IJARETS
International Journal of Advanced Research in Engineering Technology & Science
ISSN: 2349-2819
Email: editor@ijarets.org April- 2015 Volume 2, Issue-4 www.ijarets.org

"Analytical aspects of Nitrogen and Sulphur on growth, yield and quality of Mustard [Brassica Juncea (L.) Czern and Coss] in Selected varieties"

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1.1 Introduction

Oilseed crops occupy an important place and role in Indian agricultural economy as well as in human life. They are not only rich sources of energy and carriers of fat soluble vitamins A, D, E and K but are major sources of raw materials for a wide range of industrial products also. More than 80 per cent of our country's requirements of vegetable oils and fats are derived from seven annual edible oilseed crops viz. groundnut, rapeseed mustard, sesamum, safflower, sunflower, niger, soybean and two non-edible oilseeds; linseed and castor.

Oilseed crops occupying sizeable share (15 per cent) of the country's gross cropped area and contribute about 11 per cent value of agricultural products. Amongst different oilseed crops rapeseed-mustard having prominance in Northern India, rank second after groundnut and contribute nearly 31 percent of the total oilseed's production in the country. In India, rapeseed mustard occupied 6.28 mha area with a production of 6.5 m tonnes (Economic survey, 2017-18). To meet the edible oil requirement of the burgeoning population, the present level of oilseeds production will have to be boosted up to 26.0 m tonnes to meet the edible oil requirement by the end present decade.

Therefore, it becomes imperative to increase the productivity of rapeseed mustard per unit area per unit time in this country which still has a great scope to exploit the potential yield of existing cultivars along with bringing more area under irrigation, use of balanced fertilizers and introducing newly developed promising varieties.

Amongst the agronomic factors known to augment the crop production, fertilizer stands first and is considered one of the most productive inputs in agriculture. Of the major nutrient elements nitrogen and sulphur have important role in seed protein and oil synthesis. Work so far done indicated positive role of both of these nutrients in promoting yield and quality of seed of mustard. Differential trends in seed yield of mustard under a particular agro-climatic conditions have been noticed due to varying nutrient levels particularly nitrogen and sulphur fertilization. Application of fertilizers containing these two nutrient elements have been recognised to be the most important constraints and often inadequate application of N and S at farmer's fields reduce the yield levels of mustard.

Of the major nutrient elements, nitrogen which is insufficient in most of the Indian soils, plays appreciably an important role in *Brassica* crops and have shown higher response to nitrogen upto 80-100 kg ha^{-1}.

In view of the increasing incidence of sulphur deficiencies in soil and crops mainly because of low level of fertilizer input in high sulphur requiring crops, particularly oilseeds, application of sulphur assumes added importance. Oleiferous brassicae in general have high sulphur requirement owing to high sulphur containing amino acids in them. Based on the impact of sulphur application on the yield and oil content of oilseeds, it has been reported that each unit of sulphur added to sulphur deficient soils can augment the supply of edible oil by 3-3.5 units (Tandon, 2015). Mustard crop responds remarkably to sulphur application. Adequate supply of sulphur to rape-seed-mustard promotes the synthesis of sulphur containing aminoacids, protein and oil. The average yield responses to sulphur for rapeseed mustard grown in sulphur deficient soils were observed to be 30 per cent and the impact of sulphur application on oil content was upto 9.6 per cent in mustard (Tandon, 2015).

Recently, a number of varieties have been developed by different centres but their performance varies from place to place depending on soil and climate. These varieties also react to various inputs including nitrogen and sulphur applications. Much information is not available on these aspects especially under western parts of Uttar Pradesh.

