Response of mustard (*Brassica juncea* L.) to different bio-regulators under varying fertility levels

Abstract

A field experiment on "Response of mustard (*Brassica juncea* L.) to different bio-regulators under varying fertility levels" was carried out at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, S. D. Agricultural University, Sardarkrushinagar during *rabi* 2017-18. With regard to the effect of different bio-regulators on mustard, all growth attributes studied during the course of investigation such as dry matter accumulation per plant, number of primary branches and secondary branches per plant showed significant improvement due to application of cycocel (CCC) @ 1500 ppm (B_3). Whereas significantly the lowest plant height was exhibited under treatment B_3. Similarly, treatments B_3 (Cycocel @ 1500 ppm) and B_1 (Brassinosteroid @ 0.5 ppm) remained comparable and exhibited significantly higher values of yield components and quality parameters *viz*., number of seeds per siliqua, number of siliquae per plant, test weight, seed yield per plant, protein content and oil yield. Application of cycocel @ 1500 ppm (B_3) also significantly increased N and S content in seed and stover and also resulted in significant improvement in uptake of N, P, S and Zn in seed, stover and total uptake followed by treatment B_1 (Brassinosteroid @ 0.5 ppm). However, harvest index, phosphorus and zinc content in seed and stover as well as available nutrients status in the soil (N, P_2O_5, S and Zn) did not influenced due to application of different bio-regulators. Treatment B_3 (Cycocel @ 1500 ppm) realized the highest net return (₹ 64,090/ha) followed by treatment B_1 (Brassinosteroid @ 0.5 ppm). The results of the present investigation indicated that all the growth attributes in terms of plant height, number of primary and secondary branches per plant; yield attributes *viz*., number of seeds per siliqua, number of siliquae per plant, test weight, seed yield per plant, seed, stover yield and quality parameters *viz*., oil content, oil yield and protein content showed significant improvement due to application of balanced fertilization treatment N_4 ($N_{50}P_{50}S_{40}Zn_{1.7}$), though it was at par with treatment N_3 ($N_{50}P_{50}S_{40}$). Application of $N_{50}P_{50}S_{40}Zn_{1.7}$ (N_4) registered significantly higher N, P_2O_5, S and Zn content (%) in seed and stover and seed, stover and total uptake by mustard followed by treatment N_3 ($N_{50}P_{50}S_{40}$). Similarly, application of $N_{50}P_{50}S_{40}Zn_{1.7}$ (N_4) noted significantly higher available N (180.38 kg/ha), P_2O_5(39.68 kg/ha), S (8.49 mg/kg) and Zn (0.46 mg/kg), being at par with treatment N_3 ($N_{50}P_{50}S_{40}$) except available Zn status in soil. From economic point of view, the maximum net return (₹ 64,897/ha) and benefit cost ratio (3.13) were received with application of 50 kg N + 50 kg P_2O_5+ 40 kg S + 1.7 kg Zn/ha (N_4) followed by treatment N_3 ($N_{50}P_{50}S_{40}$).

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Kay words: Bio-regulators, fertility levels, cycocel, salicylic acid, brassinosteroid, nitrogen, phosphorus, sulphur, zinc

Introduction

Indian mustard [*Brassica juncea* L.] is most important and highly promising *rabi* oilseed crop under different agro-climatic conditions because of its wide adaptability and comparatively high production potential. It performs well on sandy loam to loamy sand and as rainfed crop on conserved moisture on medium black soil in larger parts of Northern and Northern-Western regions of India. Among the various oilseed crops grown in India, mustard and rapeseed assume significance in the national economy by occupying second position in the area and production next to groundnut. The oil is used as cooking oil, medicine, industrial purposes, hair oil, pickles oil, grease, vegetable ghee etc. Its seed is also used as condiment. The oil content in mustard seeds varies from 37 to 40 per cent. Its cake is used as cattle feed and as a manure. Worldwide, India is the fourth largest mustard producer. The productivity of oilseed crops are low due to (i) their allocation to rainfed situation (91 per cent) and (ii) poor nourishment that too with imbalance use of fertilizers. Modern agriculture is based on high yielding crop varieties, intensive cropping, use of high analysis fertilizers and irrigation. Intensive cropping and exploiting agriculture deplete secondary and micronutrients reserves of the soil and have an adverse effect on crop yield.

