

Effect of Nitrogen and Sulphur Levels on Growth, Yield and Quality of Seed in Radish (*Raphanus sativus* L.)

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ABSTRACT: A field investigation was carried out at Bahaduri Farm, Research Block of Department of Vegetable Science, College of Horticulture, Mandsaur (M.P) during 2020-21. Twelve treatments comprised of four levels of nitrogen (N₁-60, N₂-80, N₃-100 and N₄-120 kg/ha) and three levels of sulphur S₁-15, S₂-30 and S₃-45 kg/ha) were laid in factorial randomized block design with three replications. Observations were recorded on plant height at harvest stage, number of branches per plant at harvest stage, fresh weight of shoot at harvest stage, dry weight of shoot at harvest stage, days to 50% flowering, days to 50% maturity, number of siliqua per plant, siliqua length (cm), number of seed per siliqua, siliqua yield per plant (g), seed yield per plant (g), seed yield (q/ha). Quality of radish seed was determined with respect to germination (%), 100 seed weight (g) and seedling vigour index-I. Findings revealed that application of N₂S₂ (80kg nitrogen +30kg sulphur/ha) resulted in highest seed yield (10.69q/ha). Highest seed germination (91.67%) noted with N₃S₃ which was at par to N₂S₃ (90%) and N₂S₂ (89%).

Keywords: Radish, *Raphanus sativus* Nitrogen, Sulphur, Growth, Yield, Seed quality

INTRODUCTION

Radish (*Raphanus sativus* L.) is an important root vegetable crop grown all over the world. In India, it is grown in one or the other part of the country throughout the year. The main edible portion in radish is fleshy roots which develop from both the primary root and the hypocotyls. Besides, radish leaves are also nutritious and used for culinary purposes. Seeds of radish are source of non-drying fatty oil which is suitable for soap making, illuminating and edible purposes [1]. Bahadur and Bala [2] reported that radish seeds contain up to 48% oil which is not suitable for human consumption but a potential source of bio fuel.

Seed is an important input for production of a crop. Factors like nutrition, climate and water management etc. affect the yield and quality of seed. Timely application of balanced quantity of fertilizers, therefore, play vital role in seed production. Among the major essential nutrients required by the plants for their growth, development and yield, the role of nitrogen most vital as it is a primary constituent of metabolically active compounds like protein, nucleic acids, chlorophyll and certain important enzymes [3]. Nitrogen encourages vegetative growth and governs to a considerable degree the utilization of other nutrients. It plays an important part in the building up of

protoplasm and protein which induce cell division and initiate meristematic activities when applied in optimum quantity. Low nitrogen availability causes a decrease in cell size especially cell division [4]. Nitrogen improves the absorption and respiration process in plant and activates vegetation. It plays vital role in transferring energy with in plant cells and formation of meristem tissue, promoting root growth, flowering and development of seed and fruit [5].

Sulphur is the fourth essential plant nutrient after N, P and K in balanced fertilization. Sulphur has been known for its role in the synthesis of carbohydrates, proteins, vitamins, oils and flavour compounds. Sulphur is indispensable for synthesis of essential amino acids like—cysteine, cystine and methionine; formation of chlorophyll, glucosides and glucosinolates (mustard oils); activation of enzymes and sulphhydryl (SH-) linkages that are the source of pungency in oilseeds [6]. The members of cruciferous family are characterized by their high sulphur requirement for crop growth, yield and quality. Sulphur is an essential input to sustain yields in many Indian soils due to widespread deficiency of sulphur as reported in many districts. However, the responses to sulphur application vary due to difference in location, soil types, available sulphur status, genotype and crop management

conditions. Radish yield is reported to increase with S application [7]. Keeping these facts in view, this experiment was carried out with the objectives to study the effects of nitrogen and sulphur levels on growth, yield, quality and economics of seed production of radish.