1.2 Objectives :

1. To study the comparative performance of mustard varieties under semi-arid climatic conditions of Uttarakhand.

2. To study the effect of nitrogen, sulphur and their interaction on the growth, yield and quality of mustard varieties.

3. To work out the economic optimum doses of nitrogen and sulphur for mustard.

The experimental results presented in the preceding chapter gave a detailed account of the influence of nitrogen and sulphur fertilization on the growth and yield of different cultivars of mustard [*Brassica juncea* (L) Czern and Coss]. The significant experimental findings obtained during the course of investigation are discussed below with possible explanation and evidence wherever necessary in order to find out the 'cause and effect' relationship among different treatments with respect to various attributes studied and sort out information of practical value.

The growth and yield performance of a crop is a function of number of metabolic processes taking place in the plant body, which in turn are affected by a variety inherent and environmental factors to which the plant is exposed. Besides, the varietal choice for a particular agro-climatic condition, the nutrient requirements during the crop growth are of considerable importance.

The interaction between nitrogen and sulphur being synergistic with each other not only increased the yield but also improved the quality of each variety of mustard studied under the present scenario of depleted soil nutrients. The significant interactions have been discussed where-ever felt necessary.

Varieties

The varieties differed in respect of plant height. The difference in height may be attributed to genetical vigour. Variety RH-30 was taller than Vardan and Bio-902. The number of secondary and total number of branches was significantly affected by varieties. Variety Vardan showed superiority in this character. Varietal differences in height and number of branches have also been reported by Bhan (2009), Singh (2009), Sharma et al (2009), Garnayak et al (2000) and Singh et al (2001).

The reproductive growth is related to vegetative growth of a plant which mainly includes the height, number of primary, secondary and total number of branches, varieties differed in respect of yield attributes viz. number of siliquae per plant, length of siliqua, number of grains/siliqua, weight of grains/plant and 1000 grain weight. Variety Vardan proved significantly superior than Bio-902 and RH-30 in respect of these yield attributing characters except 1000 grain weight where variety RH-30 produced bolder grains which in turn gave higher 1000 grain weight. Differences in yield attributing characters due to varieties have also been reported by Saik and Bhargava (2005), Sharma et al (2009), Garnayak et al (2000), Singh et al (2000), Kumar et al (2001) and Singh et al (2001).

The seed yield of mustard was greatly influenced by varieties. Variety Vardan produced significantly higher grain yield during both years. The higher seed yield of variety Vardan may be attributed to higher number of siliquae/plant, number of grains/siliqua and weight of grains per plant in comparison to Bio-902 and RH-30. Variety RH-30 though produced bolder grains and consequently higher 1000 grain weight but this could not compensate the higher number of siliquae/plant, grains/siliqua and total grain weight/plant of variety Vardan. Difference in grain yield of mustard due to varieties have also been reported by Bhan (2001), Kumar and Malik (2003), Saran and Giri (2004), Kumar and Singh (2005), Shyamraj (2006), Kumar and Singh (2009), Sharma et al (2009), Singh (2009), Singh et al (2016), Singh and Rajput (2016), Garnayak et al (2000), Singh et al (2000), Kumar et al (2001) and Singh et al (2001).

Stover yield is the result of alround development of a plant. Variety Vardan having higher number of branches produced higher stover yield. Harvest index remained unaffected by varieties during both years of study. Saik and Bhargava (2005), Sharma et al (2009), Singh et al (2016) and Kumar et al (2001), however, recorded significant differences in harvest index of mustard varieties in their studies.

Variety Vardan produced significantly higher total dry matter per hectare. This may be attributed to higher grain and stover yield of variety Vardan as compared to variety Bio-902 and RH-30.

Nitrogen content (%) in seed and stover and nitrogen uptake differed significantly due to varieties. The N content was higher in seeds and stover of variety Vardan than Bio-902 and RH-30 during both years of study. Since uptake is related to its content in seed and stover and the grain and stover yield of the plant, variety Vardan consequently recorded higher uptake of N. Varietal differences in N uptake have also been observed by Bishnoi and Singh (2000).

Sulphur content and uptake was higher due to variety Vardan in comparison to Bio-902 and RH-30. The higher uptake of S in this variety is also because of its higher grain and stover yield.

