SKUAST Journal of Research 26(4): 567-574; (2024)
(*DO I NO: 10.5958/2349-297X.2024.00063.7*); NASS rating: 4.88

Research Paper

Plant growth and nutrient uptake of mustard (*Brassica juncea* L.) as influenced by application of phosphorus and sulphur

Sudheer Bhargav[1], Ram Lakhan Pal[2*], Mubeen[3], Nadeem Khan[4], Meraj Ahmad[5], Salman Ahmad[6], Sanjeev Kumar[7], Raj Bahadur[8] and Farooq Khan[9]

[1,2]Department of Soil Science and Agricultural Chemistry, Kulbhaskar Ashram Post Graduate College, Prayagraj, U.P; [3,5 &7]Faculty of Agriculture, Mohammad Ali Jauhar University, Rampur, U.P; [4&6]Department of Agriculture, Integral Institute of Agricultural Science and Technology, Integral University, Lucknow, U.P; [8]Department of Crop Physiology, Acharya Deva University of Agriculture & Technology, Kumarganj, Ayoudhya U.P; [9]Division of Basic Science and Humanities, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar Jammu and Kashmir (India)
* email: *rlpal2000@gmail.com*

(Received March 29, 2024; accepted May 11, 2024)

ABSTRACT

The experiment was conducted during rabi season of year 2022-23 at the Research farm of Kulbhaskar Ashram Post Graduate College, Prayagraj, Uttar Pradesh to find out the effect of Phosphorus and sulphur on plant growth and nutrient uptake of mustard cv Varuna. The experiment was conducted in Randomized Block Design with 10 treatments of varying phosphorus and sulphur levels and replicated thrice. The treatment T_{10} (P_{80}+S_{60}) showed maximum increase in height of 191.19 cm at harvest stage. The treatment T10 also showed maximum number of primary and secondary branches per plant. Higher nitrogen, Phosphorus and Potassium uptake was observed in the plots treated with T_{10} (P_{80}+S_{60}). Similarly higher nutrient content was observed in the treatment T10 with the application of Phosphorus and Sulphur at 80 and 60 kg ha^{-1}, respectively. Similarly, higher Sulphur content and Uptake was observed in Treatment T10. In conclusion, T10 was superior in overall growth and yield of mustard with maximum number of primary and secondary branches per plant.

Key words: Plant growth, mustard, nutrient uptake, phosphorus, sulphur.

Mustard (*Brassica juncea L* Czern and Coss) is a significant edible oilseed crop in India, alongside peanuts and soybean. It accounts for almost one-third of total oilseed output in the nation. Mustard is an oilseed crop from the Cruciferae family (also known as Brassicaceae). Indian mustard or brown mustard is a natural amphidiploid with chromosomal number (2n=36). It is self-pollinated; however, insects and other causes contribute to some pollination (2-15%). Mustard originated in China and north-east India, from which it spread to Afghanistan via Punjab (Sharma *et al*., 2021). It is the major *rabi* oilseed crops of India, which occupy a prominent place being next in importance to groundnut, both in area and production, meeting the fat requirement of about 50 per cent population in the state of Rajasthan, Madhya Pradesh, Uttar Pradesh, Punjab, Bihar, Orissa, West Bengal and Assam. India is one of the largest producers of Mustard in the world.

Phosphorus (P) promotes root development and enlargement (Russel and Appleyapd, 1915) affect seed germination, cell wall division, flowering, fruiting, synthesis of fat, starch and in fact most biochemical activities (Singh and Singh, 2012). Phosphorus fertilization is of prime importance for normal growth and development of plants because of its vital role in chlorophyll synthesis and involvements in various physiological and metabolic processes of the plant (Mehta *et al.,* 2005).The S containing amino acids (e.g. cystine, cysteine and methionine) are precursors of other secondary plant products like S-containing plant products of *Brassica* species such as glucosinolates and coenzymes. Glucosinolates are preformed resistance barriers contributing general plant defence mechanism (Schlösser, 1983). Sulphur is essential for protein formation, important for high protein content, a component of vitamin A and activates certain enzyme systems

in plants (Havlin *et al.,* 2004). Moreover, Phosphorous and sulphur are closely related to each other because both of these elements are necessary for the synthesis of proteins and their quantity is always maintained at a constant ratio in plant tissue (Dijshorn *et al,* 1960).