MATERIAL AND METHODS

A field experiment was conducted at Bahadri Farm, Research Block of Department of Vegetable Science, College of Horticulture, Mandsaur (M.P) during rabi season 2020-21. Twelve treatments comprised of four levels of nitrogen (N_1 -60, N_2 -80, N_3 -100 and N_4 -120 kg/ha) and three levels of sulphur S_1 -15, S_2 -30 and S_3 -45 kg/ha) were evaluated in factorial randomized block design with three replications. The soil of the experimental field was medium black (Vertisol) clay loam in texture, having soil pH 7.30, electrical conductivity 0.34 dSm⁻¹, available nitrogen 202kg/ha, available phosphorus 10.5kg/ha and available potassium 365kg/ha. The calculated quantities of nitrogen and sulphur as per treatments were applied to the respective plot. Application of nitrogen was done in two split doses. The half quantity of nitrogen was applied as basal at the time of steckling planting. The remaining half dose of nitrogen as per treatment was applied as a top dressing at 30 days after steckling planting. Whole quantity of sulphur was applied in the form of bentonite sulphur granules as basal application. Besides, uniform dose of 80kg/ha P_2O_5 and 60kg/ha of K_2O was given as basal application. Nitrogen was given in the form of DAP (Di ammonium phosphate) and urea, phosphorus (P_2O_5) as DAP and potash (K_2O) as muriate of potash. Pure, healthy and good quality seed of radish variety Japanese White was used for raising radish roots for preparing stecklings for seed production. About two months before the planting for seed production, seed was sown in lines at a spacing of 30 cm and covered with soil. When roots reached to the appropriate size for steckling purpose, these were uprooted and about 2.5 to 3.0 inches portion of root and 3 - 4 inches portion of shoot were taken for planting purpose as stecklings. These stecklings were treated with fungicide solution (Mancozeb 75% WP 2g + carbendazim 50% WP 1g/litre of water) and thereafter planted in the well prepared plots of 3×2.4 m² at a spacing of 60cm×30cm. Standard package of practices were followed for raising the seed crop of radish. Pods were harvested at dry stage when they turned light yellow and became well filled up.

At harvest, observations were recorded on plant height; number of branches per plant at harvest stage; fresh

weight of shoot at harvest stage; dry weight of shoot at harvest stage; days to 50% flowering; days to 50% maturity; number of siliqua per plant, siliqua length (cm); number of seed per siliqua; siliqua yield per plant (g); seed yield per plant (g); and seed yield (q/ha). Quality of seed was determined with respect to germination (%), 100 seed weight (g) and seedling vigour index. Germination (%) was determined according to the rules of International Seed Testing Association [8]. Seedling vigour index-I was calculated adopting the method of Abdul-Baki and Anderson [9]. Economic analysis of different nitrogen and sulphur levels was worked out in terms of gross and net income as well as benefit: cost ratio. The data collected from various observations recorded in the field as well as laboratory were subjected to statistical analysis to know the degree of variation amongst all the treatments. The analysis of variance was carried out for each character separately as suggested by Panse and Sukhatme [10].

RESULTS AND DISCUSSION

Growth parameters

Effect of different treatments on the crop growth was studied with respect to plant height, number of branches per plant, fresh and dry weight of shoot (g) per plant and data have been presented in Table 1.

Nitrogen levels registered significant effect on plant height. There was gradual increase in plant height with increasing doses of nitrogen. Highest plant height was noted with N_4 which was significantly superior over all the nitrogen levels. Number of branches increased with growth period with significant increase with the application of N_2 , N_3 and N_4 over N_1 . The differences among N_2 , N_3 and N_4 were not significant. Fresh weight of shoot per plant increased up to 60DAP thereafter a slight decrease in fresh weight was observed with advancement in growth stages. There was significant increase in fresh weight with application of N_2 as compared to N_1 at all the stages under study. However, further increase in nitrogen levels i.e. N_3 and N_4 had no significant effect on fresh weight of shoot per plant over N_2 . Dry weight of shoot per plant showed increase with growth period up to 90 DAP which declined at harvest stage, due to leaf senescence. Application of N_2 registered significant increase in dry weight of shoot per plant over N_1 at all stages under study. Further higher levels of nitrogen i.e. N_3 and N_4 did not imparted a significant effect on dry weight of shoot per plant over N_2 . Nitrogen is a structural part of protein,

