SUMMARY AND CONCLUSIONS

There has been a tremendous increase in food grain production mainly through developments in crop science and production technology over the last four decades. However, there is increasing concern as to whether development in science and technology will be adequate to meet the increasing demands of growing population. Much of the increase in food grain production is attributable to use of high yielding cultivars and adequate use of nitrogenous, phosphatic and potassic fertilizers. Switch over and rapid acceptance by the growers of high analysis fertilizers following World War II greatly increased the crop demands for some secondary and micronutrients.

Production of oilseeds in recent years has fallen short of the requirement due to a number of reasons such as inadequate attention to the nutritional requirements of oilseed crops. In addition to nitrogen, another major nutrient, which has been attributed to have a multiple role in oilseed crop nutrition is sulphur. As such, sulphur deficiency in soils where these crops are raised, is considered as a major factor responsible for low oilseed production in India. Further, low availability of S in soil limits N use efficiency. The two nutrients are closely related, synergistic and of vital importance for plants, because they are the major constituent of amino acids - the building blocks of proteins. A strong interaction between nitrogen and sulphur for seed yield, oil yield and oil quality in rapeseed-mustard has been established in many studies. It is, therefore, likely that the interaction between N and S metabolism is stringer in oilseed crops. Though several studies are able to demonstrate the essentiality of sulphur nutrition and interaction between N and S in optimizing seed and oil yield in rapeseed-mustard, but still insufficient to provide the biochemical basis of synergistic effect of S and N on lipid biosynthesis. Hence, an attempt has been made in the present study to work out the interactive effect of S and N on various biochemical parameters related to growth, yield and lipid biosynthesis in rapeseed-mustard genotypes viz., Brassica juncea cv. Pusa Jai Kisan, Brassica juncea cv. Varuna, Brassica campestris cv. Pusa Gold and Eruca sativa.

The salient features of the findings obtained in this study are as follows:

1. Biomass accumulation, leaf area index, leaf area duration and seed dry weight were maximum with the application of S_{20+20} N_{50+50} in Brassica juncea cv. Pusa Jai Kisan, S_{40} N_{50+50} in Brassica juncea cv. Varuna and S_{20+10+10} N_{50+25+25} in Brassica campestris cv. Pusa Gold and Eruca sativa.
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SUMMARY AND CONCLUSIONS

2. Chlorophyll, soluble protein and amino acids contents in the leaves were maximum with the application of \( S_{20+20} N_{50+50} \) in *Brassica juncea* cv. Pusa Jai Kisan, \( S_{40} N_{50+50} \) in *Brassica juncea* cv. Varuna and \( S_{20+10+10} N_{50+25+25} \) in *Brassica campestris* cv. Pusa Gold and *Eruca sativa*.

3. Chlorophyll, soluble protein and total sugar contents in the podwall and seeds were maximum with the application of \( S_{20+20} N_{50+50} \) in *Brassica juncea* cv. Pusa Jai Kisan, \( S_{40} N_{50+50} \) in *Brassica juncea* cv. Varuna and \( S_{20+10+10} N_{50+25+25} \) in *Brassica campestris* cv. Pusa Gold and *Eruca sativa*.

4. *In vivo* nitrate reductase activity and *in vitro* ATP-sulphurylase activity in the leaves, podwall and seeds were higher with the application of \( S_{20+20} N_{50+50} \) in *Brassica juncea* cv. Pusa Jai Kisan, \( S_{40} N_{50+50} \) in *Brassica juncea* cv. Varuna and \( S_{20+10+10} N_{50+25+25} \) in *Brassica campestris* cv. Pusa Gold and *Eruca sativa*.

5. Acetyl-CoA carboxylase activity, acetyl-CoA pool and lipid accumulation in the seeds were higher with the application of \( S_{20+20} N_{50+50} \) in *Brassica juncea* cv. Pusa Jai Kisan, \( S_{40} N_{50+50} \) in *Brassica juncea* cv. Varuna and \( S_{20+10+10} N_{50+25+25} \) in *Brassica campestris* cv. Pusa Gold and *Eruca sativa*.