MATERIALS AND METHODS

Experimental site: The experiment was conducted during rabi season of year 2022-23 at the Research farm of Kulbhaskar Ashram Post Graduate College, Prayagraj, Uttar Pradesh. Prayagraj is located between 24°26' N latitudes and 81°56' E longitudes. Prayagraj lies in the southern part of the state Uttar Pradesh in India at an elevation of 98 meter. The climate of Prayagraj is characterized by long and hot summer, a fairly pleasant monsoon and cold season. The winter usually extend from mid -November to February followed by the summer which continues till middle of June. Rainy season lasts till the end of September. The average maximum and minimum temperature during winters lies 35°C and 8°C, respectively. The edaphic properties of the experimental site is described in Table 1.

Table 1: Edaphic conditions during the experiment

Parameters	Value	Methods used
Physio-chemical properties		
pH (1:2.5)	7.5	By Glass Electrode pH meter.
EC (dSm^{-1})	0.38	By Electrical Conductivity meter.
Chemical properties		
Organic carbon (%)	0.45	Walkley and Black's Rapid Titration method (Jackson,1973)
Available Nitrogen (Kg ha^{-1})	235	Alkaline Potassium Permanganate method (Subbiah and Asija, 1956)
Available Phosphorus ($Kgha^{-1}$)	27	Olsen's methods (Olsen *et al.* 1954)
Available Potassium (Kg ha^{-1})	219	Neutral- N- Ammonium Acetate using Flame Photometer (Jackson, 1973)
Available Sulphur (Kg ha^{-1})	18.4	Extraction with 0.15% $CaCl_2$ (Chesnin and Yien 1951)

Experimental Details: The experiment was conducted in Randomized Block Design with 10 treatments (Table-2) replicated thrice. The variety sown was *Varuna* (T-59).

Field preparation: At proper moisture condition the field was ploughed once with tractor drawn mould board plough followed by two-disc harrowing. Each planking was done after each ploughing to level the field.

Application of fertilizer: The fertilizers were applied @100kg N, 60kg P_2O_5 and 40 kg K_2O ha^{-1} through Urea, Di-Ammonium Phosphate and Muriate of Potash, respectively. Half dose of nitrogen and full doses of phosphorus and potassium were applied as basal dose at the sowing time as per treatments except control. The remaining half dose of nitrogen was top-dressed after first irrigation of mustard crop.The seed rate sown was 4.75 kg $ha^{-1}$and was sown at a row distance of 30 cm in the experimental plots.

Two irrigations were applied to crop as per schedule. The first irrigation was given after 30 days of sowing at the flowering stage and 2nd irrigation at the stage of Pod formation.

Table 2: Details of treatment

Treatment Symbol	Details of treatment
T_1	Absolute control
T_2	$P_{40} + S_{20}$
T_3	$P_{40} + S_{20}$
T_4	$P_{40} + S_{60}$
T_5	$P_{60} + S_{20}$
T_6	$P_{60} + S_{40}$
T_7	$P_{60} + S_{60}$
T_8	$P_{80} + S_{20}$
T_9	$P_{80} + S_{40}$
T_{10}	$P_{80} + S_{60}$