Among the qualities, oil content (%) is the most important, oil content is influenced by external characters to some extent and varieties as well being genetically different. Variety Vardan had higher oil content in its grain than Bio-902 and RH-30. The oil yield was also higher in Vardan because of higher grain yield of this cultivar. Differences in oil content and oil yield due to varieties have also been reported by Kumar and Rahman (1998), Rastogi (2000), Bhan (2001), Saran and De (2009), Bishnoi and Singh (2009) and Singh et al (2016).

Protein content and protein yield differed due to varieties. Variety RH-30 had higher protein content in its seeds but the protein yield remained significantly lower as compared to Vardan and Bio 902. This may be due to its lowest grain yield ha^{-1}. Variety Vardan had the lowest protein content in seeds but produced significantly highest protein yield ha^{-1} owing to its highest grain yield during both years. Such differences have also been observed by several workers in their studies. Saran and De (2009), Kumar and Malik (2003), Singh (2009) reported variation in protein content in mustard seeds due to varieties.

1.3 Nitrogen Fertilization

Nitrogen fertilization contributed to a greater extent in influencing the seed yield of mustard on account of its pronounced effect on the growth and yield attributes of the plant at various stages of the crop growth. The various growth parameters including plant height, dry matter accumulation (per plant) number of branches were affected to greater extent with the increase in the rates of nitrogen fertilization. However, the plant height at 100 kg increased numerically and not significantly.

These results are in close conformity with the findings of Yadav (1995), Sharma (2006), Singh (2009), Mohan and Sharma (2014), Tomar et al (2016), Bhari et al (2000), Garnayak et al (2000) and Kumar et al (2001).

The other growth characters also showed an increasing trend at higher rates of nitrogen with the advancement of the crop age. The highest dry matter accumulation was recorded with the application of 100 kg N ha^{-1} during both the years.

Higher levels of nitrogen application resulted in alround development of plant during both the years, which not only resulted in higher production of dry matter but also contributed towards the stronger reproductive phase, thereby resulting in higher seed yield at higher nitrogen level.

The reproductive growth depends on vegetative growth of the plant and vigorous vegetative growth due to greater cell division and more meristemetic activity increased the supply of photosynthates for the formation of branches.

The number of seed per siliqua, length of siliqua, number of grains per siliqua, weight of grains per plant and 1000 seed weight were higher at 100 kg N ha^{-1} application, because of increased translocation of food material for the formation of the seeds. Patel et al (2000), Singh and Rathi (2004), Singh and Dixit (2009), Parihar and Tripathi (2009), Dubey and Khan (2015), Khanpara (2015), Tomar et al (2016), Singh (2019), Bhari et al (2000), Garnayak et al (2000) also reported highest 1000-seed weight with the application of nitrogen.

The total number of branches and number of siliquae per plant were more at higher nitrogen levels. Among the various yield attributes, increased number of siliquae, higher seed weight per plant and higher 1000-seed weight showed their additive effect in influencing the seed yield with increasing rates of nitrogen application. Number of siliqua per plant had a significant positive correlation with the seed yield per hectare. Sinha (2009) reported that seed yield of mustard was positively correlated with number of branches, dry matter accumulation per plant, number of siliquae per plant and 1000-seed weight. Kumar and Gangwar (2005) reported that higher values of yield attributes in toria were obtained with the application of 90 kg N ha^{-1}. Singh et al (2005) observed more values of yield attributes in mustard with the application of 120 kg N ha^{-1}. All these yield attributes had their pronounced effect in increasing the seed yield of mustard at higher rates of nitrogen fertilization.

The seed yield as well as stover yield increased significantly with the application of nitrogen and the maximum seed yield was recorded with the application of 100 kg N ha^{-1} during both the years. The increase in seed yield with the application of 50 and 100 kg N ha^{-1} amounted to 59.57 and 95.03 per cent during 2017-18 and 55.77 and 88.96 per cent during 2018-19 over no nitrogen respectively.