Table 1. Effect of different levels of nitrogen and sulphur and their combinations on growth and phenological parameters in radish

Treatments	Plant height (cm)	Number of branches per plant	Fresh weight of shoot (g) per plant	Dry weight of shoot (g) per plant	Days to 50% flowering	Days to 50% maturity
Nitrogen levels						
N ₁	101.96	9.06	342.41	92.92	51.11	92.39
N ₂	116.49	13.80	523.21	125.67	54.83	105.25
N ₃	119.32	13.82	527.24	125.29	57.08	111.34
N ₄	130.00	14.42	532.47	129.33	58.36	117.36
S.Em±	3.02	0.21	8.81	1.98	0.98	1.90
CD at 5%	8.86	0.63	25.83	5.80	2.88	5.56
Sulphur levels (S)						
S ₁	110.58	11.55	441.98	106.31	53.64	103.09
S ₂	120.38	13.59	502.93	125.96	55.51	106.53
S ₃	119.88	13.18	499.08	122.65	56.88	110.13
S.Em±	2.62	0.19	7.63	1.71	0.85	1.64
CD at 5%	7.67	0.54	22.37	5.02	2.49	4.81
Combined effect of nitrogen and sulphur						
N ₁ S ₁	97.50	7.33	328.70	88.78	49.09	89.30
N ₁ S ₂	104.71	10.17	351.42	95.61	51.65	93.15
N ₁ S ₃	103.67	9.69	347.10	94.38	52.59	94.72
N ₂ S ₁	108.23	12.91	477.60	108.30	53.11	103.42
N ₂ S ₂	121.43	15.10	556.98	139.58	54.15	104.49
N ₂ S ₃	119.80	13.40	535.07	129.14	57.23	107.84
N ₃ S ₁	116.37	12.92	479.75	113.07	55.16	107.28
N ₃ S ₂	120.93	14.31	551.45	133.34	57.59	110.81
N ₃ S ₃	120.67	14.23	550.51	129.46	58.49	115.94
N ₄ S ₁	120.20	13.04	481.88	115.08	57.21	112.36
N ₄ S ₂	134.43	14.81	551.89	135.29	58.66	117.67
N ₄ S ₃	135.37	15.41	563.64	137.62	59.23	122.04
S.Em±	5.23	0.37	15.26	3.42	1.7	3.28
CD at 5%	NS	1.09	NS	10.04	NS	NS

nucleic acids and enzymes. It increases cell division and cell size thereby help in enhancing the plant height and number of branches. It is also a major component of chlorophyll. Accumulation of photosynthates in plants resulted in enhancement of fresh and dry weight of shoots. Excessive use of nitrogen over N₂ did not have any significant contribution in increasing these parameters except plant height due to apical dominance causing lanky growth and lodging during later stages. These results are in conformity with the findings of Sharma [11], Panwar *et al.* [12], El-Desuki *et al.* [13], Tripathi *et al.* [14] and Poudel *et al.* [15].

Application of different sulphur levels showed significant effects on plant height, number of branches, fresh and dry weight of shoot. Highest plant height, number branches, fresh and dry weight of shoot per plant was recorded with sulphur level S₂ (30kg S/ha) which was significantly superior over S₁ but at par with S₃. Sulphur has an important role in synthesis of carbohydrates,

proteins, chlorophyll, oils, certain vitamins and biosynthesis of secondary metabolites like glucosinolates in brassicas. Balanced dose of sulphur also helps in maintaining enhanced meristematic activity and photosynthesis in radish [16-17].

