

EFFECT OF NITROGEN AND SULPHUR LEVELS ON PRODUCTIVITY AND QUALITY OF RADISH UNDER DRIP IRRIGATION

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Received-01.08.2021, Revised-11.08.2021, Accepted-24.08.2021

Abstract: A field experiment was conducted at Research farm, Agricultural Research Station, S K Rajasthan Agricultural University, Bikaner during *rabi* season of 2019-20 on loamy sand soil. The experiment comprising four levels of each nitrogen (Control, 40, 60 and 80 kg ha⁻¹) and sulphur levels (Control, 15, 30 and 45 kg ha⁻¹) making 16 treatment combinations replicated three times in factorial randomized block design. Application of 60 kg N ha⁻¹ recorded significantly higher yield attributes, yield and chlorophyll content of radish over control and 40 kg N ha⁻¹ and remained statistically at par with 80 kg N ha⁻¹. Increasing levels of nitrogen significantly decreased pungency level in root up to 60 kg N ha⁻¹, yet, it was statistically at par with 80 kg N ha⁻¹. The increasing level of sulphur up to 30 kg S ha⁻¹ significantly increased the yield attributes, yield and chlorophyll content of radish and was at par with 45 kg S ha⁻¹. Pungency level in root increased significantly as a result of increasing levels of sulphur up to 45 kg S ha⁻¹ over rest of all applied treatment.

Keywords: Chlorophyll, Nitrogen, Pungency, Radish, Sulphur

INTRODUCTION

Radish (*Raphanus sativus* L.), an open pollinated root and leafy vegetable is a widespread tropical and temperate crop. Radish is grown for its young tippy tuberous root which is used either raw or cooked. It is an excellent source of minerals such as calcium, potassium and phosphorus. It is a splendid source of carbohydrates, protein and vitamins A and C (Bakhsh *et al.*, 2006). The leaves of radish are beneficial reservoir for extraction of protein on a commercial manner. Its consumption preclude constipation, increase appetite and utile for jaundice, liver disorders (Brintha and Seran 2009). Radish is an pabulum root vegetable with a pungent taste, due to glucosinolates (GLS) which is a class of nitrogen and sulphur containing plant secondary metabolites with diverse effects on crop characteristics including flavour, nutrient content, resistance to herbivores and benefits to human health (Baik *et al.*, 2003; Clay *et al.*, 2009 and Lee *et al.*, 2016). Nitrogen is the most deficient element especially in coarse texture sandy soil of Rajasthan. Nitrogen play a very important role in the physiological process of plant, makes plant dark green colour, improves the absorption and respiration process in plant and increase the vegetative growth. An adequate supplying of nitrogen is related with vigorous vegetative growth and more effective use of available inputs, finally stellar to higher productivity but excessive use of nitrogen negatively affects the quality as well as yield of crops (Chen *et al.*, 2004). Nitrogen also plays an important role 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 (Akand

et al., 2015). Radish plant with more leaves can give more root yield as compared to the plants having less leaves. Nitrogen is the chief component of protein and chlorophyll. Nitrogen has shown some effects on the accumulation of glucosinolates (Shattuck and Wang 1993 and Zhao *et al.*, 1994). Sulphur has been widely recognized as the fourth major plant nutrient after nitrogen, phosphorus and potassium for since last many years. Available sulphur in soil is often ranged between 5-10 ppm in light texture soils of Rajasthan. Sulphur has known for its function in the synthesis of sulphur containing amino acid (cystine, cysteine and methionine), carbohydrates, proteins, vitamins, oils, flavour compounds and chlorophyll. Sulphur is a crucial input to maintain yields in many Indian soils due to widespread deficiency of sulphur reported in many districts. Cruciferous crops have shown improvement in the yield and quality through application of sulphur under field conditions. The level of glucosinolates in these plants is highly dependent on genetic factors as well as environmental determinants such as the available soil sulphur content. Glucosinolates provide crucifers with a sulphur storage pool that is used to maintain normal metabolism under conditions of sulphur deficiency and as such, their accumulation and the supplying of sulphur are closely related (Nikiforova *et al.* 2003 and Schonhof *et al.* 2007). Taking into consideration the above facts, the present investigation was planned to evaluate effect of nitrogen and sulphur on yield attributes and yield of radish under drip irrigation in western Rajasthan.