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Nitrogen is one of the important plant nutrients and it invariably improves the vegetative growth which is manifested through increase in primary and secondary branches, number of siliqua and dry matter production per plant which ultimately leads to higher seed yield. Nitrogen also improves the quality of produce. Both nitrogen and sulphur are closely linked in protein metabolism and thus the relationship between S and N in plant reported to be synergistic. N and S increase the concentration and uptake of one another in the plant (Dongarkar *et al*., 2005). Among the primary nutrient, phosphorus plays an important role in plant growth and development. Phosphorus plays many essential functions in plant life and it's role in energy storage and transfer is the most important, which acts as "Energy currency" within plant. Sulphur deficiency is wide-spread in India. Experimental evidences suggest that deficiency of this element can reduce crop yields up to 35 per cent even without appearance of visible symptoms on plants (Pal and Singh, 1992). Zinc plays an important role in plant system for the proper growth and development. Zinc is an important constituent of several enzymes which regulates various metabolic processes in the plants and also influence the formation of several growth hormones in plants. Zinc stimulates the pod setting, seed formation and oil synthesis in the seeds of mustard and increases the biological (seed and stover) yield of mustard.

Cycocel (2-Chloro ethyl 3-methyl ammonium chloride) is the most usual anionic plant growth regulator. There are reports that anionic compounds treated plants were tolerant to drought conditions compared to untreated plants. Brassinosteroid enhances cell division, cell elongation and also cell differentiation. It promotes the polymerase activities of RNA and DNA and their replication, transcription and translation. It increases proton pump action and regulates plant metabolism for improved growth (Ananthi and Vanangamudi 2014). Exogenous application of salicylic acid enhances the growth and productivity of plants. The flower inducing domain of salicylic acid is important phytohormone that can enhance flowering in a variety of ornamental plants. Foliar application of brassinosteroid (Sairam 1994), salicylic acid (Hegazi *et al.,* 1996) and cycocel (Bagdi and Afria 2008) have been reported to be effective for enhancing mustard and other crops productivity by some worker under different environmental condition. It has been reported that these bio-regulators play vital role in greater participating of photosynthates toward reproductive sink thereby improving harvest index.

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Material and methods

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A field experiment was conducted in plot B-8 at the Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, S. D. Agricultural University, Sardarkrushinagar during *rabi* season of the year 2017-18. The experiment comprising of sixteen treatment combinations consisting of four bio-regulators *viz.,* B_0: Water spray, B_1: Brassinosteriod @ 0.5 ppm, B_2: Salicylic acid @ 100 ppm and B_3: Cycocel @ 1500 ppm and four fertility levels *viz.,* N_1: 50 kg N/ha, N_2: 50 kg N/ha + 50 kg P_2O_5/ha, N_3: 50 kg N/ha + 50 kg P_2O_5/ha + 40 kg S/ha and N_4: 50 kg N/ha + 50 kg P_2O_5/ha + 40 kg S/ha + 1.7 kg Zn/ha. These treatment combinations were replicated thrice in a randomized block design with factorial concept and variety GDM 4 was taken as test crop.The soil of the experimental field was loamy sand in texture, low in organic carbon (0.18 %) and available nitrogen (175 kg/ha), medium in available P_2O_5 (37.1 kg/ha) and low in available sulphur (6.9 kg/ha) and zinc (0.31 ppm) with soil pH of 7.3. Geographically, Sardarkrushinagar is situated at 24˚19' N latitude and 72˚19' E longitude with an altitude of 154.52 m above the mean sea level. It is located in the North Gujarat Agro-climatic Zone. The winter season is fairly cold and dry start from end of October and continues till the end of February. The minimum temperature of the year is reached in the months of December and January. The seed rate was used 3.5 kg per ha with 45 x 15 cm spacing. The foliar spray of brassinosteroid @ 0.5 ppm, salicylic acid @ 100 ppm and cycocel @ 1500 ppm as well as water spray in control were made at 35 and 50 DAS as per treatments. A spray volume of 500 lit/ha was used in experiment. The total quantity of phosphorus and zinc and half dose of nitrogen were applied in opened furrow at the time of sowing as per treatments. The remaining half dose of nitrogen was top dressed at 32 DAS at the time of third irrigation. Elemental sulphur was incubated by mixing the required quantity of elemental sulphur with the soil of same plot in which to be applied. Elemental sulphur was thoroughly mixed with soil and kept in shade by covering with gunny bag. It was moistened through frequent sprinkling of water for 21 days for resulting to convert the insoluble sulphur in to soluble form.