Combined effects of nitrogen and sulphur levels were significant on number of branches and dry weight of shoot per plant. Application of N₄S₃ recorded maximum number of branches which was followed by N₂S₂ and N₄S₂ which were at par with each other. Highest dry weight of shoot per plant was recorded with N₂S₂ which was at par with N₄S₃ > N₄S₂ > N₂S₂. Effects of N and S are strongly correlated as both are essential substrates in protein synthesis. Sulphur deficiency reduces nitrogen uptake and vice versa. Optimum amount of N and S has synergistic effect on their uptake by plant. Plants assimilate inorganic sulphur into cysteine, which is further converted into methionine, by reduction process, regulated by nitrogen content. This positive effect of

nitrogen and sulphur is attributed to superior performance of N₂S₂ on growth as reported in earlier studies [18-20].

Phenological parameters

Effect of different treatments on phenology of radish seed crop was studied in terms of days to 50% flowering and days to 50% maturity (Table 1).

Nitrogen levels registered significant effect on days to 50% flowering and days to 50% maturity. As nitrogen prolongs the vegetative stage, increasing nitrogen levels delayed the 50% flowering. Maximum days to 50% flowering were taken with application of N₄ which was at par to N₃ but significantly late as compared to N₁ and N₂. Similar effect of nitrogen was also reflected in days to 50% maturity. Maximum days to 50% maturity were taken with application of N₄ which were significantly more than all other nitrogen levels. Delayed flowering and maturity due to excess of nitrogen has also been reported by Sharma [11] and Panwar *et al.* [12].

There was significant effect of sulphur application on days to 50% flowering and days to 50% maturity in radish. Maximum days to 50% flowering and 50% maturity were taken under S₃ (45kg S/ha) which was at par to S₂, but significantly late as compared to S₁. Earliest 50% flowering and 50% maturity was commenced with sulphur levels S₁ (15kg S/ha) which was at par to S₂. Sulphur enhances the process of tissue differentiation from somatic to reproductive and development of floral primordia which might be attributed to early flowering and maturity. These results are corroborated with the findings of [16,17, 21]. Combined effect of nitrogen and sulphur levels were non significant on days to 50% flowering and days to 50% maturity in the present investigation.

Seed yield attributes

Findings (Table 2) revealed significant effect of nitrogen levels on number of siliqua per plant, siliqua length, number of seed per siliqua, siliqua yield per plant, seed yield per plant, seed yield per hectare and harvest index. Number of siliqua per plant, siliqua length number of seed per siliqua, siliqua yield per plant and seed yield per plant registered significant increase with application of N₂ over N₁. But further increase in nitrogen levels had indicated non significant effect on all these attributes. There was significant reduction in all these yield parameters with application of N₄ as compared to N₂ and N₃. Seed yield per hectare also indicated significant impact of nitrogen

levels. There was significant increase in seed yield with N₂ over N₁. Further increase in nitrogen level i.e. N₃ had showed no significant enhancement as compared to N₂. Application of N₄ had recorded significantly lower seed yield as compared to N₂ and N₃. Nitrogen is an important nutrient and influences cell division and cell enlargement which reflected in more plant height and number of branches. It is also a structural component of chlorophyll thereby enhances photosynthesis and accumulation of carbohydrates in the plant which had resulted in increase of fresh and dry weight. Higher growth attributes further contributed to the improvement in yield attributes as witnessed with higher number of siliqua per plant, siliqua length (cm), number of seed per siliqua, siliqua yield per plant (g), seed yield per plant (g). However, excessive nitrogen level N₄ has caused more plant height which caused lodging and resulted in reduction in other growth parameters and yield attributes. Higher growth and yield attributes with N₂ and N₃ level of nitrogen further contributed to higher seed yield per hectare. Harvest index had indicated significant increase with application of N₂ and N₃ as compared to N₁. But N₂ and N₃ were at par. Application of N₄ had registered significantly lower harvest index as compared to N₃, N₂ and N₁. Balanced dose of N might have resulted in proportionately higher translocation of food material from source to sink which ultimately contributed in higher harvest index. These findings are in agreement with [11,12, 22-24].

