The Bioscan 13(2): 689-693, 2018
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.com

INFLUENCE OF K, S AND ZN ON GROWTH, YIELD, NUTRIENT UPTAKE AND QUALITY PARAMETERS OF MUSTARD IN UDIC HAPLUSTEPTS KANPUR

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KEYWORDS
Soil Fertility
Nutrient uptake
Protein content
udic Haplustepts

Received on :
26.08.2017

Accepted on :
08.04.2018

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ABSTRACT
The Present investigation were conducted for two rabi season during 2011-12 and 2012-13 in the field of Nawabganj Research Farm, C.S. Azad University of Agriculture and Technology, Kanpur, to study the effect of potassium, sulphur and zinc application on yield attributes, yield, quality parameters of mustard.Treatment consisted of 3 levels each of potassium, (0, 60 and 80 kg/ ha), sulphur (0, 40 and 60 kg /ha) and zinc (0, 3.0 and 5.0 kg /ha). The Results indicated that yield attributes,seed and Stover yield increased significantly with the use of K,S and Zn over the control.K, S and Zn application @ 60 kg K_2O/ha, 40 kg S /ha and 3.0 kg Zn / hasignificantly increased yield attributes, seed and stover yields and further increase, levels of these nutrients, reduced yield attributes, seed and stover yield of mustard during both the years. The uptake of nutrients significantly increased upto K_{60} S_{40} $Zn_{3.0}$ levels and further increasing of K, S and Zn doses, decline nutrients uptake by mustard crop (vari. Pitambri).Oil and protein content significantly increased by the use of 60 kg K_2O and 40 kg S /ha.

INTRODUCTION

India is the fourth largest oilseed economy in the world after USA, China and Brazil rapeseed-mustard is predominantly grown in the northern belt of India and its production has been growing over the past decade. Mustard is also an extremely versatile crop and can easily be grown even in dry, arid and scantily irrigated areas. Being strongly pest-resistant, it is a safe and cost-effective crop for Indian farmers to focus on. The world production of rapeseed-mustard has been increasing at rapid rate in several countries largely in response to the continuing increase in demand for edible oils and its products. (Yadav *et al.,* 2017) The nutrient requirements of mustard is similar to rice and wheat and they thrive under varied edaphic regimes. In general, farmers apply low rates of nitrogen (N) and phosphorus (P), but potassium (K) is frequently absent from their fertilizer schedule. This lack of K is responsible for low yields and poor crop quality because, apart from other major physiological and biochemical requirements in plant growth, K is a key nutrient element in the biosynthesis of oil in oilseeds and protein in pulse crops. (Tiwari *et al.,* 2012) Potassium (K) is very essential plant nutrient in balanced fertilization for sustainable crop production. Although potassium application to soils is proved to be beneficial as increase in crop yield, preventing diseases and pest infestation, increases nutrient use efficiency of other nutrients. Sulpur perform many physiological functions and most of the S in plants occurs as amino acids and application is expressed on yield and oil content of produce. It involved in the synthesis amino acids, *i.e.* cysteine, cysteine and methionine which are important components of plant protein (Jaiswal *et al.*,2015). Zinc is involved in the biosynthesis of a plant hormones like indol acetic acid (IAA) which is a component of variety of enzymes such as carbonate anhydrase, alcohol dehydrogenase etc. Zinc play a role in nucleic acid and protein synthesis and helps in the utilization of phosphorus and nitrogen as well as in seed formation. (Raj *et al.,* 2013). Yet there is a lack of sufficient research information pertaining to the effect of potassium, sulper and zinc fertilization on yield of mustard in udic Haplustepts of central Utter Pradesh so the paper deals with the influence of K, S and Zn on growth, yield, nutrient uptake and quality parameters of mustard.