Result and discussion

Effect on bio-regulators

Plant population of mustard at 20 DAS and at harvest was not varied significantly due to foliar application of bio-regulators. Foliar application of brassinosteriod @ 0.5 ppm (B_1) resulted into significantly higher plant height at 45, 60, 90 DAS and at harvest, Whereas cycocel spray drastically reduced plant height at different growth stages. Dry matter accumulation per plant at different growth period recorded maximum under treatment cycocel @ 1500 ppm (B_3) followed by foliar application of brassinosteroid (B_1). Remarkably higher number of primary and secondary branches per plant was recorded with treatment B_3 being at par with treatment B_1. With respect to improvement in yield attributes viz., numbers of seeds per siliqua, number of siliquae per plant, test weight, seed yield per plant, seed yield and stover yield, treatment B_3 (foliar application of cycocel @ 1500 ppm) emerged out as the best treatment being at par with trea

Table 1 : Effect of bio-regulators and fertility levels on plant population, plant height and dry matter accumulation per plant of mustard

Treatments	Plant population (per meter row length)		Plant height (cm)				Dry matter accumulation (g)			
	20 DAS	**At harvest**	**45 DAS**	**60 DAS**	**90 DAS**	**At harvest**	**45 DAS**	**60 DAS**	**90 DAS**	**At harvest**
Bio-regulators (B)										
B_0 : Water spray (control)	6.3	6.2	64.8	104.6	154.7	162.7	4.6	23.1	34.6	43.6
B_1 : Brassinosteroid (0.5 ppm)	6.5	6.3	78.8	131.6	165.4	175.5	6.8	27.1	37.8	50.5
B_2 : Salicylic acid (100 ppm)	6.4	6.4	72.3	119.5	158.6	174.8	6.3	26.7	37.2	48.8
B_3 : Cycocel (1500 ppm)	6.8	6.4	60.4	88.6	151.5	159.4	7.5	27.9	38.8	52.1
S.Em.±	0.2	0.2	2.0	2.8	3.2	3.5	0.2	0.8	0.9	1.2
C.D. (P=0.05)	NS	NS	5.8	8.1	9.3	10.0	0.6	2.2	2.5	3.5
Fertility levels (N)										
N_1 : N_{50}	6.2	6.2	65.1	105.9	152.1	160.8	4.8	23.8	33.1	44.5
N_2 : N_{50} P_{50}	6.4	6.2	66.8	109.4	153.6	165.9	5.9	25.8	36.2	47.8
N_3 : N_{50} P_{50} S_{40}	6.5	6.3	70.6	111.5	161.0	171.1	7.0	27.0	38.6	50.2
N_4 : N_{50} P_{50} S_{40} $Zn_{1.7}$	6.9	6.4	73.9	117.4	163.4	174.5	7.7	28.2	40.6	52.5
S.Em.±	0.2	0.2	2.0	2.8	3.2	3.5	0.2	0.8	0.9	1.2
C.D. (P=0.05)	NS	NS	5.8	8.1	9.3	10.0	0.6	2.2	2.5	3.5
Interaction (B x N)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V. %	10.4	12.3	10.0	8.7	7.1	7.18	12.1	10.2	8.1	8.6