Sulphur levels imposed significant effect on all yield attributes and seed yield per hectare. Harvest index had denoted non-significant effect of sulphur levels in the present experiment. Number of siliqua per plant and siliqua length exhibited significant increase with S₂ over S₁. Further increase in sulphur level S₃ as compared to S₂ indicated non-significant influence on both number of siliqua per plant and siliqua length. Similar trend was observed in case of number of seed per siliqua, siliqua yield per plant, seed yield per plant and seed yield per hectare. Enhanced growth attributes due to positive effect of sulphur on chlorophyll content and meristematic activities consequently increased the yield parameters and yield. Similar observations were also reported by [16,17, 22 and 24].

Combined effect of nitrogen and sulphur levels had registered significant effect on number of siliqua per plant, siliqua yield per plant, seed yield per plant and seed yield per hectare. Siliqua length, number of seed per siliqua as well as harvest index had showed non significant

Table 2. Effect of different levels of nitrogen and sulphur and their combinations on yield parameters and yield in radish

Treatments	Number of siliqua per plant	Siliqua length (cm)	Number of seed per siliqua	Siliqua yield per plant (g)	Seed yield per plant (g)	Seed yield (q/ha)	Harvest index (%)
Nitrogen levels							
N ₁	299.09	4.76	5.23	46.48	11.74	5.59	11.23
N ₂	468.40	6.02	6.63	72.96	19.71	8.93	13.59
N ₃	477.22	6.20	6.66	72.45	19.81	9.07	13.64
N ₄	417.22	5.56	7.01	62.10	14.59	6.76	10.17
S.Em±	9.6	0.15	0.21	1.62	0.44	0.33	0.37
CD at 5%	28.14	0.43	0.61	4.75	1.29	0.98	1.09
Sulphur levels (S)							
S ₁	379.68	5.13	5.81	55.48	14.59	6.14	12.06
S ₂	433.30	5.89	6.41	66.89	17.46	8.38	12.05
S ₃	433.47	5.88	6.93	68.12	17.33	8.24	12.35
S.Em±	8.31	0.13	0.18	1.40	0.38	0.29	0.32
CD at 5%	24.37	0.37	0.53	4.11	1.12	0.85	0.94
Combined effect of nitrogen and sulphur							
N ₁ S ₁	290.71	4.64	5.10	45.19	11.52	5.12	11.49
N ₁ S ₂	299.37	4.77	5.20	46.89	11.77	5.70	10.96
N ₁ S ₃	307.18	4.86	5.40	47.36	11.93	5.95	11.23
N ₂ S ₁	397.99	5.12	5.55	63.08	17.31	6.67	13.81
N ₂ S ₂	516.71	6.64	7.10	80.21	22.11	10.69	13.68
N ₂ S ₃	490.49	6.29	7.23	75.60	19.71	9.44	13.27
N ₃ S ₁	423.77	5.55	5.98	60.22	16.56	6.70	12.80
N ₃ S ₂	498.32	6.47	6.37	77.60	21.08	10.05	13.65
N ₃ S ₃	509.58	6.58	7.64	79.53	21.80	10.45	14.45
N ₄ S ₁	406.23	5.20	6.63	53.43	12.99	6.07	10.15
N ₄ S ₂	418.80	5.68	6.98	62.88	14.90	7.09	9.91
N ₄ S ₃	426.62	5.79	7.43	69.99	15.89	7.13	10.45
S.Em±	16.62	0.26	0.36	2.81	0.76	0.58	0.64
CD at 5%	48.74	NS	NS	8.23	2.23	1.70	NS

influence of sulphur levels. Highest number of siliqua per plant was noted with application of N₂S₂ which was followed by N₃S₃, N₃S₂ and N₂S₃ with non significant differences with each other. This increase in number of siliqua per plant further contributed in highest siliqua yield per plant, seed yield per plant as well as seed yield per hectare under N₂S₂. It was followed by N₃S₃, N₃S₂ and N₂S₃ with at par performance. Synergistic effect of N and S on growth attributes may be ascribed to the enhancement in yield parameters and seed yield. These findings are corroborated with those reported by [18, 20 and 22].