The seed yield was higher during 2017-18 as compared to 2018-19 mainly because of prevalence of higher temperature at maturity leading to poor seed development and lack of rainfall during initial stages of crop growth in 2018-19. The increase in yield of mustard due to nitrogen application may be because of the fact that nitrogen played an important role in the synthesis of chlorophyll and amino acid which constitute building blocks of proteins. The harvest index decreased nonsignificantly at higher levels of nitrogen which indicated increase in yield rather than stover yield with the increase in nitrogen dose.

These findings are in close conformity with the finding of Dalal et al (1992), Murthy (1967), Yadav (1995), Malhotra et al (1998), Sinha (2009), Maity et al (2000), Bhan (2001), Sharma and Kumar (2009), Rana et al (1991), Dubey and Khan (2015), Buttar and Aulakh (2019) and Bhari et al (2000).

Nitrogen influenced the seed yield through a source-sink relationship and addition to higher production of photosynthates it lead to increased translocation to reproductive parts. Nitrogen being most important plant nutrient is needed for growth and development of plant and is known to increase the yield of Brassica species (Saran and De, 2009 and Kumar and Gangwar, 2005).

Nitrogen percent in seeds and stover as well as nitrogen uptake remained higher with the application 100 kg N ha^{-1} during both the years, while the lowest values were recorded in unfertilized control. The application of nitrogen not only increased the nitrogen content but also increased the sulphur content in seed. Application of nitrogen is known to increase the root cation exchange capacity, which enhanced the nitrogen absorption in plants. Nitrogen content in seeds and stover increased with the increase in the rates of nitrogen application upto 100 kg N ha^{-1} (Khan and Agrawal, 2003 and Sharma, 2006). Aulakh et al (2000). Desai (2003) and Rathore (2008) also reported that increasing levels of nitrogen increased the sulphur content in mustard. Yadav (1995), Saran and De (2009), Khan (2000), Kumar (2006), Patil and Bhargava (2007), Rana et al (1991) and Ali et al (2016) also reported increase in N content in seed and stover due to higher levels of N application

The nitrogen and sulphur uptake in seeds and stover at harvest and the total uptake of nitrogen and sulphur were increased significantly with the higher doses of nitrogen application during both the years due to increased dry matter production. The increase with higher levels of nitrogen application was also reported by Sharma (2006), Kumar (2006) and Narang et al (2015) in case of nitrogen uptake and Aulakh et al (2000), Desai (2003) and Khanpara et al (2015) in case of sulphur uptake.

The higher levels of nitrogen fertilization decreased the oil content though the decrease was non-significant but increased the oil yield per hectare significantly. This may be due to the fact that more availability of nitrogen increased the proportion of proteinous substance in seeds. As per pathway of degradation, carbohydrates are degraded to acetyl Co-A. In case of insufficient supply of nitrogen acetyl Co-A is used for the synthesis of fatty acids by using acetyl carrying proteins (ACP) resulting in higher oil content in seeds at lower levels. Although, nitrogen application resulted in reduced oil percent in seeds but it increased the oil yield per hectare significantly. Since, oil yield per hectare also increased due to nitrogen application upto 100 kg ha^{-1} because of increase in seed yield. Decrease in oil content due to increasing levels of nitrogen has been reported by Bishnoi and Singh (2009), Singh (2009), Khan (2010), Rana et al (1991), Dubey and Khan (2015), Ali et al (2016), and Sharma et al (2017). Increase in oil yield with increasing levels of nitrogen was recorded by Singh and Rathi (2005), Singh et al (1991), Mohan and Sharma (2014), Singh et al (2014) and Singh and Saran (2015).