MATERIALS AND METHODS

The Field Experiment was conducted during rabi 2011-12 and 2012-13 in Nawabganj Research Farm, C.S. Azad University of Agriculture and Technology, Kanpur to study the effect of different doses potassium, sulphur and zinc on the yield, quality parameters of mustard was carried out in udic Haplustepts series soil. Treatment consisted of 3 levels each of potassium, (0,60 and 80 kg/ ha),sulphur (0, 40 and 60 kg/ha) and zinc (0,3.0 and 5.0 kg/ha) applied as a whole at the time of sowing. The experiment laid out in a factorial randomized block design with three replications. Mustard (Pitambri) was sown during third week of October and harvested at first week of March. The plant samples were collected at harvest, oven dried at 70°C, processed and analyzed for total K, S and Zn following standard procedures. The grain and straw yield of mustard were recorded and soil

samples (0–20 cm) were collected from each plot after harvest of mustard. These samples were analyzed for pH (1:2.5 soil: water suspension), electrical conductivity by conductivity meter, organic carbon by rapid titration method (Walkley and Black 1936). Available N was estimated by alkaline permanganate method (Subbiah and Asija 1956), available P by Olsen's method (Olsen *et al.,* 1954), available K by ammonium acetate extraction method (Jackson 1967) and available S was estimated by turbidimetric method (Chesnin and Yien 1950). The Available Zn was extracted with DTPA and determined by atomic absorption spectrophotometer as described by Lindsay and Norvell, (1978). Oil content was determined by the Soxhlet's extractor using petroleum ether as extractant and oil yield was determined by multiplying the same with seed yield. The soil of experiment field loamy sand and initial pH (1:2.5) was 7.5 , EC (1:2.5) 0.30 dSm^{-1}, organic carbon 0.41, $CaCO_3$ (%) 24,Available N 174.1kg/ ha, Available P 24.2 kg /ha and K 208.0kg /ha, Sulphur16.80 kg /ha and zinc 0.35 mg/kg.

RESULTS AND DISCUSSION

Growth and yield attributes

Different production factors had marked effect on growth and yield attributes characteristics (Table1).Increasing levels of potassium upto 60 kg ha^{-1}, sulphur 40 kg ha^{-1} and zinc 3.0 kg ha^{-1} increased, plant height, dry matter production /plant, primary and secondary branches /plant, number of siliqua, siliqua length and test weight of one thousand grains of mustard. Biswas and Poddar (2015) also described that

Table 1: Effect of K, S and Zn levels on Growth Characters of Mustard var. pitambri

Treatment	Plant height (cm)		No. of branches /plant				No. of siliquae /plant		No. of seed /Siliquae		Length of siliqua (cm)		1000 Seed weight(g)	
			Primary		Secondary									
	Y*	Y**	Y*	Y**	Y*	Y**	Y*	Y**	Y*	Y**	Y*	Y**	Y*	Y**
K level kg /ha														
K_0	114.2	116.7	5.2	5.4	15.4	16.4	181.1	185	10.6	11.5	4.56	4.76	4.97	4.99
K_{60}	138.7	142.5	6.1	6.3	18	19.1	217.9	221.8	11.6	12.5	5.92	6.19	5.1	5.11
K_{80}	131.9	134.7	5.8	6.2	17.4	18.4	209.2	213.1	11.4	12.3	5.28	5.49	5.08	5.09
S.E.(d)	1.59	2.02	0.07	0.08	0.16	0.15	2.41	2.35	0.16	0.17	0.19	0.22	0.03	0.03
C.D. (P=0.05)	3.19	4.05	0.15	0.16	0.33	0.29	4.84	4.72	0.33	0.34	0.38	0.43	0.06	0.05
S level kg /ha														
S_0	117.4	121.4	5.29	5.64	15.8	16.8	186.1	189.5	10.7	11.7	4.94	5.13	4.99	5.01
S_{40}	135	138	5.91	6.19	17.6	18.7	214.3	217.6	11.4	12.4	5.38	5.63	5.08	5.1
S_{60}	132.4	134.5	5.79	6.1	17.3	18.4	207.7	212.8	11.3	12.3	5.43	5.68	5.07	5.08
S.E.(d)	1.59	2.02	0.07	0.08	0.16	0.15	2.41	2.35	0.16	0.17	0.19	0.22	0.03	0.03
C.D. (P=0.05)	3.19	4.05	0.15	0.16	0.33	0.29	4.84	4.72	0.33	0.34	0.38	0.43	0.06	0.05
Zn level kg /ha														
Zn_0	122.9	124.4	5.4	5.8	17.4	17.2	192.8	195.6	10.9	11.8	5.21	5.44	5	5.02
$Zn_{3.0}$	131.8	135.4	5.8	6.1	17.2	18.4	208.8	213.6	11.4	12.3	5.22	5.45	5.08	5.09
$Zn_{5.0}$	130.1	134.2	5.7	6	16.9	18.3	206.4	210.7	11.3	12.2	5.33	5.54	5.06	5.08
S.E.(d)	1.59	2.02	0.07	0.08	0.16	0.15	2.41	2.35	0.16	0.17	0.19	0.22	0.03	0.03
C.D. (P=0.05)	3.19	4.05	0.15	0.16	0.33	0.29	4.84	4.72	0.33	0.34	NS	NS	0.06	0.05

