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RESPONSE OF MUSTARD (*BRASSICA JUNCEA* L.) CZERNJ. & COSSON) TO POTASSIUM WITH OTHER NUTRIENTS ON YIELD AND QUALITY

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ABSTRACT
A field experiment to evaluate response of mustard (*Brassica juncea* L.) Czernj. and Cosson) to potassium in combination with other nutrients on yield and quality was conducted at N. E. Borlaug Crop Research Centre of Govind Ballabh Pant University of Agriculture and Technology, Pantnagar (Uttarakhand) during *rabi* season of 2012-13. The experiment, comprising of twelve treatments was laid out in Randomized Block Design with three replications. The results revealed that higher seed yield per hectare (1817 kg ha^{-1}) was obtained at 150% NPK due to higher values of yield attributing characters *viz.* number of siliquae per plant (324.5), length of siliqua (4 cm), 1000- seed weight (3.7 g) and seed weight per plant (13.9 g). Protein yield (306 kg ha^{-1}) and oil yield (736 kg ha^{-1}) was also recorded maximum at 150% NPK level. Therefore, it can be concluded that application of 150% NPK should be used for improvement of yield and quality of mustard under tarai condition of Uttarakhand.

INTRODUCTION

Rapeseeds mustard are important oilseed crops which rank third in vegetable oils after soybean and palm while second in oilseed proteins production after soybean in the world (USDA, 2011). The global production of rapeseed-mustard was 62.45 mt from an acerage of 33.64 mha with a total productivity of 18.56 q/ha (FAO STAT, 2011). In India, the annual production of rapeseed-mustard was about 8.17 mt covering an area of about 6.51 mha with a total productivity of 12.57 q/ha (GOI, 2011). It is estimated that 58 mt of oilseeds will be required by the year 2020, wherein the share of rapeseed-mustard will be around 24.2 mt (Bartaria *et al.,* 2001).

The most important constraints to crop growth are those caused by shortage of plant nutrients. The nutrient requirement of oilseed crops, in general, is very high for almost all the essential mineral nutrients which are to be supplied in adequate quantities. Nutrient use efficiency is barely 30-40 per cent and approximately more than 60 per cent of applied nutrients are lost through various ways. It has been estimated that less than 15 per cent of nutrients absorbed by the oilseeds are contributed by fertilizers while the remaining are obtained from soil resources, organic manures, biological sources and residues as well as wastes (Davari and Mirzakhani, 2009). Application of potassium upto 60 kg ha^{-1} also significantly increased grain yields of Indian mustard. On an average, with the high potassium application of 80 kg ha^{-1}, 37.2% increase in grain yield was achieved as reported by Tiwari *et al.* (2012). Seed yield and yield attributes of Indian mustard increased with increasing level of nitrogen and phosphorus upto 120 and 80 kg ha^{-1} respectively. Also reported in maize-mustard sequence, 100/75% of RDF + 2 t FYM gave highest seed yield and quality of the oil (Shekhawat *et al.,* 2012). Significant increase in protein and oil content in mustard seed due to application of 150 kg N ha^{-1} compared to 50 kg N ha^{-1} (Singh *et al.,* 2010).

Thus, adequate nutrient supply increases the seed and oil yields by improving the setting pattern of siliquae on branches, number of siliquae per plant and other yield attributes. Farmers most commonly use di ammonium phosphate that supplies only nitrogen and phosphorus. So, for obtaining maximum efficiency of added fertilizer, balanced fertilization to crops including use of potassium and micronutrients, is essential. Micronutrient helps in photosynthetic activities and proper utilization of nitrogen and phosphorus (Verma and Baigh, 2012). Therefore, the present experiment was conducted to evaluate response of mustard to potassium in combination with other nutrients on yield and quality.

The objectives of this study were to examine the effects of potassium with different nutrients on mustard yield, their yield attributing traits and quality parameters.