RESULTS AND DISCUSSION

Plant Height: The plant height was recorded at 30 ,60, 90, days after sowing (DAS) and at harvest and results of the data and analyzed are depicted in table 3. The data indicated that the effect of phosphorus and sulphur

on plant height are significant. It was observed that height of the plant significantly increase in all treatment at different days over control. The maximum plant height at 30 DAS was recorded in T_5 (P_{60}+S_{20}). However, from 60 days onwards the plant height did not vary significantly with the application of different treatments. At 60 DAS, 90 DAS and at harvest in treatment T_{10} (P_{80}+S_{60}) showed maximum increase in height. Minimum height recorded in T_1 (Absolute control) followed by T_5 (P_{60}+S_{20}) in all stage of plant height. This result is in conformity with the results of the study conducted by (Patil *et al.,* 2018). Rajput *et al*. (2018) found that growth characteristics, including plant height, the number of primary and secondary branches per plant, the number of leaves per plant, and dry matter accumulation per plant, were highest at 120 kg N ha^{-1} and 60 kg S ha^{-1}. The maximum seed yield (19.20 and 18.39 q ha^{-1}) and stover yield (59.49 and 57.21 q ha^{-1}) were achieved at 120 kg N ha^{-1}, which was comparable to the yield at 80 kg N ha^{-1}.

Table3: Effect of phosphorus and Sulphur on Plant height at different stages of mustard crop

Treatments	Plant Height (cm)			
	30 DAS	60 DAS	90 DAS	At Harvest
T_1 (Absolute control)	20.86	75.56	165.68	166.69
T_2 (P_{40} + S_{20})	24.66	97.66	187.78	188.79
T_3 (P_{40} + S_{40})	23.46	98.26	188.38	189.30
T_4 (P_{40} + S_{40})	24.06	85.66	175.78	176.80
T_5 (P_{60} + S_{20})	25.46	92.26	182.38	183.40
T_6 (P_{60} + S_{40})	23.06	89.46	179.58	180.59
T_7 (P_{60} + S_{60})	24.06	90.46	180.58	181.59
T_8 (P_{80} + S_{20})	25.06	91.26	181.38	182.39
T_9 (P_{80} + S_{40})	24.66	99.06	189.18	190.19
T_{10} (P_{80} + S_{60})	23.06	100.06	190.18	191.19
SEm	**0.472**	**1.816**	**0.039**	**3.612**
CD (P=0.05)	**1.413**	**5.436**	**0.118**	**10.816**

Number of primary branches: Data on primary branch per plant as influenced by different fertility levels are presented in table 4. Primary branches at 30 DAS were found significantly higher in treatment T10(P80+S60) and was on a par with T8 (P80+S20) while least number of primary branches were reported treatment T1(absolute control). At 60 DAS treatment as in 30 DAS treatment T9 (P80+S40) was showing maximum values of primary branches and it was on a par with treatment T8(P80+S20).At later stages that is at 90 DAS maximum number of primary branches were reported in the treatment T10(P80+S60) fertility level and least number of primary branches reported in treatment T1(absolute control) at harvesting stage also similar trend was reported and at both the stages that is 90 DAS and at harvesting primary branches did not vary significantly. The variation in number of primary branches may be attributed to the application of higher dose of nitrogen along with higher dose of Phosphorus and Sulphur which accelerated physiological processes inside the plant and sprouting of lateral buds as a result of which branching increased followed by increased vegetative growth this resulted in increased number of primary branches/plant (Singh and Meena, 2004). Similar results were also obtained by (Patil *et al.,* 2018). Kumar and Yadav (2007) reported that the optimum dose of S and P was computed as 47.5 and 40.2 kg, and 44.0 and 40.2 kg for the first and second years respectively. Nath et al. (2018) observed that the supply of 75 kg P2O5/ha and 30 kg S/ha increase in plant height, branches number/ plant, siliqua number per plant, seed number per siliqua, grain yield, the stover yield, siliqua length than application of low dose 50 kg P/ha and 20 kg S/ha a in mustard.

Number of Secondary branches: Data on Secondary branch per plant as influenced by different fertility levels are presented in table 5. Data on secondary branches per plant was collected on 60 DAS, 90 DAS and at harvest reported that number of secondary branches at different crop growth stages were found significantly influenced with varying fertility levels. At 60 DAS maximum number of secondary branches were reported in treatment T_{10} (P_{80}+S_{60}) and which was on a par with treatment T_6 (P_{60}+S_{40}), T_7 (P_{60}+S_{60}), T_9 (P_{80}+S_{40}).