(Brassinosteriod @ 0.5 ppm). Harvest index was not significantly affected due to different treatments of bio-regulators. Among the bio-regulators, treatment cycocel gave significantly higher oil yield followed by treatment brassinosteroid. But oil content did not differ significantly due to different bio-regulators treatments. Higher protein content was noted under treatment B_3, but found at par with treatments B_1 and B_2. Treatment cycocel spray (B_3) registered maximum concentration of N and S in seed as well as stover of mustard over control, but it did not differ significantly with respect to P and Zn content. N, P, S and Zn uptake in seed, stover as well as total uptake were highest under treatment B_3 (foliar application of cycocel @ 1500 ppm) followed by treatment B_1. In present experimentation, available nutrient status of N, P_2O_5, S and Zn were not influenced significantly due to spray of bio-regulators. Maximum gross realization (₹ 94491/ha), net return (₹ 64090/ha) with BCR of 3.11 was secured with treatment B_3 (foliar application of cycocel @ 1500 ppm) followed by treatment B_1. Brassinosteroid enhances cell division, cell elongation and also cell differentiation which is expressed morphologically through increase in plant height. It promotes the polymerase activities of RNA and DNA and their replication, transcription and translation. It increases proton pump action and regulates plant metabolism for improved growth and plant height. Cycocel on account of its regulatory role played in inhibition of cell division resulted in drastic reduction in plant height. Nakul (2001) reported that application cycocel @ 1500 ppm reduce the growth of safflower. The better root development, improve plant height and number of primary and secondary branches per plant helped in consumption of applied and native nutrients from soil with betterment of source to sink relationship which leads to accumulation of greater biomass as compared to control. The spectacular positive impact of increase in chlorophyll formation leads to augment in photosynthesis and root development improves luxury uptake and translocation of plant nutrient from the soil to plant parts ultimately increased number of primary and secondary branches per plant. Significant improvement in yield attributes due to application of bio-regulators as compared to water spray (control) suggest that bio-regulators might have resulted in efficiency translocation of photosynthetic assimilates toward reproductive sinks. Significant enhancement in stover yield under bio-regulators treatment seems to be due to their direct impact on periodical plant height and dry matter accumulation by virtue of increased nutrient uptake and photosynthetic efficiency. Brassinosteroid application bring changes in enzyme activity, apparently affect nucleic acid metabolism so that the level of accumulated RNA, DNA and protein in the tissue increased during growth (Bagdi and Afria 2008).

Table 2 : Effect bio-regulators and fertility levels on number of primary and secondary branches per plant, number of seeds per siliqua, number of siliquae per plant, test weight, seed yield per plant, seed yield, stover yield and harvest index of mustard

Treatments	Number of branches per plant		Number of seeds per siliqua	Number of siliquae per plant	Test weight (g)	Seed yield per plant (g)	Seed yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)
	primary	secondary							
Bio-regulators (B)									
B_0 : Water spray (control)	4.8	15.8	12.7	233.2	4.3	14.6	2034	4463	31.4
B_1 : Brassinosteroid (0.5 ppm)	5.4	17.6	15.1	263.5	4.9	17.3	2530	5136	33.0
B_2 : Salicylic acid (100 ppm)	5.3	17.0	14.0	252.4	4.8	16.2	2368	4894	32.8
B_3 : Cycocel (1500 ppm)	5.8	18.6	15.4	272.3	5.1	17.9	2624	5277	33.3
S.Em.±	0.2	0.5	0.4	6.2	0.1	0.59	86	148	1.2
C.D. (P=0.05)	0.4	1.3	1.2	17.8	0.3	1.72	250	428	NS
Fertility levels (N)									
N_1 : N_{50}	4.9	15.5	12.7	239.7	4.3	14.5	2103	4306	32.8
N_2 : N_{50} P_{50}	5.1	16.5	14.0	247.1	4.7	16.0	2319	4709	33.1
N_3 : N_{50} P_{50} S_{40}	5.5	18.1	14.9	261.8	5.0	17.6	2512	5284	32.3
N_4 : N_{50} P_{50} S_{40} $Zn_{1.7}$	5.7	18.9	15.6	272.8	5.2	17.8	2622	5471	32.4
S.Em.±	0.2	0.5	0.4	6.2	0.1	0.59	86	148	1.2
C.D. (P=0.05)	0.4	1.3	1.2	17.8	0.3	1.72	250	428	NS
Interaction (B x N)	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V. %	10.0	9.1	10.4	8.4	8.4	12.4	13	10	13.1

Table 3 : Effect of bioregulators and fertility levels on oil content, oil yield and protein content