MATERIALS AND METHODS

The field study was conducted during *rabi* season of 2012-13 at G.B. Pant University of Agriculture and Technology,

Table 1: Yield and yield attributes as influenced by different nutrient levels

Treatment	Number of siliquae/ plant	Number of seeds/ siliqua	Length of siliqua (cm)	1000-seed weight (g)	Seed weight/ plant (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})
100% K	288.9	12.1	3.7	3.5	13.8	1104	5388
100% N	280.6	11.7	3.5	3.4	12.0	1220	6239
100% NK	305.0	11.6	3.1	3.3	13.7	1282	6680
100% NP	278.6	11.7	3.5	3.2	10.9	1250	5933
50% NPK	219.9	11.3	2.9	3.1	10.8	1391	6554
100% NPK (RDF)*	269.1	11.9	3.6	3.2	11.0	1429	7350
150% NPK	324.5	13.5	4.0	3.7	13.9	1817	8228
100% NPK + S @ 40 kg/ha	323.5	12.2	3.7	3.2	12.9	1567	6885
100% NPK + $ZnSO_4$ @ 25 kg/ha	319.7	11.6	3.4	3.5	11.3	1531	7534
100% NPK + Borax @ 0.2% (foliar)	282.6	12.6	3.6	3.4	13.0	1460	6868
100% NPK + FYM** @ 2.5 t/ha (dry weight)	310.7	12.4	3.7	3.6	12.2	1609	7538
Control	185.0	10.7	2.7	2.7	7.9	625	2683
S Em ±	26.4	1.0	0.2	0.1	1.1	49	506
C D (P=0.05)	77.4	NS	0.5	0.4	3.2	144	1485

Table 2: Protein content in seed and protein yield as influenced by different nutrient levels

Treatment	Protein content (%)	Protein yield(kg ha^{-1})	Oil content (%)	Oil yield (kg ha^{-1})
100% K	18.3	171.6	41.3	504.5
100% N	18.4	191.3	40.9	511.1
100% NK	18.5	201.2	41.1	629.0
100% NP	20.2	214.8	40.7	566.0
50% NPK	18.6	220.8	40.6	448.6
100% NPK (RDF)*	19.5	236.8	40.7	522.1
150% NPK	19.9	306.0	40.5	736.0
100% NPK + S @ 40 kg/ha	18.8	250.3	41.0	595.0
100% NPK + $ZnSO_4$ @ 25 kg/ha	20.1	261.6	40.8	596.4
100% NPK + Borax @ 0.2% (foliar)	18.6	230.2	40.8	631.5
100% NPK + FYM** @ 2.5 t/ha (dry weight)	19.6	267.3	40.7	655.5
Control	17.9	94.3	40.3	251.4
S Em ±	0.9	11.8	0.20	21.0
C D (P=0.05)	NS	34.5	NS	61.6

*RDF = 120: 60: 40 kg N, P_2O_5 and K_2O ha^{-1}, **40% moisture

Pantnagar (29°N latitude, 79.29°E longitude and 243.8 m above the mean sea level) district U.S. Nagar, Uttarakhand, India. The climate of Pantnagar is humid subtropical with hot summers, heavy rains in monsoon period and extreme cold in winters. The soil of the experimental site was silty clay loam in texture having medium organic carbon (0.62%), low available nitrogen (156.80 kg/ha), medium available phosphorus (20.60 kg/ha) and medium available potassium (127.80 kg/ha) contents with slightly alkaline in reaction (pH 7.6). A 3 time replicated trials with 12 treatments *viz*. T_1 (100% K), T_2 (100% N), T_3 (100% NK), T_4 (100% NP), T_5 (50% NPK), T_6 (100% NPK), T_7 (150% NPK), T_8 (100% NPK + S @ 40 kg/ha), T_9 (100% NPK + $ZnSO_4$ @ 25 kg/ha), T_{10} (100% NPK + Borax @ 0.2% (foliar)), T_{11} (100% NPK + FYM @ 2.5 t/ha (dry weight)) and T_{12} (control- no fertilizer application) were laid out in randomized block design (Fisher, 1947).

Mustard, variety NDRE 4, was sown @ 5 kg ha^{-1}, in rows, 30 cm apart on October 16, 2012 and harvested on February 27, 2013. Intercultural operations were done as and when necessary. Grain and straw yields were recorded from the whole plot harvest. The oil content in seed was determined by Soxhlet's extraction method taking petroleum ether as a solvent. Protein content in seeds was obtained by multiplying N content with a constant factor of 6.25 (A.O.A.C., 1960). Protein and oil yield was computed by multiplying the protein and oil content value with seed yield divided by 100 and multiplied by moisture correction factor, as per treatment. During crop period, a total rainfall of 178.3 mm was received.

The experimental data were analyzed by using STPR-3 programme, designed and developed by Department of Mathematics and Statistics of College of Basic Science and Humanities (CBSH), Pantnagar.