MATERIALS AND METHODS

The experiment was conducted at Research farm, Agricultural Research Station, SKRAU, Bikaner

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during *rabi*, 2019-20. Geographically, it is situated at 28° 10' N latitude and 73° 18' E longitude at an altitude of 223.88 m above mean sea level. The relative humidity of the locality fluctuates between 32.4 to 92.1 percent, total rainfall was 34 mm and average maximum and minimum temperature 2.3°C to 35.6°C respectively. The experiment comprises four levels of each nitrogen (Control, 40, 60 and 80 kg ha⁻¹) and sulphur levels (Control, 15, 30 and 45 kg ha⁻¹) with three replication and making 16 treatment combinations. Observations were recorded at five randomly selected and labeled plants from each treatment and each replication for yield attributes and yield. Yield attributes parameters of the following traits were recorded *viz.*, plant height (cm), number of leaves, root length and diameter (cm), fresh weight plant⁻¹ (g). The samples were first air dried for some days and then in hot air oven at 65°C temperature till constant weight reached. The weight was recorded and expressed as dry weight plant⁻¹ (g). Total yield (q ha⁻¹) included root weight with leaves in kilograms plot⁻¹ was recorded at two to three days intervals. Chlorophyll content was worked out at 45 DAS. Hiscox and Israelstem (1979) demonstrated that the absorption spectrum (600-680nm) for chlorophyll extracted in dimethyl sulfoxide (DMSO) was virtually identical to that for extracted in 90 per cent acetone. Chlorophyll was extracted in DMSO and transmittance recorded with spectrophotometer at 645 and 663 nm. Arnon's equation (1949) was used to work out chlorophyll content. Isothiocyanate content (pungency) of radish was determined by the method of extraction (Carlson *et al.*, 1985). Experimental data recorded in various observations were statistically analysed with the help of Fisher's analysis of variance technique (Fisher, 1950). The critical difference (CD) for the treatment comparisons were worked out wherever the variance ratio (F test) was found significant at 5% level of significance.

RESULTS AND DISCUSSION

Yield attributes and yield

Results revealed that (Table 1 and Fig. 1) the effect of different levels of nitrogen application significantly influenced all experiment traits at maturity stages. Progressive increase in level of nitrogen significantly increased the plant height of radish up to treatment N₆₀ and was at par with treatment N₈₀. The increase in plant height under treatment N₆₀ was 39.85 and 11.12 per cent higher over control and treatment N₄₀, respectively. Progressive increase in level of nitrogen significantly improved the number of leaves per plant of radish up to treatment N₆₀ and at par with treatment N₈₀. The increase in number of leaves per plant under treatment N₆₀ was 56.83 and 20.59 per cent higher over control and treatment N₄₀, respectively. Application of 80 kg N ha⁻¹ resulted