Treatments	Oil content (%)	Oil yield (kg/ha)	Protein content (%)
Bio-regulators (B)			
B_0 : Water spray (control)	37.7	768	18.7
B_1 : Brassinosteroid (0.5 ppm)	37.8	957	20.0
B_2 : Salicylic acid (100 ppm)	37.6	892	19.7
B_3 : Cycocel (1500 ppm)	37.9	998	20.0
S.Em.±	0.46	36	0.30
C.D. (P=0.05)	NS	103	0.88
Fertility levels (N)			
N_1 : N_{50}	36.9	776	18.9
N_2 : N_{50} P_{50}	37.1	861	19.0
N_3 : N_{50} P_{50} S_{40}	38.2	961	19.9
N_4 : N_{50} P_{50} S_{40} $Zn_{1.68}$	38.8	1016	20.5
S.Em.±	0.46	36	0.30
C.D. (P=0.05)	1.32	103	0.88
Interaction (B x N)	NS	NS	NS
C.V. %	4.2	13.6	5.4

The positive impact of bio-regulators on N and S concentration seems to be on account of better developed canopy which might have maintained adequate supply of metabolites for better root growth. Thus, better developed root system might have facilitated the greater extraction of nutrients from soil and translocation to plant parts. As nutrient uptake by the crop is primarily governed by total dry matter accumulation and secondarily on nutrient concentration at cellular level. Thus, enhanced uptake due to bio-regulator treatments in present study seems to be in accordance with improvement in both these factors.

Effect on fertility levels

Plant population (At 20 DAS and at harvest) of mustard did not vary significantly due to different fertility levels. The maximum growth attribute *viz*., plant height and dry matter accumulation per plant, number of primary and secondary branches per plant were recorded significantly higher under the fertilization of treatment N_4 ($N_{50}P_{50}S_{40}Zn_{1.7}$) followed by treatment N_3. The yield attributes *viz*., number of seeds per siliqua, number of siliquae per plant, test weight, seed yield per plant were improved significantly with the application of treatment N_4 ($N_{50}P_{50}S_{50}Zn_{1.7}$), but failed to differ significantly from treatment N_3 ($N_{50}P_{50}S_{40}$). Significantly higher seed (2622 kg/ha) and stover (5471 kg/ha) yields was recorded under treatment N_4 ($N_{50}P_{50}S_{50}Zn_{1.7}$), which remained statistically at par with treatment N_3 ($N_{50}P_{50}S_{40}$). None of the balanced fertilization treatments vary significantly with respect to harvest index. Significantly higher oil content in seed and oil yield was noted under treatment N_4 ($N_{50}P_{50}S_{50}Zn_{1.7}$), but found at par with treatment N_3. An application of $N_{50}P_{50}S_{50}Zn_{1.7}$ (N_4) recorded significantly higher protein content in seed, but failed to differ significantly from treatment N_3. Balanced fertilization with treatment N_4 ($N_{50}P_{50}S_{50}Zn_{1.7}$) registered significantly higher content of N, P, S and Zn in both seed and stover. However, it remained at par with treatment N_3 with respect to N and P content. Crop fertilized with treatment N_4 ($N_{50}P_{50}S_{50}Zn_{1.7}$) taken up the highest quantum of N, P, S and Zn by seed, stover and total uptake followed by treatment N_3. Significantly higher available N, P_2O_5, S and Zn status in soil after harvest of crop was observed under treatment N_4, but it was at par with treatment N_3 except for Zn content. On the basis of net realization, treatment N_4 ($N_{50}P_{50}S_{50}Zn_{1.7}$) realized the highest net realization of ₹ 64897/ha with BCR of 3.13.

The positive impact of these bio-regulators on overall improvement in growth parameters appear to be on account of increased photosynthetic efficiency by virtue of enhancement in chlorophyll content and greater development of assimilating apparatus ultimately resulted into increased plant height and dry matter accumulation at every growth periods which validate the fact. More number of primary and secondary branches per plant in this treatment is due to application of major (N and P) and micronutrient (S and Zn) in balanced proportion from inorganic fertilizer which resulted in better availability of N, P, S and Zn in soil resulted in higher accumulation and translocation in plant might have improved vegetative growth and ultimately increased primary and secondary branches per plant in mustard. The increased availability of photosynthetes might have increased number of flowers and their fertilization resulted in higher number of seeds per siliqua, number of siliquae per plant and weight of 1000 seeds. Increase in seed yield and stover yield were mainly because of remarkable improvement increase in plant height number of primary and secondary branches per plant resulted from combined effect of macro and micronutrient that provide balanced nutrition to the plant ultimately resulted in maximum seed yield and stover yield. The results further showed that sulphur was major constitute responsible for increase in oil content of seed.

