CHAPTER V

DISCUSSION
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The present studies are mainly aimed to find out the suitable level of nitrogen and sulphur for better growth, flowering, fruiting, yield, metabolic activities and oil content of Indian mustard (*Brassica juncea* L.) cultivar Varuna as well as to study the interaction effect of nitrogen and sulphur. Indian mustard (*Brassica juncea* L.) also popularly called as "Rai" is one of the important crops of *Brassica* group in mustard growing states especially in North India. This crop is considered to be most adoptable crop under moderate adversities of soil, climate, sowing time, disease and insect-pests.

Nitrogen and sulphur are the two important fertilizer elements which are indispensable of plant life and these nutrients play an important role in improving the growth and development accompanied by higher yield of field crops especially to Indian mustard.

Nitrogen is taken up by the plants in higher amount as it is indispensable constituent of protein and nucleic acid that play
fundamental role in metabolism, growth, reproduction and transmission of heritable characters. Moreover, protein forms the basis of enzymes responsible to control and regulate the bio-chemical changes at the germination to the stage of maturity. Nitrogen is taken up, generally, by the plants either as ammonium or as nitrate ions. The absorbed nitrate ions are rapidly reduced to ammonium ions through a molybdenum containing enzymes. The ammonium ions and some of the carbohydrates manufactured in the green leaves are converted into amino acids. Hence, as the level of nitrogen supply increases, the extra protein produced allows the plant leaves to grow larger. The amount of leaf area available for photosynthesis in many crop is roughly proportional to the amount of nitrogen supply.

Next to nitrogen, sulphur is now recognised as the fourth major nutrient in addition to phosphorus and potassium. Sulphur is involved in the formation of chlorophyll, activation of enzymes in the formation of glucosides or glucosinolates (mustard oil) which provides the pungency in oils.

Sulphur improves crop yield, oil percentage in oilseeds, plant proteins, quality of tobacco and vegetables as well as nutritional quality of forages (Tandon, 1995).

Thus, nitrogen and sulphur play an important role in improving the quality and marketability of the produce. The benefit
of nitrogen and sulphur application is thus two fold - (i) increase in growth, flowering, fruiting and yield and (ii) increase in crop quality.

The results related to the present field experimentation have been described observationwise in the previous chapter of Experimental Findings and the same are being described in the present chapter in the light of research work available so far summerised in the chapter of Review of Literature.

5.1 Effect of Nitrogen; Sulphur; and Interaction Nitrogen and Sulphur:

In the present investigation, the effect of varying levels of N, S and NS has been observed on growth parameters, yield attributes, yield, oil content and other metabolic activities as described below:

5.1 (a) Effect on Growth Parameters:

In the present studies, increasing dose of nitrogen promoted all the growth parameters. Plant height increased linearly with nitrogen application upto 100 kg/ha, but the significant effect was restricted to 80 kg N/ha over control as well as 100 kg N/ha over 80 kg at all the stages of crop growth (30, 60 and 90 DAS). Howard and
Rahman (1924) working on linseed also obtained an increase in plant height with application of nitrogen. Ali Mohammad (1930) and Johnson (1932) also obtained an increase in plant height with nitrogen application. Watson (1952), Mathur et al., (1958) and Khan and Gupta (1959) reported an increase in height in plant with nitrogen supply. The beneficial effect of nitrogen has already been reported on plant height by Singh and Singh (1959) and Tripathi (1969).

Similar results were also obtained by Horedyski and Pierton (1962), Singh et al., (1966), Pandey et al. (1970), Reddy (1983), Guleria et al. (1983, 1984). Dhillon et al. (1987), Sharma and Ray (1987) Raghubanshi et al. (1987), Singh and Saran (1987) and Singh and Mishra (1994), Thakur et al. (1997), Singh et al. (2000) and Udai Burman et al. (2003) respectively in oilseed and other crops. The positive effect of nitrogen on green leaves/plant was more distinct at 60 days as compared to 30 days after sowing.

Nitrogen with increasing dose upto 100 kg/ha significantly increased the primary branches while such increase in the secondary plus other and total branches was correlated with increasing dose of nitrogen.

Similar results were also obtained by Sandhu and Singh (1960), Tripathi (1969), Bhardwaj (1975), Tripathi and Siddiqui (1979), Sharma and Ray (1987), Raghubanshi et al. (1987), Singh and Saran
(1987) and Sharma and Tiwari (2003) respectively.

In this research work carried on mustard, fresh and dry weight both were increased significantly up to 100 kg N/ha and 80 kg/ha respectively. On the other hand, increasing levels of nitrogen delayed the time of flowering and maturity.