Table 2 : Effect of K, S and Zn levels on yield and quality characters of mustard var. pitambri

Treatment	Seed yield (t/ ha)		Stover yield (t /ha)		Harvest Index (%)		Oil content (%)		Oil yield (kg /ha)		Protein content (% in meal)		Protein yield (kg /ha)	
	Y**	Y*	Y**	Y*	Y**	Y*	Y**	Y*	Y**	Y*	Y**	Y*	Y**	
K level kg /ha														
K_0	1.583	1.661	3.557	3.571	30.8	31.8	37.89	38.1	598	633	19.63	21.21	311	352
K_{60}	1.945	2.018	4.192	4.162	31.7	32.6	38.91	39.18	759	793	23.05	23.53	448	475
K_{80}	1.941	1.979	4.098	4.123	32.2	32.4	38.87	38.94	755	772	22.69	22.19	440	439
S.E.(d)	0.02	0.02	0.03	0.04	0.22	0.26	0.28	0.31	0.09	0.09	0.57	0.56	0.12	0.11
C.D. (P=0.05)	0.042	0.037	0.047	0.068	0.443	0.532	0.556	0.624	0.183	0.191	1.14	1.12	0.24	0.22
S level kg /ha														
S_0	1.685	1.746	3.661	3.735	31.5	31.8	37.42	37.32	631	651	20.35	20.91	343	365
S_{40}	1.906	1.978	4.16	4.19	31.4	32.1	38.75	38.98	738	771	22.83	23.44	435	464
S_{60}	1.878	1.935	4.026	4.1	31.8	32.1	39.35	39.92	739	772	22.61	22.43	425	434
S.E.(d)	0.02	0.02	0.03	0.04	0.22	0.26	0.28	0.31	0.09	0.09	0.57	0.56	0.12	0.11
C.D. (P=0.05)	0.414	0.371	0.471	0.679	0.443	0.532	0.556	0.624	0.183	0.191	1.14	1.12	0.24	0.22
Zn level kg /ha														
Zn_0	1.749	1.798	3.77	3.826	31.7	31.8	38.23	38.5	670	693	21.2	21.42	371	385
$Zn_{3.0}$	1.865	1.935	4.051	4.034	31.5	31.9	38.58	38.85	721	754	22.18	22.83	414	442
$Zn_{5.0}$	1.864	1.926	4.026	39.95	31.5	32.3	38.71	38.87	719	751	21.99	22.67	408	437
S.E.(d)	0.02	0.02	0.03	0.04	0.22	0.26	0.28	0.31	0.09	0.09	0.57	0.56	0.12	0.11
C.D. (P=0.05)	0.042	0.037	0.047	0.068	0.443	0.532	NS	NS	0.183	0.191	NS	NS	0.24	0.22

2011-12 **2012-13

Table3: Effect of K, S and Zn levels on nutrients uptake of mustard var. pitambri