Seed quality

The seed quality was determined with respect to 100 seed weight (g), germination (%) and seedling vigour index (Table 3).

The results revealed significant effect of nitrogen levels on all three parameters. There was significant increase in germination (%) with N₂ over N₁. Further increase in nitrogen level had non-significant impact on germination (%) in the present investigation. Significant increase in 100 seed weight was observed with application of N₂ over N₁. Beyond N₂, no significant impact on 100 seed weight was recorded with higher levels of nitrogen. Highest seedling vigour was noted with N₃ which was at par to N₂, but significantly higher than N₁ and N₄. Higher germination and 100 seed weight may be the reason for high seedling vigour with optimum nitrogen dose. Proper nitrogen dose increases plumpness in grains which ultimately caused higher 100 seed weight. These results also find support with the findings of [12, 22].

In case of sulphur highest germination (%) was observed with S₃, which was at par with S₂. Both S₂ and S₃ sulphur

Table 3. Effect of different levels of nitrogen and sulphur and their combinations on seed quality and economic parameters in radish

Treatments	Germination (%)	100 seed weight (g)	Seedling vigour index-I	Gross income (Rs/ha)	Net income (Rs/ha)	B:C Ratio
Nitrogen levels						
N ₁	68.33	1.37	664.89	335333.47	261612.49	3.55
N ₂	85.22	1.67	746.06	535980.21	465020.33	6.55
N ₃	85.67	1.71	753.95	544038.37	472846.74	6.64
N ₄	80.56	1.66	725.95	405659.89	334236.51	4.68
S.E.m±	1.39	0.02	8.46	20097.05	20097.05	0.28
CD at 5%	4.08	0.06	24.80	58942.64	58942.64	0.82
Sulphur levels (S)						
S ₁	75.00	1.50	675.70	368401.29	297243.52	4.19
S ₂	81.58	1.67	735.67	502826.52	431003.35	6.02
S ₃	83.25	1.65	756.49	494531.15	422040.19	5.84
S.E.m±	1.21	0.02	7.32	17404.56	17404.56	0.24
CD at 5%	3.54	0.05	21.48	51045.82	51045.82	0.71
Combined effect of nitrogen and sulphur						
N ₁ S ₁	63.33	1.30	661.54	306900.46	233845.68	3.20
N ₁ S ₂	68.67	1.40	668.90	341956.15	268235.97	3.64
N ₁ S ₃	73.00	1.41	668.90	357143.81	282755.83	3.80
N ₂ S ₁	76.67	1.58	672.70	400397.44	330103.76	4.70
N ₂ S ₂	89.00	1.78	774.90	641195.20	570236.12	8.04
N ₂ S ₃	90.00	1.66	790.57	566348.00	494721.12	6.91
N ₃ S ₁	81.67	1.65	681.88	402238.90	331713.47	4.70
N ₃ S ₂	83.67	1.71	769.03	603048.66	531857.83	7.47
N ₃ S ₃	91.67	1.79	809.87	626827.55	554968.92	7.72
N ₄ S ₁	78.33	1.48	686.69	364068.36	293311.18	4.15
N ₄ S ₂	85.00	1.77	734.54	425106.06	353683.48	4.95
N ₄ S ₃	78.33	1.74	756.63	427805.26	355714.88	4.93
S.E.m±	2.41	0.04	14.65	34809.12	34809.12	0.48
CD at 5%	7.07	0.11	42.96	102091.65	102091.66	1.42

levels were significantly superior over S₁. There was significant increase in 100 seed weight and seedling vigour index with S₂ over S₁. Further increase in sulphur level S₃ had non significant influence on both 100 seed weight and seedling vigour index-I as compared to S₂. Enhancement in quality parameters may be ascribed to the increased oil and protein synthesis and accumulation in developing seed. These findings are in agreement with [16, 22].