30.48 cm root length that was 44.79, 16.69 and 4.95 per cent higher than with N₀, N₄₀ and N₆₀ treatment respectively. Although, nitrogen application at treatment N₈₀ maximized the root length, yet, it was statistically at par with treatment N₆₀. Application of nitrogen at treatment N₆₀ recorded 4.26 cm root diameter that was significantly higher over treatment N₀ and N₄₀ with corresponding increase of 53.75 and 22.76 per cent at treatment N₆₀. However, N₈₀ treatment was statistically at par with N₆₀ treatment. Application of nitrogen upto treatment N₆₀ significantly increased the fresh weight of plant over preceding levels. The increase in fresh weight of plant at N₆₀ level was 9.86 and 3.73 per cent over treatment N₀ and N₄₀, respectively and which was statistically at par with treatment N₈₀. Dry weight of plant 26.10 g was recorded under the treatment N₆₀ that was significantly higher over treatment N₀ and N₄₀ with corresponding increase of 53.08 and 18.31 per cent. Although, application of nitrogen at treatment N₈₀ maximized the dry weight of plant, yet, it was statistically at par with treatment N₆₀. Total yield of radish improved significantly with successive increase in level of nitrogen up to treatment N₆₀ which resulted in total yield of 310.6 q ha⁻¹ with an increase of 13.48 and 4.61 per cent over treatment N₀ and N₄₀, respectively. Application of nitrogen N₈₀ recorded the highest total yield of 318.2 q ha⁻¹, which was found at par with N₆₀. It is because of the fact that application of nitrogen has been reported to higher dose of nitrogen increased plant height. Minimum plant height might be due to the result of unavailability of nitrogen and other nutrients required by the plants for their normal growth and development. Due to the role of nitrogen for cell division, cell enlargement and protein synthesis. Increase in number of leaves per plant increase the size of root length and diameter as well as fresh and dry weight of plant. This positive correlation is mainly due to excessive storage of carbohydrates due to increased photosynthetic activity in the plant. Higher level of nitrogen may be attributed to increased uptake of nitrogen which being the constituent of protein and component of protoplasm that might favorably affect the chlorophyll content of the leaves resulting in increased synthesis of carbohydrates which are further utilized in building up of new cells. It is well understood fact that total yield is highly and positively affected by plant height, number of leaves per plant, root length, root diameter, fresh weight of plant. The similar results were also reported by Baloch *et al.*, (2014), Lakra *et al.*, (2017), Tripathi *et al.*, (2017), Poudel *et al.*, (2018) and Rampal *et al.*, (2019).

Progressive increase in level of sulphur significantly enhanced the plant height of radish up to treatment S₃₀ and was at par with treatment S₄₅. The increase in plant height under treatment S₃₀ was 26.58 and 9.01 per cent higher over control and treatment S₁₅, respectively. Increasing level of sulphur significantly

increasing number of leaves per plant of radish up to treatment S₃₀ and was at par with treatment S₄₅. The increase in the number of leaves per plant under treatment S₃₀ was 36.07 and 18.0 per cent higher respectively than control and treatment S₁₅. Sulphur application at treatment S₄₅ recorded 29.53 cm root length that was 29.12, 13.97 and 4.01 per cent higher than treatment S₀, S₁₅ and S₃₀, respectively. Although, sulphur application at treatment S₄₅ maximized the root length, yet, it was statistically at par with treatment S₃₀. Application of sulphur at treatment S₃₀ recorded 4.02 cm root diameter that was significantly higher over treatment S₀ and S₁₅ with corresponding increase of 63.75 and 18.23 per cent at treatment S₃₀. However, treatment S₄₅ was statistically at par with treatment S₃₀. Sulphur application up to treatment S₃₀ significantly increased the fresh weight of plant over preceding levels. The increase in fresh weight of plant with this level was 6.89 and 3.25 per cent over treatment S₀ and S₁₅, respectively. Maximum fresh weight of plant was recorded in treatment S₄₅ (291.83 g) which was statistically at par with treatment S₃₀ (288.43 g). Sulphur application at treatment S₄₅ recorded 26.32 g dry weight of plant that was 43.04, 19.47 and 2.85 per cent higher than treatment S₀, S₁₅ and S₃₀, severally, it was statistically at par with treatment S₃₀. It significantly improved the total yield of radish over preceding level up to treatment S₃₀. It recorded total yield of 309.6 q ha⁻¹ and thus increased the 11.72 and 3.89 per cent over treatment S₀ and S₁₅, respectively. Maximum total yield (314.6 q ha⁻¹) was recorded at treatment S₄₅ which was statistically at par with S₃₀ treatment. The profound influence of sulphur fertilization on the yield attributing characters could be attributed to increased metabolic processes in plants which seem to have promoted meristematic activities causing higher growth and expansion of photosynthetic surface. Thus, it is obvious that the improved growth and development of the crop plants in the present investigation might be the result of enhanced energy transformation and enzyme activation in carbohydrate metabolism and subsequent greater photosynthesis partitioning in the yield attribute characters. The higher content of sulphur in plants is known to play role in better development and thickening of xylem and collenchyma tissues. The total yield of radish is the cumulative effect of yield attributing characters. These results are in close conformity with the findings of Sriramachandrasekharan (2012), Murmu *et al.*, (2015), Kumar *et al.*, (2016) and Bala and Bahadur (2017).