Treatment	Potassium uptake (kg/ha)						Sulphur uptake (kg/ha)						Zinc uptake (kg/ha)					
	Grain		Straw		Total		Grain		Straw		Total		Grain		Straw		Total	
	Y*	Y**	Y*	Y**	Y*	Y**	Y*	Y**	Y*	Y**	Y*	Y**	Y*	Y**	Y*	Y**	Y*	Y**
K level kg /ha																		
K_0	13.49	15.33	46.45	51.81	59.94	67.16	9.01	10.74	11.97	12.09	20.98	22.86	0.111	0.147	0.119	0.129	0.229	0.276
K_{60}	19.25	20.89	65.26	69.66	84.51	89.35	12.88	15.12	16.16	16.33	29.03	31.56	0.163	0.202	0.166	0.17	0.329	0.375
K_{80}	18.81	20.03	62.64	67.14	81.45	87.39	12.4	14.56	14.9	15.41	27.32	30.02	0.16	0.196	0.158	0.16	0.316	0.357
S.E.(d)	0.36	0.51	0.87	0.76	1.24	1.27	0.17	0.22	0.27	0.26	0.45	0.48	0.003	0.003	0.002	0.002	0.005	0.006
C.D. (P=0.05)	0.72	1.02	1.75	1.54	2.47	2.55	0.35	0.45	0.55	0.53	0.91	0.98	0.006	0.007	0.003	0.004	0.01	0.013
S level kg /ha																		
S_0	15.49	16.78	49.06	56.06	64.55	72.84	9.84	11.66	12.37	12.79	22.21	24.45	0.126	0.16	0.129	0.137	0.255	0.297
S_{40}	18.38	20.11	64.15	68.95	82.53	89.06	12.36	14.68	15.76	16.15	28.12	30.83	0.155	0.195	0.162	0.169	0.317	0.364
S_{60}	17.67	19.36	61.14	66.77	78.81	86.13	12.09	14.08	14.91	15.63	27	29.71	0.153	0.191	0.152	0.16	0.305	0.351
S.E.(d)	0.36	0.51	0.87	0.764	1.233	1.272	0.17	0.22	0.27	0.26	0.45	0.48	0.003	0.004	0.002	0.003	0.005	0.006
C.D. (P=0.05)	0.73	1.02	1.75	1.534	2.473	2.553	0.35	0.45	0.55	0.53	0.91	0.98	0.006	0.008	0.004	0.006	0.01	0.013
Zn level kg /ha																		
Zn_0	15.67	17.18	53.04	58.44	68.71	75.72	10.65	12.3	12.93	13.05	23.58	25.5	0.135	0.17	0.143	0.148	0.273	0.315
$Zn_{3.0}$	18.22	16.58	61.27	65.75	79.5	87.26	11.88	14.1	15.28	15.61	27.27	30.09	0.15	0.188	0.158	0.164	0.305	0.35
$Zn_{5.0}$	17.66	1995	60.04	64.42	77.7	85.07	11.75	14.03	14.83	15.17	26.58	29.42	0.149	0.187	0.157	0.164	0.299	0.346
S.E.(d)	0.36	0.51	0.87	0.76	1.24	1.27	0.17	0.22	0.27	0.26	0.45	0.48	0.003	0.004	0.002	0.003	0.005	0.006
C.D. (P=0.05)	0.72	1.02	1.75	1.54	2.47	2.55	0.35	0.45	0.55	0.53	0.91	0.98	0.006	0.007	0.004	0.006	0.01	0.013

significant in booting of plant height with the application of 60 kg S ha^{-1}against 0 kg S ha^{-1}. Increasing dose of K, S and Zn beyond 60, 40 and 3.0 kg ha^{-1} respectively tended to decline these yield attributing characters.Potassium and sulphur when combined together increased significantly test weight of 1000 seed weight.Combination of K Zn and S Zn also showed theirs positive effect on test weight and other yield attributing characters under study, since potassium, sulphur and zinc are essential for plant growth, like, potassium accelerate activation in metabolic process, carbohydrates translocation and protein synthesized. Sulphur required for carbohydrate formation and plant vital role in photosynthesis by influencing the formation of chlorophyll which ultimately improved growth and development. Zinc play role as catalyst in most of physiological process and metal activation enzymes, promoting growth and development of plant. Participated in catabolic physiological process of the plants and their stimulating effects on such yield attributing are quiet likely. These results are in line with those reported by Singh*et al*. (2010).

Grain and stover yield

Grain and stover yield were always significantly increased due to application of potassium and recorded 1.551 and 4.098 t/ ha during first year and 1.886 and 4.123 t/ ha during second year, respectively. At 60 kg K_2O /haresponse of potassium on grain yield were 22.84 and 21.52 percent and on stover 17.85 and 16.64 percent over control during 2011-12 and 2012-13, respectively. Since K application had pronounce improvement in yield contributory characters and thereafter, were found to be positively correlated with yield beneficial effect of K on grain and stover yields was very much expected higher yield response with the application of potassium was also reported. Application of sulphur @ 40 kg/ ha significantly increased grain and stover yields during both the years. The highest grain yields 1.906 and 1.978 t/ha of mustard were recorded with the application of sulphur @ 40 kg/ha which were 13.10 and 13.34 % higher in comparison to control during 2011-12 and 2012-13, respectively.