Table 4: Effect of phosphorus and Sulphur on Number of primary branches as affected by different fertility levels at different growth stages

S. No.	Primary branches/plant			
	30DAS	**60DAS**	**90DAS**	**At harvest**
T_1 (Absolute control)	3.4	6.33	8.75	11.87
T_2 (P_{40} + S_{20})	4.4	6.45	8.91	12.42
T_3 (P_{40} + S_{40})	3.8	6.53	9.02	12.57
T_4 (P_{40} + S_{40})	4.0	6.73	9.30	12.96
T_5(P_{60} + S_{20})	3.7	6.40	9.30	12.50
T_6 (P_{60} + S_{40})	3.6	6.66	9.21	12.83
T_7 (P_{60} + S_{60})	4.3	6.90	9.54	13.30
T_8 (P_{80} + S_{20})	4.8	7.44	10.28	13.30
T_9 (P_{80} + S_{40})	4.6	7.80	10.40	13.50
T_{10} P_{80} + S_{60})	5.1	7.67	10.60	13.76
SEm	**0.084**	**0.137**	**0.189**	**0.255**
CD(P=0.05)	**0.250**	**0.409**	**0.566**	**0.763**

While at 90 DAS maximum number of secondary branches were reported in treatment T_{10} (P_{80}+S_{60}) and it was on a par with treatment T_8 (P_{80}+S_{20}), T_5(P_{60}+S_{20}). Similarly, at harvesting also maximum secondary branches were reported in treatment T_{10} (P_{80}+S_{60}) and it was on par withT_7 (P_{60}+S_{60}), T_8(P_{80}+S_{20}), T_9 (P_{80}+S_{40}).

Table 5: Effect of phosphorus and Sulphur on Number of Secondary branches at different growth stages of mustard crop

S. No.	Secondary branches/plant		
	60DAS	**90DAS**	**At harvest**
T_1	7.97	13.33	14.19
T_2	8.93	14.58	15.90
T_3	8.50	14.75	15.80
T_4	8.79	15.20	16.57
T_5	8.86	15.80	16.40
T_6	10.15	15.06	16.42
T_7	9.05	15.61	17.02
T_8	9.83	15.82	17.34
T_9	9.0	16.31	17.30
T_{10}	10.36	16.64	17.87
SEm	**0.182**	**0.305**	**0.327**
CD(P=0.05)	**0.546**	**0.914**	**0.980**

This increase in the number of secondary branches the result of all the metabolic reactions, varying fertility levels, crop response to applied nutrients and increased photosynthetic activity due to increased phosphorus application along with Sulphur treatments which accelerated process of cell differentiation and activity of

meristematic tissues also having a greater number of primary branches led to development of higher number of secondary branches. Similar results were also obtained by (Patil *et al.,* 2018). Kumar *et al.,* (2022) reported that the minimum no. of primary branches was recorded in the control of nitrogen level N0 (5.667) and sulphur level S0 (6.500) at 90 DAS. The highest no. of primary branches was observed in nitrogen level of N3 (8.833) and sulphur level S3 (7.750). They also found that at maturity, the highest no. of secondary branches was observed i.e., 21.667 and 19.000 which were in N3 (N120 kg) and S3 (S-45kg).

Nitrogen content and Uptake: The data pertaining to nitrogen content as influenced by varying fertility is given in table 6. Nitrogen content in seed increased with increasing the nitrogen doses being significantly higher in T_{10} (P_{60}+S_{20}) and was on as par with T_3(P_{40}+S_{40}), T_8(P_{80}+S_{20}), T_5(P_{60}+S_{20}), respectively. Whereas, the minimum nitrogen content in seed was found in T_4 (P_{40}+S_{60}). Straw nitrogen content was found higher in T_4 (P_{40}+S_{60}) and it was on at par with the treatments T_5(P_{60}+S_{20}). From the result it may be concluded that nutrient content in seed and straw is a function of dry matter accumulation and nutrient uptake under different fertility levels.