Quality parameters

An appraisal of data presented in table 2 and fig. 2 indicated that nitrogen fertilization in radish significantly influenced the chlorophyll content in leaves. Chlorophyll content in treatment N₈₀ recorded significantly superior over rest of treatment but remained statistically at par with treatment

N₆₀. The total chlorophyll content in leaves increased due to nitrogen fertilization might be due to fact that nitrogen is so vital element and component of chlorophyll synthesis. Similar results in plant has also been reported by Basha and El-Aila (2015) and kudra and Ruza (2017). The highest pungency level in root was recorded (386.7 µg 100 g⁻¹ root) under control and lowest pungency level in treatment N₈₀ (374.3 µg 100 g⁻¹ root) which was statistically at par with treatment N₆₀ (Table 2 and Fig. 3). The decreased the pungency level in root due to nitrogen fertilization might be due to the fact that glucosinolates are nitrogen and sulphur containing compounds suggesting that sulphur and nitrogen concentrations in the plant tissue strongly affect glucosinolate concentration. O-acetylserine (OAS) plays a major role in this sulphur and nitrogen levels as OAS is derived from sulphur and nitrogen assimilation pathways. When nitrogen was limited OAS formation was reduced. OAS is a precursor of the nitrogen and sulphur containing amino acids (*i.e.* cysteine and methionine) which are basic metabolites of glucosinolate synthesis. Therefore, high nitrogen could lead to an accumulation of OAS and reduced cysteine and methionine synthesis, resulting in a lack of precursors for glucosinolate synthesis and in a reduced glucosinolate concentration. Similar results were also reported by Li *et al.* (2007), Schonhof *et al.* (2007) and Gerendas *et al.* (2009).

Data presented in table 2 and fig. 2 showed that sulphur fertilization in radish significantly influenced the chlorophyll content in leaves. Chlorophyll content in treatment S₄₅ recorded significantly superior over rest of treatment but remained statistically at par with S₃₀ treatment. The synergistic effect of sulphur fertilization on synthesis of chlorophyll in radish leaves at 45 DAS. Sulphur being a constituent of succinyl co-enzymes A involved in chlorophyll formation. Higher chlorophyll content of leaves in presence of sulphur might be due to on account of enhanced synthesis of chlorophyll fertilization containing amino acids particularly methionine which is involved in iron metabolism and is an important component of cell for chlorophyll synthesis. This is in close conformity with the findings of Kumawat *et al.* (2006), Jat *et al.* (2012) and Houhou *et al.* (2018). Pungency level in root was significantly influenced by sulphur application. The maximum pungency level in root was recorded (391.4 µg 100 g⁻¹ root) under treatment S₄₅ in comparison to all applied treatment (Table 2 and Fig. 3). The increased the pungency level in root due to sulphur fertilization might be due to glucosinolates are nitrogen and sulphur containing compounds suggesting that nitrogen and sulphur concentrations in the plant tissue strongly affect glucosinolate concentration. O-acetylserine (OAS) plays a major role in this nitrogen and sulphur levels as OAS is derived from nitrogen and sulphur assimilation pathways. When sulphur was limited, OAS was

seentoaccumulate. OAS is a precursor of the nitrogen and sulphur containing amin oacids viz. cysteine and methionine which are basicmetabolites of glucosinolate synthesis. Therefore, high sulphur could reduced to an accumulation of OAS and increased cysteine and methionine synthesis,

resulting increasedthe availability of precursors for glucosinolate synthesis and in an increased glucosinolate concentration. Similar as, Li *et al.* (2007), Schonhof *et al.* (2007) and Gerendas *et al.* (2009) also reported that application of sulphur fertilizer increased pungency level in root.

