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Yogesh Upadhyay
Department of soil science, Sam Higginbottom Institute of Agriculture, Technology & Sciences, Allahabad, (U.P.) India

Narendra Swaroop
Department of soil science, Sam Higginbottom Institute of Agriculture, Technology & Sciences, Allahabad, (U.P.) India

Soman Singh Dhruw
Department of soil science, Sam Higginbottom Institute of Agriculture, Technology & Sciences, Allahabad, (U.P.) India

Ashish Mashih
Department of soil science, Sam Higginbottom Institute of Agriculture, Technology & Sciences, Allahabad, 211 007 (U.P.) India

Prakash Dev Verma
Department of soil science, Sam Higginbottom Institute of Agriculture, Technology & Sciences, Allahabad, 211 007 (U.P.) India

Correspondence
Yogesh Upadhyay
Department of soil science, Sam Higginbottom Institute of Agriculture, Technology & Sciences, Allahabad, (U.P.) India

Interaction Effects of different doses of Sulphur and Zinc with NPK on Growth of Yellow Mustard (*Brassica compestris* L.)

Yogesh Upadhyay, Narendra Swaroop, Soman Singh Dhruw, Ashish Mashih and Prakash Dev Verma

Abstract
The field experiment was carried out at Department of Soil Science, Sam Higginbottom Institute of Agriculture, Technology and Science, Allahabad, India during *rabi season*. The experiment was laid out in 3×3 factorial randomized block design with 9 treatments in three replications. It was observed that the growth characters in treatment T_9 (@ 45 kg Sulphur ha^{-1} + 5.5 kg Zinc ha^{-1}) in respect to different day's intervals i.e. 25, 50, 75 and 100 days after sowing (DAS). Plant height was 2.25, 26.26, 104.88 and 105.40 cm found to be significant at 25 and 75 DAS but non-significant at 50 and 100 DAS, no. of leaves $plant^{-1}$ were 6.31, 10.97, 15.45 and 11.22 found to be non-significant at 25 DAS but significant at 50, 75 and 100 DAS, maximum dry weight of plant (g) was recorded as 0.99 in (T_5), 19.49 in (T_9), 19.62 in (T_5) and 21.37 (T_5) respectively at 25, 50, 75 and 100 DAS was found significant at 25, 75 and 100 DAS, whereas found non-significant at 50 DAS, maximum no. of primary branches $plant^{-1}$ was 11.33 found to be significant. Highest no of secondary branches were found in T_8 (@ 45 kg Sulphur ha^{-1} + 2.75 kg Zinc ha^{-1}) which was 16.77 and found to be significant. However, since these findings are based on one year experiment and therefore, further research may be conducted to substantiate it under Allahabad agro climatic conditions.