Table 4 : Effect of bio-regulators and fertility levels on nitrogen content, phosphorus content, sulphur content and zinc content in mustard

Treatments	Nitrogen content (%)		Phosphorus content (%)		Sulphur content (%)		Zinc content (ppm)	
	Seed	**Stover**	**Seed**	**Stover**	**Seed**	**Stover**	**Seed**	**Stover**
Bio-regulators (B)								
B_0 : Water spray (control)	2.99	0.38	0.52	0.19	0.38	0.13	39.5	8.3
B_1 : Brassinosteroid (0.5 ppm)	3.19	0.49	0.55	0.21	0.40	0.14	40.6	8.5
B_2 : Salicylic acid (100 ppm)	3.16	0.47	0.54	0.20	0.39	0.13	39.5	8.5
B_3 : Cycocel (1500 ppm)	3.20	0.49	0.56	0.20	0.41	0.15	39.7	8.7
S.Em.±	0.05	0.007	0.009	0.003	0.004	0.002	0.5	0.1
C.D. (P=0.05)	0.14	0.020	NS	NS	0.011	0.005	NS	NS
Fertility levels (N)								
N_1 : N_{50}	3.03	0.41	0.47	0.19	0.37	0.12	38.7	8.0
N_2 : N_{50} P_{50}	3.04	0.44	0.50	0.20	0.39	0.13	38.8	8.5
N_3 : N_{50} P_{50} S_{40}	3.19	0.48	0.59	0.21	0.40	0.14	40.0	8.5
N_4 : N_{50} P_{50} S_{40} $Zn_{1.7}$	3.29	0.50	0.61	0.21	0.41	0.15	41.8	9.0
S.Em.±	0.05	0.007	0.009	0.003	0.004	0.002	0.6	0.1
C.D. (P=0.05)	0.14	0.020	0.025	0.013	0.011	0.005	1.6	0.4
Interaction (B x N)	NS	NS	NS	NS	NS	NS	NS	NS
C.V. %	5.36	5.27	5.60	5.24	3.90	4.5	4.8	5.5

Table 5 : Effect of bio-regulators and fertility levels on seed, stover and total nitrogen, phosphorus, sulphur and zinc uptake by mustard

Treatments	Nitrogen uptake (kg/ha)			Phosphorus uptake (kg/ha)			Sulphur uptake (kg/ha)			Zinc uptake (g/ha)		
	Seed	Stover	Total	Seed	Stover	Total	Seed	Stover	Total	Seed	Stover	Total
Bio-regulators (B)												
B_0 : Water spray (control)	60.8	17.0	77.8	10.6	8.5	19.1	7.7	5.8	13.5	80.3	37.0	117.3
B_1 : Brassinosteroid (0.5 ppm)	80.7	25.2	105.9	13.9	10.8	24.7	10.0	7.2	17.2	102.7	43.7	146.4
B_2 : Salicylic acid (100 ppm)	74.8	23.0	97.8	12.8	9.8	22.6	9.2	6.4	15.6	93.5	41.6	135.1
B_3 : Cycocel (1500 ppm)	84.0	25.9	109.9	14.7	10.6	25.3	10.8	7.9	18.7	104.2	45.9	150.1
S.Em.±	2.8	0.8	2.6	0.5	0.4	0.6	0.31	0.21	0.34	3.8	1.5	3.7
C.D. (P=0.05)	8.2	2.2	7.5	1.5	1.0	1.7	1.01	0.62	0.99	10.9	4.2	10.7
Fertility levels (N)												
N_1 : N_{50}	63.7	17.7	81.4	9.9	8.2	18.1	7.8	5.2	13.0	81.4	34.4	115.8
N_2 : N_{50} P_{50}	70.5	20.7	91.2	11.6	9.4	21.3	9.0	6.1	15.1	90.0	40.0	130.0
N_3 : N_{50} P_{50} S_{40}	80.1	25.4	105.5	14.8	11.1	25.9	10.1	7.4	17.4	100.5	44.9	145.4
N_4 : N_{50} P_{50} S_{40} $Zn_{1.7}$	86.3	27.4	113.7	16.0	11.5	27.5	10.9	8.2	19.0	109.6	49.2	158.8
S.Em.±	2.8	0.8	2.6	0.5	0.4	0.6	0.31	0.21	0.34	3.8	1.5	3.7
C.D. (P=0.05)	8.2	2.2	7.5	1.5	1.0	1.7	1.01	0.62	0.99	10.9	4.2	10.7
Interaction (B x N)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V. %	13.1	11.6	9.2	13.5	12.40	8.8	12.6	11.02	7.32	13.8	11.9	9.4