RESULTS AND DISCUSSION

Yield attributes

All yield attributing characters viz., number of siliquae per plant, length of siliqua, 1000- seed weight and seed weight per plant were affected significantly due to different nutrient levels. 150% NPK recorded higher number of siliquae per plant, number of seeds per siliqua, length of siliqua, 1000-seed weight and seed weight per plant. The number of seeds per siliqua was not influenced significantly by the application of different nutrients. However, the control produced the lowest in all the cases. More seed weight per plant might be due to more number of siliquae per plant, more number of seeds per siliqua, more length of siliqua and higher 1000-seed weight (Table 1).

The higher value of yield attributes is the result of higher nutrient levels resulted in to better growth and more translocation of photosynthates from source to sink as reported by Rana *et al*. (2005) and Tripathi *et al*. (2010). The positive effect of supplementary nutrients on yield attributes of Indian mustard was observed by Singh and Pal (2011).

Seed yield

The data in Table 1 revealed that 150% NPK recorded significantly higher values of seed and stover yield per hectare than remaining treatments. The reason for higher yield (1817 kg ha^{-1}) at 150% NPK was production of effective yield components which contributed towards seed yield. This is due to increase in the recommended nutrients and addition of supplementary nutrients which increased the siliquae per plant, number of seeds per siliqua and siliqua length, which ultimately increase the seed yield. This was in close conformity with Singh *et al*. (2010), Singh and Pal (2011) and Shekhawat *et al*. (2012).

Positive response of nitrogen and potassium was obtained in seed yield per hectare as with the application of 100% NK, there was 16.1% and 5.1% increase in seed yield as compared to 100% K and 100% N alone. However, 100% NP recorded lower yield then 100% NK. With the application of nitrogen, phosphorus and potassium together the seed yield per hectare was also increased as compared to 100% K and 100% N alone but all the treatments were at par with each other except control, 100% K and 100% N. The increase in seed yield with N, P and K together might be due to balanced fertilization which influenced the yield attributing characters and ultimately the seed yield per hectare. The lowest stover yield was found under control treatment.

There was significant difference in the seed yield per hectare. Seed yield also increased with increase in N and K rates (Mozaffari *et al.,* 2012). The seed yield increased with the increase in level of RDF (Shukla *et al.,* 2002 and Singh and Pal, 2011). Seed yield also increased with increase in N and P rates (Premi and Kumar, 2004 and Shekhawat *et al.,* 2012).

Seed quality

The effect of different nutrients applied on protein and oil content was found to be non- significant (Table 2). 100% NP produced the maximum protein content, while higher concentration of oil in seeds at 100% K followed by 100% NK and 100% NPK + 40 kg S ha^{-1} treatments and lowest was in control. The increase in protein content might be due to higher nitrogen content in seeds as it is a mathematical value calculated from nitrogen content of seeds, as increasing nitrogen levels increases the proteinaceous substance in seeds (Singh and Pal, 2011). Protein content was higher due to higher concentration of P which increased the number of seeds (Bharose *et al.,* 2011). The increase in oil content with S fertilization may be attributed to its role in oil synthesis (Tripathi *et al.,* 2010), increase in glucosides (Kumar *et al.,* 2006 and Singh *et al.,* 2010). Increase in availability of S attribute to increased conversion of fatty acid metabolites to the end products of fatty acids as supported by Jain *et al*. (1996), Tripathi *et al*. (2010) and Singh and Pal (2011).

Increase in oil content on K application is attributed to increase in the activity of enzymes involved in fat synthesis (Singh *et al.,* 2010). Positive effect of S along with P and other nutrients on oil content is because of P as it is a constituent of phospholipids and also essential for oil synthesis (Kumar and Yadav, 2007).

The protein (306 kg ha^{-1}) and oil yield (736 kg ha^{-1}) were found significantly superior under the application of 150% NPK than other remaining treatments. The lowest protein and oil yield was recorded in the control plot. Protein and oil yield is the function of oil content in seeds multiplied by seed yield per hectare. Increase in the seed yield, increased the protein and oil yield. The results of protein and oil yield are in tune with Singh *et al*. (2010) and Tomer *et al*. (1996), respectively.

From the above discussion it may be opined that increasing the nutrient dose to 150% NPK (RDF = 120: 60: 40 kg N, P_2O_5 and K_2O ha^{-1}) resulted in achieving more seed (1817 kg ha^{-1}), protein (306 kg ha^{-1}) and oil yield (736 kg ha^{-1}) of mustard during *rabi* season.

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