Table 1. Effect of nitrogen and sulphur levels on yield attributes and yield of radish

Treatments	Plant height (cm)	Number of leaves plant ⁻¹	Root length (cm)	Root diameter (cm)	Fresh weight plant ⁻¹ (g)	Dry weight plant ⁻¹ (g)	Total yield (q ha ⁻¹)
N ₀	47.00	7.02	21.05	2.10	265.48	17.07	273.7
N ₄₀	59.15	9.13	26.12	3.47	281.18	22.06	296.9
N ₆₀	65.73	11.01	29.04	4.26	291.67	26.10	310.6
N ₈₀	67.68	11.60	30.48	4.60	293.74	27.10	318.2
SEm±	1.46	0.41	0.73	0.14	2.62	0.81	3.15
CD at 5%	4.22	1.17	2.10	0.40	7.58	2.35	9.09
S ₀	50.75	7.90	22.87	2.70	270.67	18.40	277.1
S ₁₅	58.93	9.11	25.91	3.40	280.23	22.03	298.0
S ₃₀	64.24	10.75	28.39	4.02	289.34	25.59	309.6
S ₄₅	65.63	10.99	29.53	4.30	291.83	26.32	314.6
SEm±	1.46	0.41	0.73	0.14	2.62	0.81	3.15
CD at 5%	4.22	1.17	2.10	0.40	7.58	2.35	9.09

Table 2. Effect of nitrogen and sulphur levels on total chlorophyll content at 45 DAS and pungency level of radish

Treatments	Total chlorophyll content in leaves (mg g ⁻¹)	Pungency level (µg 100 g ⁻¹ root)
N ₀	1.19	386.7
N ₄₀	1.91	380.7
N ₆₀	2.20	375.4
N ₈₀	2.30	374.3
SEm±	0.04	1.50
CD at 5%	0.12	4.34
S ₀	1.58	362.6
S ₁₅	1.84	377.2
S ₃₀	2.05	386.0
S ₄₅	2.13	391.4
SEm±	0.04	1.50
CD at 5%	0.12	4.34