Keywords: Sulphur, Zinc, Growth, Yellow Mustard

1. Introduction
Yellow mustard (*Brassica compestris* L.) commonly known as raya, rai or lahi is an important oilseed crop among the Brassica group of oilseed in India. It's the second most important edible oilseed crop in India after groundnut and accounts for nearly 30% of the total oilseeds produced in the country. Rapeseed-mustard is an important group of edible oil seed crops and contributes around 26.1% of the total oil seed production and contributes about 85% of the total rapeseed–mustard produced in India (Meena *et al.* 2011) [6]. The first position in area and second position in Production after China (Anonymous 2009) [1]. Rape seed and mustard crops are cultivated in 53 countries across the globe covering an area of 24.2 million hectare. Indians contribution to world hectare and production is 28.3 and 19.8 percent respectively. Mustard is rich in minerals like calcium, manganese, copper, iron, selenium, zinc, vitamin A, B, C and proteins. 100g mustard seed contains 508 kcal energy, 28.09g carbohydrates, 26.08g proteins, 26.08 g total fat and 12.2g dietary fiber**.** Nitrogen is the most important nutrient, which determines the growth of the mustard crop and increases the amount of protein and the yield. Phosphorus and potash are known to be efficiently utilized in the presence of nitrogen. It promotes flowering, setting of siliqua and in increase the size of siliqua and yield. Sulphur is also an important nutrient and plays an important role in physiological functions like synthesis of cystein, methionine, chlorophyll and oil content of oil seed crops. It is also responsible for synthesis of certain vitamins (B, biotin and thiamine), metabolism of carbohydrates, proteins and oil formation of flavoured compounds incrucifers. *Brassica* has the highest sulphur requirement owing to the presence of sulphur rich glucosinolates. (Ram Bharose *et al*., 2010) [2]**.** Potassium is one of the seventeen elements which are essential for growth and development of plants. It's for improving the yield and quality of different crops because of its effect on photosynthesis, water use efficiency and plant tolerance to diseases, drought and cold as well for making the balance between protein and carbohydrates. (Singh *et al*., 2010) [7]
The technology mission in oilseed initiated in 1986 paved the way to meet different challenges and complexities in the oilseed sector. There was five times increase in oilseed production during the period revising 1950-2004 under predominantly rainfed agro-ecological conditions. These were higher than even the corresponding production increase in total food grains during 2003-2004. Even with a record oilseed production of 25.1 million tones, India imported

51 lakh tones of vegetable oils costing more than Rs. 11000 crores. The country's demand for vegetable oils is expected to increase from the current level of 13 millions tones to 14.8, 18.3 and 21.8 million tons by 2010, 2015 and 2020 respectively (Hedge, 2007) [4]. In Uttar Pradesh, mustard occupies an area of 0.781 million hectares and production of 0.957 million tones (Hedge, 2007) [4]. Nearly 76% oilseeds area is rainfed which is often subjected to erratic monsoon.

The oil content of the yellow mustard seeds ranges from 41-47 % and 20-40 % protein. The seed and oil are used as condiments in the preparation of pickles and for flavoring curries and vegetables. The oil cake is mostly used as a cattle feed and the leaves of young plants are used as green vegetables. The use of mustard oil for industrial purposes is rather limited on account of its high cost. Apart from this yellow mustard cake is also used as organic manure for the soil.

The crop requires relatively cool temperate, a fair sunny and moist weather during the growing period and dry weather during harvest period. Above all the major drawback in the low yield is that is generally grown as a mixed crop potato, sugarcane and gram without the additional application of essential plant nutrient like nitrogen, phosphorus, potash and sulphur.

Materials and Methods

The experiment was conducted during *rabi season* at Crop research farm Department of Soil Science Allahabad School of Agriculture SHIATS-DU Allahabad. The experimental site is located in the sub – tropical region with 25^0 27^1 N *latitude* 81^0 51^1 E longitudes and 98 meter the sea level *altitudes*. The experiment was laid out in a 3^2 RBD factorial design with three levels of each Sulphur and Zinc with nine treatments, each consisting of three replicates. The total number of plots was 27. Yellow Mustard (*Brassica compestris* L.) Var. Krshna Super Goldi' were sown in Rabi season plots of size 2 x 2 m with row spacing 30 cm and plant to plant distance 10 cm. The Soil of experimental area falls in order of Inceptisols and is alluvial in nature, both the mechanical and chemical analysis of soil was done before starting of the experiment to ascertain the initial fertility status. The soil samples were randomly collected from0-15cm depths prior to tillage operations. The treatment consisted of nine combination of inorganic source of fertilizers T_1 (@ 15 kg S ha^{-1} + 1.35 kg Zn ha^{-1}), T_2 (@ 15 kg S ha^{-1} + 2.75 kg Zn ha^{-1}), T_3 (@ 15 kg S ha^{-1} + 5.5 kg Zn ha^{-1}), T_4 (@ 30 kg S ha^{-1} + 1.35 kg Zn ha^{-1}), T_5 (@ 30 kg S ha^{-1} + 2.75 kg Zn ha^{-1}), T_6 (@ 30 kg S ha^{-1} + 5.5 kg Zn ha^{-1}), T_7 (@ 45 kg S ha^{-1} + 1.35 kg Zn ha^{-1}), T_8 (@ 45 kg S ha^{-1} + 2.75 kg Zn ha^{-1}), T_9 (@ 45 kg S ha^{-1} + 5.5 kg Zn ha^{-1}).The source of Sulphur and Zinc as Milvet Sulphur and Zinc sulphate respectively.