Tripathi and Rao (1975) also obtained an increase in fresh and dry weight of plant with the application of nitrogen. Tripathi and Singh (1977), Reddy (1983), Singh et al. (1988), Thakur et al. (1997) and Singh et al. (2000) also observed an increase in fresh and dry weight of plant with nitrogen application.

Nitrogen is most important constituent of chlorophyll, the role of which is very well known in the process of photosynthesis. The leaves of the plant growing with a low level of nitrogen compared with other nutrients are pale/yellowish to radish green which darken rapidly as the nitrogen supply increase and become very dark green when it is excessive. The application of nitrogen favours the synthesis of protoplasm in plant body which is responsible ultimately for the cell division. As the cell division in plant increases, the plant body also increases in the size like more number of leaves, height, branches etc.

Also, in our experiment, the application of sulphur was found to increase the height of oilseed crop plant. In about 125 field
trials conducted under the FAO sulphur network during 1987-89, significance response to sulphur was obtained (Biswas and Tewatia, 1991). Similar results were also obtained by Goraya et al. (1984), Sankaran and Ramanathan (1985), Karwasra et al. (1985), Bapat and Sinha (1985), Singh (1999) and Kumar and Verma (1999) in different oilseed, pulse and cereal crops.

Similar to height, the number of leaves/plant was also found to increase with the application of sulphur to the mustard plant. The size of leaf was also found to increase over control with sulphur application. Similar results were also obtained by Dubey and Khan (1993), Jain et al. (1995), Chandel et al. (2002) and Chandel et al. (2003) respectively.

The application of sulphur to mustard crop, in this experiment, was found to have more height, more number of leaves, greater size of leaves, more branches and finally the dry matter production/plant. Goraya et al. (1984) reported that application of sulphur increased the dry matter accumulation in oilseed crop. Sankaran and Ramanathan (1985) also observed an increase in stover yield with the application of sulphur.

Karwasra et al. (1995) working on mustard also obtained an increase in dry matter production many folds with the application of sulphur. Bapat and Sinha (1985) working on blackgram and
Thirumalaiswamy et al. (1985) working on groundnut also obtained an increase in dry matter production with the application of sulphur. Similar results were also obtained by Chandel et al. (2003) in mustard.

The nitrogen x sulphur application (NS) in our experiment showed better response in case of plant height, number of leaves, number of branches and dry matter production/plant in mustard.

Synergistic behaviour of nitrogen and sulphur has been also reported by Dev et al. (1979) and Ishwari et al. (1987) in maize and wheat respectively.

Singh and Mishra (1994) working at C. S. Azad University of Agriculture and Technology, Kanpur also reported the better response of N x S application than N or S alone in increasing height, number of branches and dry matter production/plant in linseed followed by Sakai et al. (2000) in maize.

Also, working on mustard (Brassica juncea Linn.) Udai Burman et al. (2003) reported that application of nitrogen in combination with sulphur significantly improved the growth and increased the dry matter production.

5.1 (b) Effect on Flower Initiation, Flowering and Metabolic Drifts:

In the present experiment, the application of nitrogen (N),
sulphur (S) and nitrogen in combination with sulphur (N\texttimes S) slightly delayed the flower initiation and flowering but increased the number of flowers/plant. The treatment $N_{100}S_{40}$ was found more effective than rest of the treatments in respect of enhancing the number of flowers/plant in \textit{Brassica juncea} Linn. cultivar Varuna as supported by Shah (2004).

The transformation of a vegetative shoot into a reproductive shoot has attracted the attention of botanist since the middle of the 19th century. The idea that there are organ farming substances in plants was first given by Julius Sachs (1880).

Flowering is an important stage in a plant's life because the transition from vegetative to generative development involves essential changes in metabolism, translocation of nutrients, and arouses essential formative processes which are connected with the development of organs of sexual reproduction (Chailakhyan, 1968).

In our experiment, at the time of flower initiation the application of N, S, and N $\times$ S to mustard cultivar Varuna increased the Total-N, Organic-N, amino acids, protein and reducing sugar content in leaves and shoot apices, resulting an increase in number of fruits (siliquae) per plant in mustard. Results of the experiments of Rohtak Agricultural Experiment Station, also indicated that the amount of protein was increased due to increase in amount of Total-N,
Organic-N and amino acids with nitrogen application. Similar results were also obtained by Bhatty (1964), Tripathi (1969), and Nordestgard respectively.

