a high degree of variation in annual production owing to their predominant cultivation under imbalance nutrient situation. The situation is further handicapped by input starved conditions with poor crop management. Oilseeds are energy rich crops and obviously the requirement of major nutrients is very high. Improving efficiency and factor productivity under complexities of diminishing quantity response and increasing eco-awareness is critical for sustainable oilseed production. Nitrogen is the most important nutrient, which determines the growth of the mustard crop and increases the amount of protein and yield. Phosphorus and potash are known to be efficiently utilized in the presence of nitrogen. It promotes flowering, setting of siliquae and increase the size of siliquae and yield (Singh and Meena, 2004) [10]. Sulphur is a crucial element for rapeseed-mustard in determining its seed yield, oil content, quality and resistance to various biotic and abiotic stresses. Besides promoting chlorophyll formation and oil synthesis, it is an important constituent of seed protein, amino acids, various enzymes and glucosinolate. Sulphur increases the seed yield of mustard by 12 to 48% under irrigated and 17 to 124% under rainfed conditions. (Rathore *et al.*, 2015) [9]. The favourable influence of zinc application on yield of mustard may be attributed to its role in various enzymatic reactions, growth processes, hormone production and protein synthesis and also the translocation of photosynthates to seed thereby leading to higher seed yield (Bhadauria *et al.*, 2012) [2]. Boron helps to maintain balance between sugar and starch, translocation of sugar and carbohydrates, pollination and seed reproduction, cell division, nitrogen metabolism, protein formation as well as cell wall formation etc. (Trivedi, 2015) [11].

Plant nutrients, having crucial role in plant metabolism, largely influence growth, development and quality of farm produce. Nutrients like nitrogen, phosphorus and potassium are needed in large quantities by the plants and their addition through external sources is governed by soil supplying capacity, crop requirement, environment and management. Accordingly, differential behaviour in terms of crop response to added nutrients have been noted across the globe. Continuous use of high analysis fertilizers led to deficiency of secondary and micro nutrients particularly S, Zn, B etc.

Methodology

The field experiment was conducted during *rabi* season, 2015-16 to study the Effect of nutrient management on yield and nutrient uptake by Indian mustard (*Brassica juncea* L.) varietyPusa Bold at Crop Research Centre Chirori, Meerut. The soil of experimental field was sandy loam texture, alkaline in nature with pH (8.2), low in organic carbon, available nitrogen, phosphorus, potassium, sulphur, zincand boron. Twelve treatments in different nutrient management practices consisting Control,100% NPK, 100% NPK+20 kg S ha^{-1}, 100% NPK+40 kg S ha^{-1}, 100% NPK+1.5 kg B ha^{-1}, 100% NPK+20 kg Zn ha^{-1}, 100% NPK+20 kg S ha^{-1}+1.5kg B ha^{-1}, 100% NPK+20 kg S ha^{-1}+20 kg Zn ha^{-1}, 100% NPK+40 Kg S ha^{-1}+1.5 kg B ha^{-1}, 100% NPK+40 kg S ha^{-1}+20 kg Zn ha^{-1}, 100% NPK+20 kg S ha^{-1}+1.5 kg B ha^{-1}+20 kg Zn $ha^{-1}$and 100% NPK+40 kg S ha^{-1}+1.5 kg B ha^{-1}+20 kg Zn ha^{-1} were tested in randomized block design with three replication. The N, P, K, S, Zn and B per plot were applied in the reported treatment from Urea(46%), di ammonium phosphate (46% P_2O_5), muriate of potash (60% K_2O), bentonite sulphur (90% S), zinc chelate (99% Zn) and borax (11% B). the half dose of nitrogen and full dose of phosphorus, potassium, sulphur, zinc and boron was applied as basal and rest half amount of nitrogen was applied as top dressed at 35 DAS. The processed plant samples were analysed by micro-kjeldahl method (Jackson, 1967) [6] to determine nitrogen content. Wet digestion (di-acid) method (Jackson, 1973) [7] was used for preparation of aliquot to determine P, K, S, Zn and B content in plant.

Result and discussion

The balanced nutrient management practices contributed to a great extent influencing the seed yield of mustard. The seed yield increased with the increasing fertility levels and recorded highest grain, stover and biological yield 22.32, 73.52 and 95.84, q ha^{-1}(Table-1) respectively with the application of100% NPK + 40 kg S ha^{-1}+ 1.5 kg B ha^{-1}+ 20 kg Zn ha^{-1}. However the minimum yield were recorded in control plot which was significantly lower than other treatments. The seed yield is a cumulative effect of different growth and yield attributing characters. Significant increase in seed yield was recorded with incremental N, P, K, S, Zn and B levels. The probable reason may be that the increasing N, P, K, S, Zn and B levels resulted in greater accumulation of carbohydrates, protein and their translocation to the productive organs, which in turn, improved all growth and yield attributing characters, resulting more grain, stover and biomass yield. These results are in close conformity with the findings of Kumar *et al.* (2014) [8] and Rathore *et al.* (2015) [9].