The data pertaining to total nitrogen uptake as influenced by varying fertility levels is given in Table 6. Seed uptake of nitrogen was found maximum in T_{10}(P_{80}+S_{60}). However, maximum nitrogen uptake in straw was found inT_5(P_{60}+S_{20}) and it was on a par with treatment T_4(P_{40}+S_{60}). While total nitrogen uptake also varied significantly with different fertility levels and significantly higher nitrogen uptake was observed in the plots treated with T_{10} (P_{80} + S_{60}). while minimum total nitrogen uptake was observed inT_6(P_{60}+S_{40}) increase in nitrogen content was due to adequate availability of nutrients during crop growth which led to increased absorption of nutrients which increased with increasing nitrogen dose up to 100 kg/ha. This result is in conformity with the work done by (Kumar and Yadav 2007; Rana *et al.,* 2005; Gangwar *et al.,* 2011).

Table 6: Effect of phosphorus and Sulphur on Nitrogen content and uptake inmustardc rop

S. No.	Nitrogen content (%)		Nitrogen uptake (kg/ha)		
	Seed	**Straw**	**Seed**	**Straw**	**Total**
T_1	2.81	0.40	44.67	7.74	52.41
T_2	2.89	0.42	46.87	8.29	55.16
T_3	3.00	0.40	49.50	8.03	57.53
T_4	2.50	0.49	42.47	10.13	52.60
T_5	2.90	0.47	47.27	10.45	52.72
T_6	2.60	0.39	43.81	8.00	51.81
T_7	2.80	0.39	49.02	8.31	57.33
T_8	2.90	0.41	54.37	9.36	63.73
T_9	2.80	0.39	50.04	9.03	59.07
T_{10}	3.10	0.40	61.84	9.71	71.55
SEm	**0.056**	**0.008**	**0.961**	**0.183**	**1.125**
CD(P=0.05)	**0.167**	**0.025**	**2.877**	**0.548**	**3.369**

Phosphorus Content and Uptake: Data on phosphorus content as influenced by varying fertility level is given in Table 7. Data on phosphorus content in seed and straw did not vary significantly and the maximum phosphorus content was found in T_{10}(P_{80}+S_{60}) which was at par with T_3(P_{40}+S_{40}), T_4(P_{40}+S_{60}), T_7 (P_{60}+S_{60}). while minimum value was recorded in treatment T_1(absolute control). Similarly in Stover also phosphorus content was found max in same treatment T_{10}(P_{80}+S_{60}) which was at par with T_2 (P_{40}+S_{20}), T_9 (P_{80}+S_{40}), T_5 (P_{60}+S_{20}). And the minimum phosphorus content was found in T_6(P_{60}+S_{40}). The increase in the phosphorus content may be attributed to the better root growth in T_{10}(P_{80}+S_{60}) which led to increased absorption of nutrients, these results are in conformity with the work done (Kumar and Yadav, 2007)

Table 7: Effect of phosphorus and Sulphur on Phosphorus content and uptake in mustard crop

S. No.	Phosphorus content (%)		Phosphorus Uptake(kg/ha)		
	Seed	**Straw**	**Seed**	**Straw**	**Total**
T_1	0.65	0.29	10.33	5.61	15.94
T_2	0.69	0.31	11.19	6.12	17.31
T_3	0.70	0.28	11.55	5.62	17.17
T_4	0.67	0.29	11.38	6.00	17.38
T_5	0.66	0.30	10.75	6.67	17.42
T_6	0.61	0.27	10.27	5.54	15.81
T_7	0.69	0.29	12.08	6.18	18.26
T_8	0.63	0.28	11.81	6.39	18.20
T_9	0.62	0.31	11.96	7.17	19.13
T_{10}	0.71	0.32	14.16	7.77	21.93
SEm	**0.013**	**0.006**	**0.228**	**0.128**	**0.356**
CD(P=0.05)	**0.039**	**0.018**	**0.684**	**0.384**	**1.066**