Application of sulphur enhanced the stover yield significantly during both years. Highest stover yields of 4.160 and 4.073 t/ha were obtained at 40 kg S/ha, which computed 13.66 and 8.73 percent higher in comparison to the lowest yield of 3.661 and 3.746 obtained at its control in 2011-12and 2012-13, respectively. These results are in agreement with the finding of Badiger *et al*. (1982), Mishra (2001) and Jaggi (1994).Like K andS , Zinc application @ 3.0 kg Zn /ha caused considerable increase in the yield of grain and stover as yield attributes were also improved with its application. Application of zinc @ 3.0 kg Zn /ha increased grain yield 6.59 and 7.63 percent in compression to control during first and second years respectively. The highest stover yield of 4.051 and 4.034 q/ ha were with the use of 3.0 kg Zn/ ha, Stover yield were increased 7.45 and 5.44 percent over that of control during 2011-12 and 2012-13, respectively. Similar finding was reported by Shekhawat *et al*. (2012). None of the interaction except K*S in case of grain and stover yield was found to be statistically significant.

Quality characteristics

Oil content was increased significantly with the use of

Table4: Interactive effects of K and S levels on seed yield, stover yield of mustard.

S (kg/ ha)	K (kg/ha)					
	2011-12			2012-13		
	0	40	60	0	60	80
Seed Yield						
0	15.05	16.33	16.11	15.66	17.49	16.66
60	17.35	20.56	20.43	18.27	21.32	20.96
80	18.15	20.27	19.79	18.43	20.54	20.41
S.E.(d)	0.35	0.31				
C.D. (at 5%)	0.71	0.64				
Stover yield						
0	33.47	37.02	36.21	33.73	36.74	36.31
60	38.51	44.42	42.84	39.34	46.12	44.50
80	37.83	43.39	41.73	39.00	42.84	42.19
S.E.(d)	0.40	0.58				
C.D. (at 5%)	0.81	1.17				

potassium @ 60 Kg potash / ha. Increase in oil content due to potassium application is attributed to increase in the activity of enzymes involved in fat synthesis. Pathak *et al*. (1999) also arrived at similar conclusion.Application of sulphur significantly increased the percent oil in mustard seed during both the years. Increase in the oil content with sulphur application might be due to role of sulphur in oil synthesis, As sulphur is a constituent of glutathione, a compound that play a vital role in oil synthesis. These results corroborate with the findings of Chauhan *et al*. (2002), observed that the quality of oil improved by sulphur fertilization due to this, depressing effects of saponification andiodine number. Zinc application although tended to increase the percent oil in mustard seed but practically it was non-significant. None of the interaction could show any beneficial effect on oil content in mustard seed.Mean oil yields were 7.04 and 7.33 (q/ ha), respectively during first and second year. Oil yield increased significantly with the use of potassium, sulphur and zinc @ 60 kg K_2O, 40 Kg S and 3.0 Kg Zn/ ha. Similar results reported by Singh *et al*. (2003).

The mean values of protein content were 21.79 and 22.31 percent during Rabi 2011-12 and 2012-13 respectively. Protein content was increased significantly with the use of potassium @ 60 Kg K_2O /ha. This is mainly due to increased in nitrogen content in grain and stover of mustard. Potassium has a specific role in protein synthesis, presence of potassium in plant cell activate the protein synthesis enzymes in the plant cell. Similar findings have also been reported by Aulakh *et al*. (1980). Protein content significantly increased with the use of sulphur @ 40 kg per hectare and further increased dose of sulphur fail to enhance protein in the mustard seeds. This is might be due to role of sulphur in protein synthesis. Sulphur is a constituent of essential amino acids viz., methionine, cysteine and cystine. It also helps in conversion of these amino acids into high quality protein. Appropriate structure is essential for protein formation and sulphur provide di-sulphate chains and thus helps in increasing the protein content in mustard.Protein content of mustard non-significantly increased with the use of zinc. Zinc play main role in protein synthesis and as zinc deficiency resulted in sharp reduction in RNA and deformation and reduction of ribosomes hampering protein synthesis as also observed by (Kitagishi and Obata, (1986). Although various interactions stimulates the protein content in the mustard seed but the increased was non- significant.