Application of fertilizers at increasing rates significantly increased nutrient uptake of N, P, K, S, Zn and B in seed and stover of mustard crop (Table 2 &3). The positive influence of application of 100% NPK + 40 kg S ha^{-1}+ 1.5 kg B ha^{-1}+ 20 kg Zn ha^{-1}on nutrient content in the crop appears owing to improved nutritional level both in the root zone and plant system. The increased availability of these nutrients in root zone coupled with increased metabolic activity at cellular level might increase nutrient uptake and their accumulation in vegetative plant parts. Increased accumulation of nutrients in vegetative plant parts with improved metabolism led to greater translocation of these nutrients to reproductive organs of the crop and ultimately increased the contents in seed and stover. Increased uptake of N, P, K, S, Zn and B seems to be due to the fact that uptake of nutrient is a product of biomass accumulated by particular part and its nutrient content. Thus, positive impact of fertilizers application on both these aspects ultimately led to higher accumulation of nutrients. These results are in line with the findings of Chaurasia *et al.,* (2009) [4].

Nutrient uptake is a product of nutrient content and yield of crop which was affected significantly under various treatments. Significantly more availability of nutrients with the application of 100% NPK + 40 kg S ha^{-1}+ 1.5 kg B ha^{-1}+ 20 kg Zn ha^{-1} resulted higher nutrient content in plants and produce higher dry matter yields which improves growth and development of plants which ultimately resulted in higher nutrient uptake. The minimum nutrient uptake was recorded in control plot which was significantly lower than other treatments. This may be ascribed to higher yield of seed and stovervis-a-vis increased concentration recorded with these treatments in the present study. The increase in N, P, K, S, Zn and B content under recommended dose of fertilizers might be due to increased initial growth with more photosynthetic rate, which increase the demand of nutrients, consequently resulting in more absorption and translocation of these nutrients to the seeds. Higher NPKSZn & B uptake by seed and stalk with recommended dose of fertilizers might be due to the fact that the uptake by seed and stalk is determined by nutrient content in seed and stalk and seed and stalk yield. These results are in conformity with those reported by Choudhary and Bhogal (2013) [3] and Jankowski *et al.* (2014) [5].

Highest sulphur, zinc and boron uptake was also recorded with the application of 100% NPK + 40 kg S ha^{-1}+ 1.5 kg B ha^{-1}+ 20 kg Zn ha^{-1}. Greater accumulation and uptake of nutrients under this treatment could be ascribed to better availability and synergistic effect of applied nutrients.

From the above study it can be concluded that application of 100% NPK + 40 kg S ha^{-1}+ 1.5 kg B ha^{-1}+ 20 kg Zn ha^{-1}produced higher yield of mustard and higher uptake of N, P, K, S, Zn and B as compared to recommended fertilizer alone and other nutrient management treatments.

Table 1: Effect of nutrient management on seed, stover and biological yield (q ha^{-1})of mustard.

Treatment	Seed yield q ha^{-1}	Stover yield q ha^{-1}	Biological yield q ha^{-1}
Control	10.32	35.87	46.19
100% NPK	17.81	61.88	79.69
100% NPK + 20 kg ha^{-1} S	19.40	66.43	85.84
100% NPK + 40 kg ha^{-1} S	20.09	67.92	88.01
100% NPK + 1.5 kg ha^{-1} B	18.75	64.50	83.25
100% NPK + 20 kg ha^{-1}Zn	18.25	62.95	81.20
100% NPK + 20 kg ha^{-1} S + 1.5 kg ha^{-1} B	20.48	68.61	89.09
100% NPK + 20 kg ha^{-1} S + 20 kg ha^{-1}Zn	19.85	67.49	87.34
100% NPK + 40 Kg ha^{-1} S + 1.5 kg ha^{-1} B	21.44	70.97	92.41
100% NPK + 40 kg ha^{-1} S + 20 kg ha^{-1}Zn	20.91	69.42	90.33
100% NPK + 20 kg ha^{-1} S + 1.5 kg ha^{-1} B + 20 kg ha^{-1}Zn	20.35	68.58	88.93
100% NPK + 40 kg ha^{-1} S + 1.5 kg ha^{-1} B + 20 kg ha^{-1}Zn	22.32	73.52	95.84
SEm(±)	0.34	1.14	1.47
C.D. (P=0.05)	0.99	3.36	4.35

Table 2: Effect of nutrient management on N, P, K content and uptake by grain and stover in mustard.