Physical and chemical analysis of soil samples (pre-sowing)

Table 1: Physical analysis of soil

Particulars	Method employed	Results
Sand (%)	Bouyoucous Hydrometer	68.00
Silt (%)	method **Bouyoucous (1927)**	17.50
Clay (%)		14.50
Textural class		Sandy loam
Bulk density (Mg m^{-3})	Graduated measuring cylinder Black (1965)	1.63
Particle density (Mg m^{-3})	Graduated measuring cylinder Black (1965)	2.69
Pore Space (%)	Graduated measuring cylinder Black (1965)	53.22

Table 2: Chemical analysis of soil

Particulars	Method employed	Results
pH (1:2)	Glass electrode, pH meter	7.24
	(Jackson, 1958)	
EC (dS m^{-1})	EC meter (Digital Conductivity Meter)	0.23
	(Wilcox, 1950)	
Organic Carbon (%)	(Walkley and Black's method 1947)	0.49
Available Nitrogen (kg ha^{-1})	Alkaline potassium permanganate method	
	(Subbaih and Asija (1956).	280.70
Available Phosphorus (kg ha^{-1})	Colorimetric method	
	(Olsen *et al.* 1954)	17.96
Available Potassium (kg ha^{-1})	Flame photometric method	258.00
	(Toth and Prince, 1949)	
Available Sulphur (kg ha^{-1})	Turbidemetric	17.25
	(Chesnin&Yien1950)	
Available Zinc (kg ha^{-1})	Spectrophotometer	2.25
	(Shaw and Dean1952)	

Results and Discussion

Table 3: Plant growth parameter

Treatment	Plant height (cm)				Number of leaves			
	25 DAS	50 DAS	75 DAS	100 DAS	25 DAS	50 DAS	75 DAS	100 DAS
T_1	1.65	15.14	95.08	96.21	4.13	6.49	8.60	6.05
T_2	1.57	18.28	98.66	99.37	4.97	8.42	12.23	7.07
T_3	1.68	17.56	96.16	96.96	4.93	7.97	11.79	7.05
T_4	1.59	17.06	93.71	94.68	5.15	9.49	12.49	9.10
T_5	1.88	21.86	100.5	101.29	5.40	9.42	14.23	9.97
T_6	2.14	19.63	102.1	102.87	6.13	10.34	14.53	10.42
T_7	2.02	24.10	102.4	102.83	5.45	8.79	12.53	7.51
T_8	1.66	23.14	99.34	100.21	6.07	9.82	14.07	8.07
T_9	2.25	26.26	104.8	105.40	6.31	10.97	15.45	11.22
F-test	S	NS	S	NS	NS	S	S	S
S.Ed. (±)	0.124	1.579	2.443	2.436	0.923	0082	0.141	0.44
C.D. (at 05%)	0.263	3.347	5.179	5.164	1.957	0.173	0.298	0.94

Growth parameters

Table 3 & 4 shows the interaction effect of different doses of Sulphur and Zinc with NPK the important growth parameters of yellow mustard crop.

Plant height (cm)

Increase in plant height due to increasing of sulphur and zinc with NPK may be due to adequate nutrients which is turns help in vigorous vegetative growth of plants and subsequently increase the plant height through cell elongation cell division photosynthesis and turbidity of plant cell. The maximum height recorded as 2.25, 26.26, 104.88 and 105.40 respectively at 25, 50, 75 and 100 DAS in treatment T_9 (@ 45 kg Sulphur ha^{-1} + 5.5 kg Zinc ha^{-1}). Similar results have also been recorded by Tripathi *et al.* (2011) [11].