Singh and Misra (1994) and Sharma and Tiwari (2003) also obtained and increase in Total-N, Organic-N and protein with application of N, S, and N x S in linseed. Similar results were also obtained by Dwivedi et al. (2003) in Soybean and Udai Burman et al. (2003) in *Brassica juncea* Linn. with N x S application.

5.1 (c) Metabolic Drifts during Flower Initiation:

In this experiment, the amount of total-N, Organic-N, amino acids, protein and reducing sugars was found to increase in leaves and shoot apices of flower-bud initiation in *Brassica juncea* L. cultivar Varuna with the application of N, S and with combination of N and S. The amount of nitrogen increased in leaves of treated plants resulting dark green leaves due to the formation of more chlorophyll.

Also, the amount of amino acids was found to increase over control in N treated plants of mustard cultivar Varuna. As the amount of amino acids increased the synthesis of protein was also found to increase in leaves and shoot apices at the time of flower-bud initiation.

Nitrogen is most important major and indispensable
constituents of protein and nucleic acid that play a fundamental role in metabolism, growth and reproduction. Nitrogen is generally taken up by the plants and is converted into amino acids finally to protein. Results of the experiments at Rohtak Agricultural Experiment Station indicated that protein was increased due to N application (Kress, 1951). Bhatty (1964) also observed that N manuring was found to increase protein content. Similar results were also obtained by Steward and Porter (1969) and Dubey et al. (1994).

Similar to N application, S was also found to increase the amino acids content in leaves and shoot apices in mustard cultivar Varuna at flower-bud initiation. The results is also in agreement with the findings of Balasubramaniam et al., (1978) in onion; Badigar et al. (1985) in sulphur. Similar results were also obtained by Vilaya Chandram (1985), Clarson (1989), Krishnappa (1993) and Tandon (1995) respectively.

It was also observed in our experiment that S application increased the protein content in leaves and shoot apices in mustard cultivar Varuna at flower initiation. Similar results were also reported by Kress (1951), Bhatty (1964), Steward and Porter (1969), Paulraj et al. (1976), Kamer et al. (1981), Karwasra et al. (1985), Tandon (1991), Dubey et al. (1994) and Tandon (1995) respectively in different crops.
In this research work, the interaction (N x S) effect was found more favourable than N or S application in increasing the amount of total-N, Organic-N, amino acids, protein and reducing sugars in leaves and shoot apices of mustard cultivar Varuna at flower initiation. Similar results were also obtained in finger millet, Soybean, Indian mustard, Chick pea, lucern potato etc. by Singh et al. (1975), Ramamurthy and Susheela Devi (1982), Aulakh et al. (1984), Byers et al. (1984), Clement and Gessel (1985), Krishnappa (1993), Kute (1995), Tandon (1995), Dwivedi et al. (2003) and Udai Burman et al. (2003) respectively.

Thus, it is expected that with the application of N or S alone or in combination (N x S) enhance the synthesis of carbohydrate (reducing sugar), amino acids and protein which are translocated to the shoot apex resulting an increase in the amount of these compounds in the shoot apex for the formation of more flower-buds, flowers and fruits respectively.

5.1 (d) Effect on Yield Attributes:

In this experiment, the application of nitrogen was found to increase the growth parameters i.e. height, number of leaves, branches and vigour of plants resulting an increase in number of flowers and fruits (siliquae) per plant in mustard. The application
of nitrogen was also found to increase the number of seeds/siliqua and seeds/plant in mustard.

Watson (1952) also obtained an increase in seeds/capsule in linseed with nitrogen application. Beech and Norman (1964) and Pandey et al. (1970) working on linseed crop also observed an increase in number of capsules/plant and number of seeds/capsule with nitrogen application. Similar findings were also reported by Shekhawat et al. (1971), Singh et al. (1974), Ranjan (1974), Singh and Singh (1978) respectively.

With increase in the number of siliquae/plant, number of seeds/siliqua, number of seeds/plant the boldness of seeds was also observed. This is why, the 1000-seed weight was found to increase in nitrogen treated plants. The increment in 1000 seed weight was due to the application of nitrogen over control. The 1000 grain weight (test weight) was also found to increase over control in linseed with the application of nitrogen as reported by Guleria et al., (1983, 1984). The increase in capsules/plant, seeds/capsule and 1000 grain weight in linseed was also recorded by Sharma and Ray (1987), Singh and Misra (1994), Sharma and Tiwari (2003) and in mustard by Pramanik et al. (1996), Arthamwar et al. (1996) and Chandel et al., (2000) respectively.