Protein yield increased significantly with the use of potassium, sulphur and zinc. The protein yield significantly increased upto $K_{60}S_{40}$ and$Zn_{3.0}$ levels and further increased doses of K, S and Zn tented to reduced the protein yield in mustard seeds. This finding are in the line of Deo and Khandelwal (2009) and Chaudhary *et al*. (2003). The interactions $K \times S$, $K \times Zn$, $S \times Zn$ and $K \times S \times Zn$ increased protein yield but the increase was not significant during both the years of experimentation.

Uptake

On an average potassium, sulphur and zinc in the grain and stover increased significantly with the use of potassium @ 60 Kg / hectare, 40 Kg sulphur / hectare and 3.0 kg zinc/hectare and further increasing of potassium doses upto 80 kg reduced the potassium uptake by mustard but the difference between later two doses was found non-significant. Similar result was found by chaudhary *et al*. (2014). This shows the synergetic effect of potassium application on the absorption of potassium, sulphur and zinc. These results are supported by the findings of Pathak *et al*. (1999). Significant increase in uptake of these nutrients are due to increase in yield which is due to the application of sulphur. These results are in line with those reported by Mishra (2001) and Singh *et al*. (2010).Only second order interaction ($K \times S$) significantly increased uptake of sulphur in the grain and potassium- zinc in the stover of mustard crop during both years of experiment. The other interactions moderately increased K, S and Zn uptake in grain and stover of mustard but the increase was not significant. The increase in uptake of these nutrients with use of zinc might be due to its essentiality in yield of mustard and also play role of catalyst in plant body.

REFERENCES

Aulakh, M. S., Pasricha, N. S. and Sahota, N. S. 1980. Yield, nutrient concentration and quality of mustard crops as influenced by nitrogen and sulphur fertilizer.*J. Agricultural Sciences*.**94:** 545-549.

Badiger, M. K., SubbaReddy, N. P., Michael, R. and Shwaraj, B. 1982. Influence of fertilizer potassium, sulphur and calcium on yield and quality attributes of groundnut (Arachis hypogeal L.) *J. the Indian Society of Soil Science*.**30:** 166-169.

Biswas, B. And Poddar, R. 2015. Yield And Nutrients Uptake Of Sunflower (Helianthus Annuusl.) As Influenced By Different Level Of

Nitrogen And Sulphur. *The Bioscan.***10:** 439-444.

Black, C. A. 1965. Methods of Soil Analysis part I and II. *American Society of Agronomy, Inc. Publisher*, Wiseconin, U.S.

Choudhary, Pratibha, Jhajharia,Rrun , Kumar,Rohit 2014. Influence of sulphur and zinc fertilization on yield,yield components and quality traits of soybean(glycine max l.)*The Bioscan.* **9:** 137-142.

Chauhan, D. R., Ram, M. and Singh, I. 2002. Response of Indian mustard (*Brassica juncea* L.) to irrigation and fertilization with various sources and levels of sulphur. *Indian J. Agronomy.***47:** 422-426.

Chesnin, L. and Yien, C. H. 1951.Turbidimeteric determination of available sulphur in soil.*Soil Science Society of America, proceedings.***15:**149-151.

Jackson, M. L., 1973. Soil Chemical Analysis, Prentice Hall of India Private Limited, New Delhi, 187.

Jaiswal, A. D., Singh S. K., Singh, Y. K., Singh, Surendra and Yadav, S. N. 2015 .Effect of Sulphur and Boron on Yield and Quality of Mustard (Brassica juncea L.) Grown on Vindhyan Red Soil . *J. the Indian Society of Soil Science.* **63:**362-364.

Jaggi, R. C. 1994. Response of Raya (Brassica juncea L.) to sulphur through different sources in an acid Alfisol. *J. the Indian Society of Soil Science.***42:** 281-283.

Khekhawat, Kapila.,Rothore, S. S., Premi, O. P., Kandpal and Chauhan, J. S. 2012. Advances in Agronomic management of Indian mustard (Brassica Juncea (L.)Czernji.Cosson).*International J. Agronomy*. 1155.