6. Sulphur concentration in stem, leaves, podwall and seeds was maximum with the application of \( S_{20+20} N_{50+50} \) in *Brassica juncea* cv. Pusa Jai Kisan, \( S_{40} N_{50+50} \) in *Brassica juncea* cv. Varuna and \( S_{20+10+10} N_{50+25+25} \) in *Brassica campestris* cv. Pusa Gold and *Eruca sativa*.

7. Nitrogen concentration in stem, leaves, podwall and seeds was maximum with the application of \( S_{20+20} N_{50+50} \) in *Brassica juncea* cv. Pusa Jai Kisan, \( S_{40} N_{50+50} \) in *Brassica juncea* cv. Varuna and \( S_{20+10+10} N_{50+25+25} \) in *Brassica campestris* cv. Pusa Gold and *Eruca sativa*.

8. Yield components, seed yield and oil yield was maximum with the application of \( S_{20+20} N_{50+50} \) in *Brassica juncea* cv. Pusa Jai Kisan, \( S_{40} N_{50+50} \) in *Brassica juncea* cv. Varuna and \( S_{20+10+10} N_{50+25+25} \) in *Brassica campestris* cv. Pusa Gold and *Eruca sativa*.

9. Protein concentration of the seed improved markedly with the application of \( S_{20+20} N_{50+50} \) in *Brassica juncea* cv. Pusa Jai Kisan, \( S_{40} N_{50+50} \) in *Brassica juncea* cv. Varuna and \( S_{20+10+10} N_{50+25+25} \) in *Brassica campestris* cv. Pusa Gold and *Eruca sativa*.
2. Chlorophyll, soluble protein and amino acids contents in the leaves were maximum with the application of S<sub>20+20</sub> N<sub>50+50</sub> in *Brassica juncea* cv. Pusa Jai Kisan, S<sub>40</sub> N<sub>50+50</sub> in *Brassica juncea* cv. Varuna and S<sub>20+10+10</sub> N<sub>50+25+25</sub> in *Brassica campestris* cv. Pusa Gold and *Eruca sativa*.

3. Chlorophyll, soluble protein and total sugar contents in the podwall and seeds were maximum with the application of S<sub>20+20</sub> N<sub>50+50</sub> in *Brassica juncea* cv. Pusa Jai Kisan, S<sub>40</sub> N<sub>50+50</sub> in *Brassica juncea* cv. Varuna and S<sub>20+10+10</sub> N<sub>50+25+25</sub> in *Brassica campestris* cv. Pusa Gold and *Eruca sativa*.

4. *In vivo* nitrate reductase activity and *in vitro* ATP-sulphurylase activity in the leaves, podwall and seeds were higher with the application of S<sub>20+20</sub> N<sub>50+50</sub> in *Brassica juncea* cv. Pusa Jai Kisan, S<sub>40</sub> N<sub>50+50</sub> in *Brassica juncea* cv. Varuna and S<sub>20+10+10</sub> N<sub>50+25+25</sub> in *Brassica campestris* cv. Pusa Gold and *Eruca sativa*.

5. Acetyl-CoA carboxylase activity, acetyl-CoA pool and lipid accumulation in the seeds were higher with the application of S<sub>20+20</sub> N<sub>50+50</sub> in *Brassica juncea* cv. Pusa Jai Kisan, S<sub>40</sub> N<sub>50+50</sub> in *Brassica juncea* cv. Varuna and S<sub>20+10+10</sub> N<sub>50+25+25</sub> in *Brassica campestris* cv. Pusa Gold and *Eruca sativa*.

6. Sulphur concentration in stem, leaves, podwall and seeds was maximum with the application of S<sub>20+20</sub> N<sub>50+50</sub> in *Brassica juncea* cv. Pusa Jai Kisan, S<sub>40</sub> N<sub>50+50</sub> in *Brassica juncea* cv. Varuna and S<sub>20+10+10</sub> N<sub>50+25+25</sub> in *Brassica campestris* cv. Pusa Gold and *Eruca sativa*.