Number of leaves per plant

The effect of different doses of sulphur and zinc with NPK on no. of leaves $plant^{-1}$ was found significant at 50, 75 and 100 DAS, whereas found non-significant at 25 DAS. The maximum no. of leaves $plant^{-1}$ was recorded as 6.31, 10.97, 15.45 and 11.22 respectively at 25, 50, 75 and 100 DAS in treatment T_9 (@ 45 kg Sulphur ha^{-1} + 5.5 kg Zinc ha^{-1}). Similar results have also been recorded by Tripathi *et al.* (2011) [11].

Table 4: Plant growth parameter

Treatment	Dry weight of plant (g)				Number of branches	
	25 DAS	50 DAS	75 DAS	100 DAS	Primary	Secondary
T_1	0.79	16.84	18.93	20.68	8.54	10.77
T_2	0.61	15.97	19.19	20.94	9.44	11.66
T_3	0.87	15.53	19.07	20.82	9.44	13.00
T_4	0.62	15.81	18.23	19.98	9.66	13.44
T_5	0.99	18.27	19.62	21.37	9.77	14.33
T_6	0.86	17.39	17.64	19.39	10.11	15.00
T_7	0.87	17.76	19.41	21.16	10.89	15.66
T_8	0.76	15.75	17.93	19.68	10.44	16.77
T_9	0.87	19.49	17.57	19.32	11.33	15.55
F-test	S	NS	S	S	S	S
S.Ed. (±)	0.117	1.318	0.267	0.267	0.276	0.575
C.D. (at 05%)	0.248	2.794	0.567	0.567	0.584	1.218

Dry weight of plant (g)

The effect of different doses of sulphur and zinc with NPK on dry weight of plant (g) was found significant at 25, 75 and 100 DAS, whereas found non-significant at 50 DAS. The maximum no. of dry weight of plant (g) was recorded as 0.99 in (T_5), 19.49 in (T_9), 19.62 in (T_5) and 21.37 (T_5) respectively at 25, 50, 75 and 100 DAS. Similar results have also been recorded by Tripathi *et al.* (2011) [11].

Number of primary and secondary branches per plant

The effect of different doses of sulphur and zinc with NPK on no. of primary and secondary branches $plant^{-1}$ was found to be significant. The maximum no. of primary branches $plant^{-1}$ was recorded as 11.33 in treatment T_9 (@ 45 kg Sulphur ha^{-1} + 5.5 kg Zinc ha^{-1}) where as maximum no. of secondary branches $plant^{-1}$ was recorded as 16.77 in treatment T_8 (@ 45 kg Sulphur ha^{-1} + 2.75 kg Zinc ha^{-1}). Similar results have also been recorded by Tripathi *et al.* (2011) [11].

Conclusion

It is concluded that the best growth characters in treatment T_9 (@ 45 kg Sulphur ha^{-1} + 5.5 kg Zinc ha^{-1}) in respect to different days intervals i.e. 25, 50, 75 and 100 days after sowing (DAS). Plant height was 2.25, 26.26, 104.88 and 105.40 cm found to be significant at 25 and 75 DAS but non-significant at 50 and 100 DAS, no. of leaves $plant^{-1}$ were 6.31, 10.97, 15.45 and 11.22 found to be non-significant at 25 DAS but significant at 50, 75 and 100 DAS, maximum dry weight of plant (g) was recorded as 0.99 in (T_5), 19.49 in (T_9), 19.62 in (T_5) and 21.37 (T_5) respectively at 25, 50, 75 and 100 DAS was found significant at 25, 75 and 100 DAS, whereas found non-significant at 50 DAS, maximum no. of primary branches $plant^{-1}$ was 11.33 found to be significant. Highest no of secondary branches was found in T_8 (@ 45 kg Sulphur ha^{-1} + 2.75 kg Zinc ha^{-1}) which was16.77 and found to be significant.

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