Table: 6 : Effect of bio-regulators and fertility levels on available N, P_2O_5, S and Zn status of soil after harvest of mustard crop

Treatments	Available nutrient status in soil			
	N (kg/ha)	P_2O_5 (kg/ha)	S (mg/kg)	Zn (mg/kg)
Bio-regulators (B)				
B_0 : Water spray (control)	173.94	37.18	7.76	0.37
B_1 : Brassinosteroid (0.5 ppm)	177.19	38.73	7.94	0.38
B_2 : Salicylic acid (100 ppm)	174.74	37.89	7.81	0.37
B_3 : Cycocel (1500 ppm)	179.63	39.50	8.21	0.39
S.Em.±	2.10	0.61	0.14	0.01
C.D. (P=0.05)	NS	NS	NS	NS
Fertility levels (N)				
N_1 : N_{50}	170.37	36.26	7.35	0.31
N_2 : N_{50} P_{50}	175.66	37.93	7.49	0.35
N_3 : N_{50} P_{50} S_{40}	179.10	39.42	8.40	0.40
N_4 : N_{50} P_{50} S_{40} $Zn_{1.68}$	180.38	39.68	8.49	0.46
S.Em.±	2.10	0.61	0.14	0.01
C.D. (P=0.05)	6.07	1.76	0.41	0.02
Interaction (B x N)	NS	NS	NS	NS
C.V. %	4.13	5.52	6.18	5.40

Table 7 : Effect of economics on bio-regulators and fertility levels

Treatments	Seed yield (kg/ha)	Stover yield (kg/ha)	Gross realization (₹/ha)	Cost of cultivation (₹/ha)	Net realization (₹/ha)	BCR
Bio-regulators (B)						
B_0 : Water spray (control)	2034	4687	73528	28221	45307	2.61
B_1 : Brassinosteroid (0.5 ppm)	2530	5136	91129	28484	62645	3.20
B_2 : Salicylic acid (100 ppm)	2450	5056	88276	28524	59752	3.09
B_3 : Cycocel (1500 ppm)	2624	5313	94491	30401	64090	3.11
Fertility levels (N)						
N_1 : N_{50}	2123	4306	76445	26490	49955	2.88
N_2 : N_{50} P_{50}	2339	4834	84285	28640	55645	2.94
N_3 : N_{50} P_{50} S_{40}	2532	5481	91344	30050	61294	3.04
N_4 : N_{50} P_{50} S_{40} $Zn_{1.7}$	2645	5574	95349	30452	64897	3.13

This might be due to increase in glucoside formation (allysiothiocynate) and also sulphur as a constitute of multi enzyme complex. In addition to this vital role, phosphorus is also structural component of nucleic acid, phytin, phospholipids and enzymes. Sulphur is a constitute of S containing amino acid, thus influences synthesis of protein. The positive influence of NPSZn fertilization on nutrient status of plant parts seems to be due to their increased availability in the root zone. Higher content of N, P, S and Zn in both mustard seed (except P and Zn) and stover as well as drastic increase in seed yield and stover yield consequently resulted in more uptake of N, P, S and Zn by mustard crop. Several researcher have noted significantly higher uptake of N, P, K and S by seed and stover of mustard (Singh *et al*. 2010); total N, P, K and Zn uptake by mustard (Trivedi *et al*. 2013) Several researchers have reported that combine application of macro and micro-nutrients significantly increased nutrients status in the soil after harvest of crop. (Gadhiya *et al*. 2009, Ameta *et al*. 2014).

Commented [u6]: Your discussion part lacks implication or justification of the result. And also limited to support with recent and previous studies

Conclusion

In light of results obtained from present investigation, it is concluded that for getting higher seed and stover yield as well as net return from mustard, the crop should be given two foliar spray of cycocel @ 1500 ppm each at 35 and 50 days after sowing along with application of 50 kg N + 50 kg P_2O_5 +40 kg S/ha under North Gujarat Condition.

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