The data on phosphorus uptake as influenced by varying fertility levels is summarized in table 7. Phosphorus uptake in seed vary non significantly with different fertility levels being maximum inT_{10} (P_{80}+S_{60}). Phosphorus uptake in straw varied significantly and maximum value was also found inT_{10}(P_{80}+S_{60}). The minimum value for P uptake in seed and straw was recorded in T_6(P_{60}+S_{40}). Similarly, total phosphorus uptake was also found significantly higher in T_{10}(P_{80}+S_{60}). While minimum phosphorus uptake was recorded in T_6(P_{60}+S_{40}).

Table 8: Effect of phosphorus and Sulphur on Potassium content and uptake in mustard crop

S. No.	Potassium content (%)		Potassium uptake(kg/ha)		
	Seed	**Straw**	**Seed**	**Straw**	**Total**
T_1	0.66	1.92	10.49	37.17	47.66
T_2	0.68	1.93	11.02	37.92	48.94
T_3	0.70	1.91	11.55	38.37	49.92
T_4	0.69	1.90	11.72	39.31	51.03
T_5	0.69	1.92	11.24	42.72	53.96
T_6	0.59	1.89	9.94	38.78	48.72
T_7	0.73	1.87	12.78	39.86	52.64
T_8	0.61	1.92	11.43	43.83	55.26
T_9	0.68	1.88	13.12	43.54	56.66
T_{10}	0.74	1.94	14.76	47.12	61.88
SEm	**0.014**	**0.041**	**0.259**	**0.888**	**1.146**
CD(P=0.05)	**0.041**	**N/S**	**0.774**	**2.659**	**3.431**

Potassium content and Uptake: The data pertaining to potassium content as influenced by varying fertility level is in seed and straw is given in table 8. Potassium content in seed varied significantly with different fertility levels and significantly higher value was found in T_{10}(P_{80}+S_{60}) and which was on at par with treatments

$T_3(P_{40}+S_{40})$, $T_4(P_{40}+S_{60})$, $T_7(P_{60}+S_{60})$,$T_5(P_{60}+S_{20})$ however, minimum potassium content in seed was found in $T_6(P_{60}+S_{40})$.While potassium content in straw did not vary significantly but the maximum value was reported in$T_{10}(P_{80}+S_{60})$and minimum value was recorded in $T_7(P_{60}+S_{60})$. Similar results were also obtained by (Kumar and Yadav 2007).

Sulphur Content and Uptake: Data pertaining to Sulphur contentas affected by fertility levels is given in table 9. Sulphur content in seed was found significantly higher in $T_{10}(P_{80}+S_{60})$ which was found on a par with $T_5(P_{60}+S_{20})$. The Sulphur content in straw was also found significantly higher in $T_{10}(P_{80}+S_{60})$ and which was on a par with $T_4(P_{40}+S_{60})$ application the increase in Sulphur content in seed and straw may be attributed to the increased Sulphur dose which led to increase in availability of Sulphur in the soil and thus may have increased nutrient concentration in plant parts. These results are in conformity with the work done by (Kumar and Yadav, 2007); Rana *et al.,* 2005.