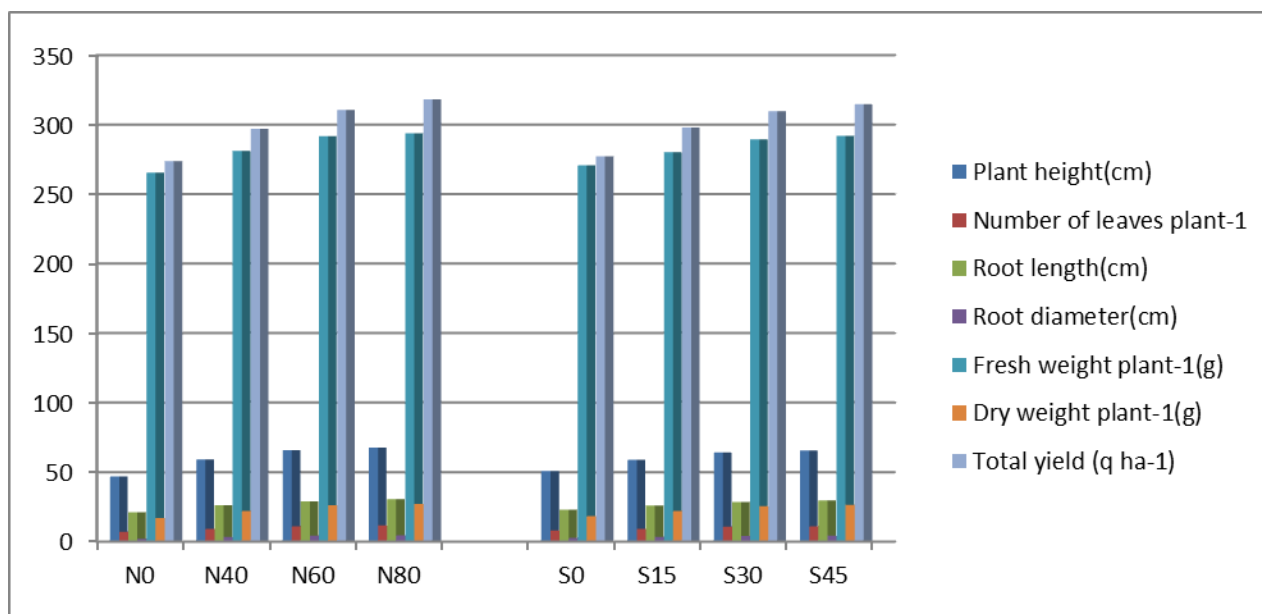


Fig. 1. Effect of nitrogen and sulphur levels on yield attributes and yield of radish

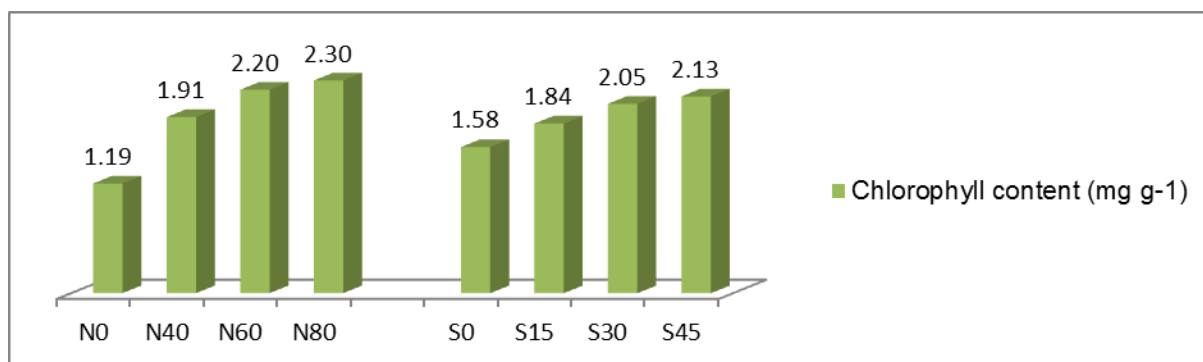


Fig. 2. Effect of nitrogen and sulphur levels on total chlorophyll content in leaves

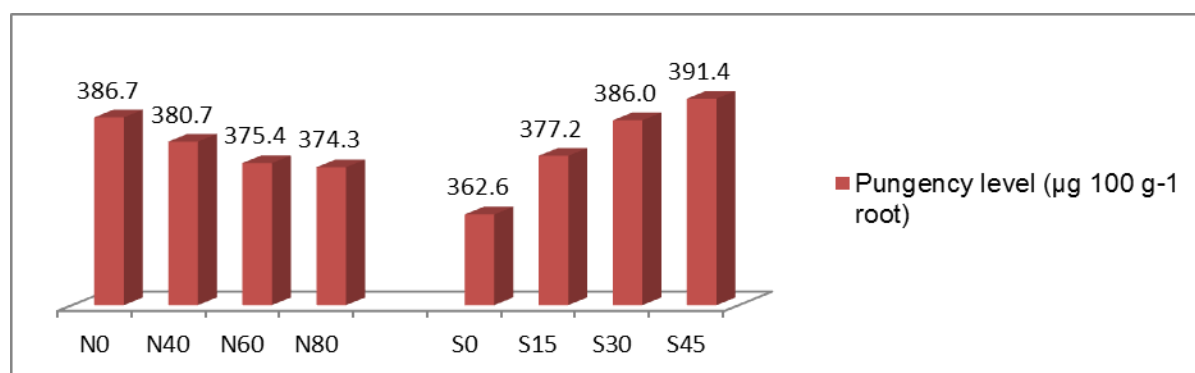


Fig. 3. Effect of nitrogen and sulphur levels on pungency level of radish

CONCLUSION

On the basis of above findings it is concluded that yield of rabi radish can be maximized in Western Rajasthan by the application of nitrogen and sulphur which gave significant higher yield attributing characters, total yield and quality characters. In regards to above mentioned parameters, the treatment N₆₀ and S₃₀ gave significantly higher values as compared to other treatments.

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