Kumar, R., Singh, D. and Singh, H. 2002. Effect of nitrogen and sowing dates on productivity of *Brassica* species. *Indian J. Agronomy.***47:** 411- 417.

Lindsay, W. L. and Norvell, W. A. 1978. Development of DTPA soil test for Zn, Fe, Mn and Cu. *J. the American Society of Soil Science.***42:** 421- 428.

Mishra, S. K. 2003. Effect of sulphur and potassium on yield, nutrient uptake and quality characteristics of mustard (Brassica juncea L.) in Udic Haplustepts of Kanpur.*J. the Indian Society of Soil Science.***51:** 544 - 548.

Mishra, S. K., Singh, R. N. and Tiwari, V. N. 2001. Effect of sulphur fertilizer on quality charactrictics of mustard ((B. juncea).*Annals of Plant and Soil.***3:** 206-213.

Mukharjee,D and Singh, R. K. 2002. Influence of sulphur iron and silicon nutrition on growth and yield of mustard. *Haryana J. Agronomy.***18:** 150 -152.

Olsen, S. R., Cole, C.V., Watanabe, F.S. and Dean, L. A. 1954.Estimation of available phosphorus in soils of extraction with sodium bicarbonate. *United State Department Agrriculture.***93:** 9-19.

Pathak, R. K., 1975. Studies on the effect of nitrogen and sulphur upon the bio-chemical composition of mustard at different stages ofcrop growth.Ph. D. Thesis, C.S.A. Uni. Kanpur, Uttar Pradesh (India).

Pathak, R. K., Tiwari, T. P. and Tiwari, K. N. 1999. Use of potassium in Uttar Pradesh Agriculture.Proceeding of workshop U.P. council of Agriculture Research and Potash and Phosphate Institute of Canada.Indian programme, Luckhnow. PP.112-119.

Piper, C. S. 1950. Soil and plant analysis.*Inter Science Publishers*, New York, NV.

Singh, Yogeshwar.,Singh,Tarkeshwar., Singh, U. N., and Rajput, P. K. 2010. Effect of nutrient management on yield, quality and economics of irrigated Indian mustard (Brassica juncea). *The Indian J. Agricultural Sciences.***80:** 691-694.

Statistical Year Book 2013. Press information bureau ,Government of India. Chapter no.8.

Subbiah, B.V. and Asija, G. L. 1956.A rapid procedure for the estimation of available nitrogen in soil.*Current science.* **25:** 259-260.

Tiwari, D. D. 2011. Potassium management for oilseeds and pulses in Uttar Pradesh Bulletin in U.P. C.S.A.U.A.T., Kanpur. P. 9.

Tiwari, K. N. 1989. Sulphur research and agricultural production in in U.P. Bulletin C.S.A.U.A.T., Kanpur. P. 46.

Tiwari, D. D., Pandey, S. B. and Dubey, M. K. 2012. Effect of Potassium Application on Yield and Quality Characteristics of Pigeon Pea (Cajanus cajan) and Mustard (Brassica juncea L. Czern) Crops in Central Plain Zone of Uttar Pradesh. I*nternational Potash Institute.* p.31.

Tiwari, K. N., Dwivedi, B. S. and Pathak, A. N. 1989. Relative effectiveness iron pyrites and gypsum as sulphur fertilizer for different cultivars of mustard (Brassica juncea L.). *fertilizer new.***8:** 279-282.

Tiwari, V. N., Upadhyay, R. M.,Pandey, R. K. and Mishra, S. K. 2000. Effect of applied 'S' on oil content and oil yield of mustard. *Annals of Plant and Soil Research.***2:** 256-258.

Tomar, T. S., Singh, S. and Tomar, S. 1997. Response of Indian mustard (*Brassica juncea* L.) to nitrogen phosphorus and sulphur fertilizer. *Indian J. Agronomy.***4:** 148-151.

Sachadav, M. S. and Dev, D. L. 1990. Application of sulphur increasing the oil content in mustard seed.*Fertilizer News.***7:** 49-56.

Yadav, Ramesh, Chuadhari T. L and O. P Dixit 2017. Effect of potassium and sulpher on yield and Quality Characteristics of mustard. *Haryana Farming.* **6:** 45-50.