Combined effects of nitrogen and sulphur were significant on 100 seed weight and seedling vigour index-I. Germination (%) did not show significant effect of combined applications of nitrogen and sulphur. Highest 100 seed weight was recorded with N₃S₃ which was at par with N₂S₂ and N₃S₂. Application of N₃S₃ had registered highest seedling vigour index-I which was at par with N₂S₃, N₂S₂ and N₃S₂. These findings are in line with [18, 22]. Considering the cost of fertilization with N₂S₂

(INR 775.71/1000m²) as compared to N₃S₃ (INR 865.66) or N₃S₂ (INR 798.88), it was found most effective [25].

On the basis of results obtained in the present investigation, it is concluded that application of N₃S₃ (100 kg nitrogen +45 kg sulphur/ha) resulted in highest seed yield and quality, and was also most cost effective.

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REFERENCES

- SRIMATHI P, R SUDHA AND K MALARKODI (2012). Radish. In: Vanangmudi *et al.* (eds.) *Advances in Seed Science and Technology Vol. II Quality Seed Production in Vegetables*. Agrobios (India), Jodhpur pp 605-620.

2. BAHADUR KUNVAR PHATEH AND SHASHI BALA (2017). Response of Different Sources and Levels of Sulphur in an Alluvial Soil of Varanasi on Growth and Yield Attributing Characters of Radish (*Raphanus Sativus* L.) Cv. Pusa Chetki. *Chemical Science Review and Letters*, **6**(22): 1198-1204.
3. BALOCH PA, R UDDIN, FK NIZAMANI, AH SOLANGI AND AA SIDDIQUI (2014). Effect of nitrogen, phosphorus and potassium fertilizers on growth and yield characteristics of radish (*Raphanus sativus* L.). *American-Eurasian Journal of Agricultural & Environmental Sciences*, **14**(6): 565-569.
4. AKAND MDH, HEMK MAZED, MD AI PULOK, JF MOONMOON AND SG PARTHO (2015). Influence of different dose of nitrogen on the growth and yield of cabbage (*Brassica oleracea* var. capitata L.). *International Journal of Multidisciplinary Research and Development*, **2**(2): 11-14.
5. ARUNA LAKRA, DEVI SINGH, VM PRASAD, DEEPANSHU AND MOHD SHABI (2017). Effect of nitrogen and phosphorus on growth and yield of radish (*Raphanus sativus* L.) CV. Pusha chetki under shade net condition. *The Pharma Innovation Journal*, **6**(11): 768-770.
6. KUMAR VINOD, SHASHANK TYAGI, S. C. PAUL, S. K. DUBEY AND SHRUTI SUMAN (2018). Effect of sources and doses of sulphur on S uptake and yield of mustard (*Brassica juncea* L.). *International Journal of Current Microbiology and Applied Sciences*, **7**(Special Issue): 5042-5047
7. KUTE SB (1997). Sulfur in Indian agriculture. National Symposium on sulfur in balanced fertilization, New Delhi, pp-S 111-2 / 1February 13-14.
8. ANONYMOUS (2011). International Rules for Seed Testing. International Seed Testing Association. Zürichstr. 50, CH-8303 Bassersdorf, Switzerland.
9. ABDUL-BAKI AA AND JD ANDERSON (1973). Vigor determination in soybean seed by multiple criteria. *Crop Science*, **13**: 630-633.
10. PANSE VG AND PV SUKHATME (1985). *Statistical Methods for Agricultural Workers*. ICAR Pub. New Delhi.
11. SHARMA AK (2000). Effect of nitrogen and phosphorus on seed yield in radish (*Raphanus sativus*). *Agricultural Science Digest*, **20**(1):46-49.