The application of sulphur at 20 and 40 kg/ha to Indian
mustard (*Brassica juncea* L.) cultivar Varuna, in this experiment, was found to increase the number of siliquae/plant, number of seeds/siliqua and number of seeds/plant and 1000-grain weight respectively. Karle (1982) also obtained an increase in yield attributes specially 1000-grain weight with the application of sulphur in oilseed crops. Bulbule (1983) and Karle et al. (1985) also reported that sulphur treatment increased the yield attributes in oilseed crops.

Field experiment undertaken at Dholi (Bihar), Kanpur (U.P.), and Varanasi (U.P.) have been shown distinct benefit of adding sulphur to cereals, pulses and oilseeds (Saha and Luthra, 1984; Tiwari et al. (1984 a), 1984 b); Singh et al., 1991; Tripathi and Sharma, 1993; Sharma and Sakal, 1993 a, 1993 b).

In this experiment, N x S application was found more effective than N or S applied alone in respect of increasing flowering, fruiting, number of siliquae/plant, seeds/siliqua and seeds/plant in Indian mustard (*Brassica juncea* L.) cultivar Varuna. The 1000 grain weight (test weight) was also found to increase over control with nitrogen in combination with sulphur. Similar results were also obtained by Singh and Misra (1994) and Sharma and Tiwari (2003) respectively.
5.1 (d) Effect on Yield:

In this experiment, a linear increase in biological, stalk and seed yield was recorded with increasing levels of nitrogen up to 100 kg/ha in Indian mustard (*Brassica juncea* Linn.) cultivar Varuna. Anderson *et al.* (1956) found 28% increase in yield with the application of nitrogen over control. Beech and Norman (1964) and Pandey *et al.* (1970) also obtained an increase in seed yield. Similar results were also obtained by Horedyski and Pierton (1962), Dybing (1964), Agrawal (1965), and Singh *et al.* (1966) in oilseed crop.

Also, working on oilseed crop, Tomar and Singh (1973), Singh *et al.*, (1974) and Ranjan (1974) also noted an increase in seed yield/plant and seed yield/ha. Singh and Singh (1978) obtained higher seed yield of linseed with the application of nitrogen.


Panwar and Bhardwaj (1975) and Mahendra *et al.* (1977) observed better response in seed yield in linseed, sarson, and rai with
application of 80 kg N/ha. Similar results were also obtained by Singh (1968), Nazir et al. (1987) and Mahajan et al. (1987) in different oilseed crops with the application of 50-80 kg N/ha.

At Central Arid Zone Research Institute, Jodhpur working on Brassica juncea L. Udai Burman et al., (2003) also observed an increase in seed yield with the application of nitrogen. Rana et al., (2003) working at Division of Agronomy, Indian Agricultural Research Institute, New Delhi also observed an increase in seed yield with the application of nitrogen in Brassica juncea L.

The slight increase in harvest index was also recorded in mustard in our experiment. The higher dose (100 kg N/ha) was found superior to lower dose (80 kg N/ha). These results are in agreement with the results already reported by Tripathi and Rao (1975), Chaudhary et al. (1992) and Arthamwar et al. (1996) respectively.

The plants of Indian mustard (Brassica juncea L.) cultivar Varuna, in this experiment, showed better response in producing more seed yield/plant and q/ha with the application of sulphur @ 20-40 kg/ha. The higher dose (40 kg/ha) was found better than its lower dose (20 kg/ha) in producing seed yield.

Yield responses to sulphur application in India has been also reported in rice (Das and Datta, 1973), wheat (Arora et al. 1983), maize (Das et al. 1975), black gram (Lal and Jaiswal 1979), green
gram (Mehta and Singh, 1979) and Onion (Balasubramanian et al. (1978). In all cases, yield increased with sulphur application.

Singh et al. (1970), Chahal and Virmani (1973), Lal and Jaiswal (1981) and Ramamurthy and Susheela Devi (1982, 1992) obtained an increase in yield of different crops like mustard, urd and tubers with the application of sulphur.

Considerable increase in yield of groundnut, mustard, sunflower, linseed, wheat, rice, chickpea, pea, lentil, Egyption clover (berseem) and potato has been recorded by Saha and Luthra (1984), Tiwari et al. (1984 a, 1984 b), Singh et al. (1991), Tripathi and Sharma (1993), Sinha and Sakal (1993 a, 1993 b) with the sulphur application.

Experiments conducted by the Fertulizer Industry under the FAO sulphur trials net work have shown that application of sulphur increased the yield of different crops like rice, groundnut and wheat (Kumar et al. 1992).

As reviewed by Tandon (1995), yield responses to 30 crop to sulphur application have been studied in India. These include cereals, millets, legumes, tubers, crucifers, forages, fibres, and vegetables. Mean yield increases due to sulphur application.