Treatment	Nitrogen Content (%)		NitrogenUptake (kg ha^{-1})		Phosphorus Content (%)		Phosphorus Uptake (kg ha^{-1})		Potassium Content (%)		Potassium Uptake (kg ha^{-1})	
	Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover
Control	2.68	0.26	27.68	9.20	0.53	0.182	5.47	6.53	0.55	1.31	5.67	46.99
100% NPK	2.72	0.28	48.51	17.31	0.56	0.189	9.98	11.68	0.58	1.40	10.33	86.63
100% NPK + 20 kg ha^{-1} S	2.77	0.32	53.75	21.03	0.62	0.203	12.03	13.49	0.66	1.47	12.81	97.81
100% NPK + 40 kg ha^{-1} S	2.83	0.37	56.86	25.13	0.66	0.215	13.26	14.58	0.73	1.54	14.67	104.60
100% NPK + 1.5 kg ha^{-1} B	2.75	0.30	51.56	19.35	0.59	0.207	11.06	13.33	0.62	1.44	11.63	92.98
100% NPK + 20 kg ha^{-1}Zn	2.74	0.29	49.94	18.26	0.58	0.205	10.61	12.91	0.60	1.41	10.95	88.77
100% NPK + 20 kg ha^{-1} S + 1.5 kg ha^{-1} B	2.89	0.39	58.74	26.98	0.68	0.225	13.84	15.41	0.80	1.56	16.28	106.99
100% NPK + 20 kg ha^{-1} S + 20 kg ha^{-1}Zn	2.81	0.34	55.84	22.98	0.65	0.197	12.90	13.27	0.71	1.52	14.09	102.71
100% NPK + 40 Kg ha^{-1} S + 1.5 kg ha^{-1} B	2.95	0.44	63.31	31.46	0.74	0.253	15.86	17.98	0.90	1.65	19.29	117.33
100% NPK + 40 kg ha^{-1} S + 20 kg ha^{-1}Zn	2.94	0.43	61.55	30.10	0.72	0.247	15.06	17.17	0.87	1.63	18.19	113.39
100% NPK + 20 kg ha^{-1} S + 1.5 kg ha^{-1} B + 20 kg ha^{-1}Zn	2.92	0.41	59.87	28.18	0.71	0.243	14.47	16.67	0.85	1.59	17.38	109.32
100% NPK + 40 kg ha^{-1} S + 1.5 kg ha^{-1} B + 20 kg ha^{-1}Zn	2.98	0.46	66.60	33.57	0.76	0.260	16.99	19.12	0.93	1.68	20.73	123.87
SEm(±)	0.04	0.02	1.15	1.69	0.02	0.01	0.57	0.84	0.02	0.05	0.53	3.20
C.D. (P=0.05)	0.13	0.06	3.38	4.98	0.07	0.03	1.67	2.47	0.06	0.16	1.57	9.46

Table 3: Effect of nutrient management on S, Zn and boron content and uptake by grain and stoverin mustard.

Treatment	Sulphur Content (%)		Sulphur Uptake (kg ha^{-1})		Zinc Content (ppm)		Zinc Uptake (g ha^{-1})		Boron Content (ppm)		Boron Uptake (g ha^{-1})	
	Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover
Control	0.44	0.23	4.50	8.37	3.54	1.71	36.56	61.20	1.43	1.01	14.74	36.36
100% NPK	0.47	0.26	8.37	16.29	3.90	1.85	69.38	114.42	1.62	1.19	28.86	73.76
100% NPK + 20 kg ha^{-1} S	0.52	0.28	10.09	18.38	4.32	2.11	83.76	140.04	1.69	1.30	32.75	86.43
100% NPK + 40 kg ha^{-1} S	0.59	0.30	11.86	20.38	4.64	2.32	93.19	157.50	1.75	1.33	35.06	90.47
100% NPK + 1.5 kg ha^{-1} B	0.50	0.27	9.38	17.41	4.13	2.01	77.38	129.83	1.67	1.29	31.26	83.07
100% NPK + 20 kg ha^{-1}Zn	0.49	0.27	8.94	16.79	4.01	1.90	73.13	119.87	1.66	1.28	30.27	80.39
100% NPK + 20 kg ha^{-1} S + 1.5 kg ha^{-1} B	0.61	0.31	12.41	21.49	4.82	2.35	98.16	160.82	1.76	1.35	35.83	92.59
100% NPK + 20 kg ha^{-1} S + 20 kg ha^{-1}Zn	0.56	0.29	11.10	19.57	4.54	2.22	90.06	149.70	1.72	1.32	34.04	89.16
100% NPK + 40 Kg ha^{-1} S + 1.5 kg ha^{-1} B	0.68	0.35	14.66	24.60	5.08	2.71	108.83	192.33	1.80	1.42	38.51	100.42
100% NPK + 40 kg ha^{-1} S + 20 kg ha^{-1}Zn	0.67	0.34	13.98	23.60	4.99	2.61	104.31	181.33	1.78	1.39	37.22	96.29
100% NPK + 20 kg ha^{-1} S + 1.5 kg ha^{-1} B + 20 kg ha^{-1}Zn	0.64	0.32	13.11	21.96	4.88	2.43	99.87	167.00	1.77	1.37	36.32	94.27
100% NPK + 40 kg ha^{-1} S + 1.5 kg ha^{-1} B + 20 kg ha^{-1}Zn	0.70	0.36	15.64	26.22	5.16	2.85	115.29	209.54	1.81	1.46	40.41	107.05
SEm(±)	0.02	0.01	0.40	0.81	0.17	0.09	3.44	5.61	0.03	0.06	0.80	3.31
C.D. (P=0.05)	0.06	0.03	1.19	2.40	0.49	0.26	10.14	16.55	0.08	0.18	2.36	9.78

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