Table 9: Effect of phosphorus and Sulphur on Sulphur content and uptake in mustard crop

S. No.	Sulphur content (%)		Sulphur uptake(kg/ha)		
	Seed	**Straw**	**Seed**	**Straw**	**Total**
T_1	1.06	0.18	16.85	3.48	20.33
T_2	1.12	0.20	18.16	3.95	22.11
T_3	1.21	0.19	19.96	3.81	23.77
T_4	1.17	0.24	19.87	4.96	24.83
T_5	1.38	0.22	22.49	4.89	27.38
T_6	1.13	0.20	19.04	4.10	23.14
T_7	1.24	0.22	21.71	4.69	26.40
T_8	1.14	0.23	21.37	5.25	26.62
T_9	1.16	0.20	22.38	4.63	27.01
T_{10}	1.39	0.26	27.73	6.31	34.04
SEm	**0.081**	**0.014**	**1.405**	**0.310**	**1.714**
CD(P=0.5)	**0.027**	**0.005**	**0.469**	**0.104**	**0.573**

CONCLUSION

As per the findings of the experiment, it can be concluded that For getting higher yield of Indian mustard cv. Varuna, the application of P_2O_5 80 $kgha^{-1}$, S 60 $kgha^{-1}$ [$T_{10}(P_{80}+ S_{60})$] was found suitable with respect to getting higher seed, yields in *Prayagraj* region. The result of the present investigation reveals the significance of application of P_2O_5 80 kg and S 60 kg per hectare in mustard crop for maximization of yield and profits.

REFERENCES

Bouyoucos, G. J. 1936. Directions for making mechanical analyses of soils by the hydrometer method. *Soil Science*, **42(3):** 225-230.

Dijishorn, W., Larup, J.W.M., Van Burg, U.E.J. 1960. A method of diagnosing the sulfur nutrition status of herbage. *Plant and Soil*, **13**: 227-241.

Gangwal, T. V., Patel, M. V. and Jadav, N. J. 2011. Effect of phosphorus, sulphur and phosphate solubilising bacteria on yield, nutrient uptake and soil fertility after harvest of mustard. *Indian Journal of Fertilizers,* **7(8):** pp.32-40.

Havlin, J. L., Beaton, J. D., Tisdale, S. L. and Nelson, W. L. 2004. Soil fertility and fertilizers. An introduction to nutrient management. 7th Ed. *Pearson Education Inc. Singapore*. 221p.

Kumar, H. and Yadav, D. S. 2007. Effect of phosphorus and sulphur levels on growth, yield and quality of Indian mustard (*Brassica juncea*) cultivars. *Indian Journal of Agronomy,* **52**: 154-157.

Mehta, T. K., Shaktawat, M. S. and Singh, S. M. 2005. Infuence of sunphur, phosphorusand farmyard manure on yield attributes and yield of maize (*Zea mays*) in southern Rajasthan condition. *Indian Journal of Agronomy,* **53**:203-205.

Olsen, S. R., Cole, C. V., Watnable F. S. and Dean, L. A. 1954. Estimation of available phosphorous in soils by extraction with sodium carbonate. U.S.D.A. Cir. No. 933 1-10.

Piper, C. S. 1967. Soil and plant analysis. Asian publishing House, Bombay, New Delhi. 131-137.

Rana K. S., Rana D. S. and Gautam R. C. 2005. Influence of phosphorus, sulphur and boron on growth, yield, nutrient uptake and economics of Indian mustard (*Brassica juncea*) under rainfed conditions. *Indian Journal of Agronomy*, **50:** 314-316.

Russel, E. J. and Appleyapd, A. 1915. The atmosphere of soil. Its, composition and causes of variation. *Journal of Agricultural Science,* **7**:1-48.

Sharma, H., Kumar, A., Singh, V., Meena, H., Priyamedha, M., Sharma, P., and Rai, P. 2021. Variability and genetic diversity study based on agro-morphological traits in a diverse set of Indian mustard [Brassica juncea (L.) Czern. & Coss.] germplasm. *Journal of Environmental Biology*, **42**: 1495–1504. https://doi.org/10.22438/jeb/42/6/mrn-1798

Singh, A. and Meena, N. L. 2004. Effect of nitrogen and sulphur on growth, yield attributes and seed yield of mustard (*Brassicajuncea*L.) in eastern plains of Rajasthan. *Indian Journal of Agronomy* **49**: 186-188.

Schlösser, E. 1983. Allgemeine Phytopathologie. Thieme Verlag, Stuttgart.