In rapeseed, increase in yield is clearly linked to increase in the harvest index (Diepen brock, 2000).

Working at Jawaharlal Nehru Krishi Vishwavidhyalaya
Jabalpur, Dwivedi et al. (2003) also observed that the application of sulphur (60 kg S/ha) resulted maximum seed yield/ha.

Shah (2004) reviewed fantastic results in crops like groundnut, Bt cotton, onion and garlic with the application of sulphur. Working with sulphur on different crops, Shah (2004) obtained 3-5 q/ha more green chillies, 1-2 q/ha more red chillies, 15-20% more yield in brinjal, lady's finger and tomato, 20-25% more yield in cucurbits, 15-20% more yield in maize respectively. With the application of sulphur he also observed 426 and 456 kg/Acre more yield in paddy with 3 kg and 4 kg S/Acre respectively.

Also in our experiment, the nitrogen in combination with sulphur (N x S) was found more effective than nitrogen and sulphur application separately in respect of increasing seed yield in mustard variety Varuna. The treatment $N_{100}S_{40}$ was found to have more seed yield in mustard in comparison to $N_{100}S_{20}$, $N_{80}S_{40}$ and $N_{80}S_{20}$ respectively. Similar results were also obtained by Ramaswami and Manicham (1985), Sankaran and Balasubramanian (1985), Nuttal (1985) and Pasricha et al. (1987) in different crops with N x S application.

Also, at Centre for Biotechnology, Faculty of Science, Hamdard University, Hamdard Nagar, New Delhi, working on mustard (Brassica juncea L.) Fazli et al. (2003) observed that application of
N x S caused up to 53% increase in seed yield. Jamal et al., (2003) working at Centre for Biotechnology, Hamdard University, Hamdard Nagar, New Delhi, also obtained an increase in seed yield in groundnut (Arachis hypogea L.) with the application of nitrogen in combination with sulphur. Rana et al., (2003) also noted an increase in seed yield of Brassica juncea L. with the application of nitrogen and sulphur (75 kg N + 30 kg S/ha). Similar results were also observed by Udai Burman et al., (2003) with application of N x S in mustard.

5.1 (e) Effect on Oil Content:

The oil content (%) in mustard cultivar Varuna in our experiment was found to increase over control with the application of nitrogen but this increase in oil content (%) was not significant. The total production of oil was more in nitrogen supplied plant due to an increase in the amount of seed i.e. increased yield of seed/plant and yield of seed q/ha.

Thus oil content and quality of seeds were significantly influenced by nitrogen application. Results of the experiments at Rohtak Agricultural Experiment Station also indicated that yield of oil was increased with adequate nitrogen supply (Kress, 1951). Similar results were also obtained by Bhatty (1964), Sinha et al.,

Also in this experiment, application of sulphur also found to increase the oil content in mustard, but was not significant. As the seed production increased with the application of sulphur, the amount of total oil production was found to increase. Tandon (1991) also reported an increase in oil content in linseed with sulphur application. Kute (1995) observed similar results with sulphur application in sunflower and groundnut. Working on linseed, Sharma and Tiwari (2003) also studied the beneficial effect of sulphur application in relation to increase the oil content in seed.

The application of N in combination with S in an experiment gave better performance than N or S applied alone. In this experiment $N_{80}S_{20}, N_{80}S_{40}, N_{100}S_{20},$ and $N_{100}S_{40}$ were found better than $N_0, N_{80}, N_{100}, S_0, S_{20}$ and $S_{40}$ treatment in respect of producing more seed yield and amount of oil content in mustard cultivar Varuna. In all these $N \times S$ combinations, $N_{100}S_{40}$ was found better than all the treatment including control.

Fazli et al., (2003) at Biotechnology Centre, Hamdard University, New Delhi observed that application of $N \times S$ caused upto
61-7% increase in oil yield in mustard. Jamal et al., (2003) at the Centre for Biotechnology, Hamdard University, New Delhi also observed an increase in oil yield in groundnut (Arachis hypogea L.) with the application of nitrogen in combination with sulphur.

Thus it is clear from the above findings that the application of N x S is better than N or S alone in Brassica juncea Linn. cultivar Varuna. The treatments N_{100}S_{20}, N_{80}S_{40}, N_{80}S_{20}, N_{100}, N_{80}, S_{40}, S_{20} and control in respect of positive effect on growth, flowering, fruiting yield and oil content in Brassica juncea Linn. cultivar Varuna by increasing the metabolites in plants.