12. PANWAR AS, AS KASHYAP, HS BAWEJA AND K MEHTA (2001). Influence of nitrogen and phosphorus on seed yield of radish (*Raphanus sativus* L.) under mid hill conditions of HP Himalayas. *Indian Journal of Hill Farming*, **14**(1): 73- 77.
13. EL- DESUKI M, SR SALMAN, MA EL-NEMR AND AMR ABDEL-MAWGOUD (2005). Effect of plant density and nitrogen application on the growth, yield and quality of radish (*Raphanus sativus* L.). *Journal of Agronomy*, **4**(3): 225-229.
14. TRIPATHI AK, RB RAM, S ROUT, A KUMAR AND SS PATRA (2017). Studies on the effect of nitrogen levels and spacing on quality traits of radish (*Raphanus sativus* L.) cv. Kashi Sweta. *International Journal of Pure & Applied Bioscience*, **5**(4): 1951-1960.
15. POUDEL P, A SHRESTHA AND RK SHRESTHA (2018). Effect of nitrogen level on growth and yield attributing characters of radish. *Horticulture International Journal*, **2**(4): 208-210.
16. S RAKESH AND GC BANIK (2016). Effect of sulphur levels and sources on growth, yield and quality of mustard in Terai region of West Bengal. *Annals of Plant and Soil Research*, **18**(2): 152-155.
17. PANDA D AND S MONDAL (2020). Effect of boronated sulphur on the growth and yield of cauliflower. *Ecology, Environment and Conservation*, **26** (Feb. Suppl.): 100-106.
18. ISLAM N, MJH BHUIYAN, MAK CHOWDHURY AND MRH BHUIYAN (2004). Effects of nitrogen and sulphur on growth, yield, protein and oil contents of mustard (cv. Agrani). *Journal of Bangladesh Agricultural University*, **2**(2):259-264.
19. ROSEN CJ, VA FRITZ, GM GARDNER, SS HECHT, SG CARMELLA AND PM KENNEY (2005). Cabbage yield and glucosinolate concentration as affected by nitrogen and sulfur fertility. *HortScience*, **40**(5):1493-1498.
20. KISKO MF, N KADHUM, NS ABID AND ZAALI (2021). Effects of nitrogen and sulfur sprays on the growth and production of broccoli (*Brassica oleracea* var. italica L.) *Baghdad Science Journal*, **18**(3): 501-508.
21. KHAN OA, SK RAINA, D RAM, MA DAR, M.A MALIK AND JA WANI (2018). Effect of different sources of sulphur on yield and quality of cauliflower (*Brassica oleracea*) under temperate conditions of Kashmir. *Indian Journal of Agricultural Sciences*, **88**(2): 284-284.
22. KUMAR S, SK VERMA, TK SINGH AND S SINGH (2009). Effect of nitrogen and sulphur on growth, yield and nutrient uptake by Indian mustard (*Brassica juncea*) under rainfed condition. *Indian Journal of Agricultural Sciences*, **79**(8): 648-50.
23. RAMEEH V, M NIAKAN AND M HOSSEIN (2019). Sulfur effects on sugar content, enzyme activity and seed yield of rapeseed (*Brassica napus* L.). *Agronomía Colombiana*, **37**(3): 311-316.
24. CHAUHAN ZY, DK PATEL AND K BHABHOR (2020). Effect of nitrogen, phosphorus and sulphur on yield, nutrient uptake and soil fertility after harvest of mustard (*Brassica juncea* L.). *International Journal of Current Microbiology and Applied Sciences*, **9**(6): 3506-3512.
25. KUMAR P, D KUMAR, S KUMAR AND S SHARMA (2013). Effect of integrated nutrient management practices on seed yield and economics of seed production in radish (*Raphanus sativus* L) cv. Chinese Pink. *Plant Archives*, **13**(1): 243-246.