7. Nitrogen concentration in stem, leaves, podwall and seeds was maximum with the application of S<sub>20+20</sub> N<sub>50+50</sub> in *Brassica juncea* cv. Pusa Jai Kisan, S<sub>40</sub> N<sub>50+50</sub> in *Brassica juncea* cv. Varuna and S<sub>20+10+10</sub> N<sub>50+25+25</sub> in *Brassica campestris* cv. Pusa Gold and *Eruca sativa*.

8. Yield components, seed yield and oil yield was maximum with the application of S<sub>20+20</sub> N<sub>50+50</sub> in *Brassica juncea* cv. Pusa Jai Kisan, S<sub>40</sub> N<sub>50+50</sub> in *Brassica juncea* cv. Varuna and S<sub>20+10+10</sub> N<sub>50+25+25</sub> in *Brassica campestris* cv. Pusa Gold and *Eruca sativa*.

9. Protein concentration of the seed improved markedly with the application of S<sub>20+20</sub> N<sub>50+50</sub> in *Brassica juncea* cv. Pusa Jai Kisan, S<sub>40</sub> N<sub>50+50</sub> in *Brassica juncea* cv. Varuna and S<sub>20+10+10</sub> N<sub>50+25+25</sub> in *Brassica campestris* cv. Pusa Gold and *Eruca sativa*.
10. Application of $S_{20}+20 \, N_{50}+50$ in *Brassica juncea* cv. Pusa Jai Kisan, $S_{40} \, N_{50}+50$ in *Brassica juncea* cv. Varuna and $S_{20+10+10} \, N_{50+25+25}$ in *Brassica campestris* cv. Pusa Gold and *Eruca sativa* resulted in maximum per cent oil content in seeds and oil yield.

11. Application of $S_{20}+20 \, N_{50}+50$ in *Brassica juncea* cv. Pusa Jai Kisan, $S_{40} \, N_{50}+50$ in *Brassica juncea* cv. Varuna and $S_{20+10+10} \, N_{50+25+25}$ in *Brassica campestris* cv. Pusa Gold and *Eruca sativa* resulted in attaining adequate N:S ratio in the seeds.

12. Application of $S_{20}+20 \, N_{50}+50$ in *Brassica juncea* cv. Pusa Jai Kisan and *Brassica juncea* cv. Varuna, $S_{20+10+10} \, N_{50+25+25}$ in *Brassica campestris* cv. Pusa Gold and *Eruca sativa* improved the quality of oil by increasing oleic acid, linoleic acid and linolenic acid and reducing erucic acid content.

13. The magnitude of response of *Eruca sativa*, a low lipid accumulating genotype, was higher to the split application of S and N when compared to the other genotypes.

From the above findings, following conclusions can be drawn:

- Sulphur must be included in the nutrient management package for optimizing the growth, seed as well as oil yield and improving the quality attributes of rapeseed-mustard.

- For achieving better quality attributes and higher seed as well as oil yields in the rapeseed-mustard crops, the S and N should be applied at the rates of 40 and 100 Kg ha$^{-1}$, respectively, constituting the balanced dose of these nutrients. 40 Kg S ha$^{-1}$ and 100 Kg N ha$^{-1}$ should be applied in two splits (1/2 at the time of sowing and 1/2 at 35 DAS) in *Brassica juncea* cv. Pusa Jai Kisan, while the same doses of S and N should be applied in three splits (1/2 at the time of sowing, 1/4 at 35 DAS and 1/4 at 55 DAS) in *Brassica campestris* cv. Pusa Gold and *Eruca sativa*. In *Brassica juncea* cv. Varuna, the amount of S i.e., entire 40 Kg ha$^{-1}$ should be applied at the time of sowing and N in two splits (1/2 at the time of sowing and 1/2 at 35 DAS).

- The phenological stage, flowering is critical in all the genotypes with respect to S and N fertilization. The inadequate supply of these nutrients to the crop at this stage limits the productivity. Hence, the entire amount of S and N must be applied before flowering for optimum seed and oil yield.

- The oil yields of rapeseed-mustard genotypes with low lipid content in the seeds can be enhanced by the split application of S and N at appropriate phenological stages.