The protein content was significantly more with the application of higher levels of nitrogen during both the years. Nitrogen is a basic constituent of protein and with the increase in the rates of nitrogen application, the nitrogen availability increased which resulted in increased protein content in seeds. Increase in protein content and seed yield with 100 kg N ha^{-1} resulted in increase in the protein yield. A highly negative correlation between oil content and protein yield but positive correlation between nitrogen rates and protein yield was also reported by many workers like Saran and De (2009), Sharma (2004), Patil and Bhargava (2007), Singh (2009), Ali et al (2016) and Sharma et al (2017).

1.4 Sulphur fertilization

Under present soil conditions, sulphur fertilization has been reported to influence the various plant growth, yield and quality parameters significantly in mustard. The plant height was significantly influenced by varying levels of sulphur fertilization during both the years and the significant increase was found upto 50 kg ha^{-1} at 60 DAS stage in 2017-18 only. The increase at higher sulphur levels was not significant at harvest stage in any of the year. The increase in plant height may be attributed mainly due to the fact that sulphur application improved the nutritional environment and hence could result in more nutrient uptake and increased dry matter production. Almost similar findings were reported by Singh (1995), Singh and Saran (2015), Khanpara et al (2015), Singh and Kumar (2016) and Singh (2019).

The increased vigour of the plant during the vegetative phase, under the sulphur levels thus contributed towards the higher production of branches and also increased the dry matter accumulation at different growth stages. The maximum dry matter accumulation per plant was recorded at 50 kg S ha^{-1}

during both the years and significantly lower dry matter accumulation was recorded under no sulphur treatment during both the years. Number of branches primary and secondary were also influenced significantly at 50 kg S ha^{-1} during both the years. Increased plant height and number of branches additively influenced the total dry matter accumulation per plant during both the years. Singnificant increase in dry matter accumulation and number of branches with the application of sulphur fertilization have been reported by Gheyi (1998)., Pasricha and Randhawa (1992), Katoria and Srinivas (2006), Dixit and Shukla (2004), Rathore (2008), Mohan and Sharma (2014), Khanpara et al (2015), Singh and Saran (2015), Dubey and Khan (2015) and Singh (2019).

Yield attributes viz. increased number of branches per plant along with increased number of siliquae, length of siliquae, more number of seeds per siliqua, higher seed weight per plant and 1000 seed weight showed their additive effect in influencing the seed yield significantly with the sulphur fertilization. Non-significant increase in length of siliqua and number of grains per siliquae was recorded due to S application. Significant increase in number of siliquae per plant, weight of grain per plant and 1000 grain weight were recorded upto 50 kg S ha^{-1} application. Increase in these parameters could be ascribed to the over all improvement in plant growth, vigour and production of sufficient photosynthates with sulphur fertilization. Similar findings were also reported by Chatterjee et al. (2005), Rathore (2008), Singh and Kumar (2016), Napalia and Jain (2000) and Singh et al (2000).

With the application of 50 kg S ha^{-1} the seed weight per plant was influenced significantly over the lower rate because of prolonged formation of primary and secondary branches and seeds under higher rates of sulphur during both the years.

Application of sulphur brought about a significant variation in seed yield of mustard during both the years. The grain yield of mustard increased with sulphur application upto 50 kg S ha^{-1} during both years of study. Seed yield of mustard is chiefly a product of yield attributing character viz. number of siliquae/plant, number of seeds/siliqua, seed weight/plant and 1000-seed weight. The increase in these characters as a result of sulphur fertilization resulted in increased seed yield of mustard. Higher stover yield was also recorded at 50 kg S ha^{-1} which may be due to increased supply of sulphur. The harvest index was not significantly influenced by sulphur rates. Singh et al (1990), Joshi et al (1993), Aulakh et al (1997), Aulakh et al (2000), Dixit (2000), Chaudhary and Sharma (2006), Kumar and Singh (2009), Kumar (2014), Singh and Saran (2015), Khanpara et al. (2015), Jaggi (2018), Nepalia and Jain (2000) and Singh et al (2000) reported similar results.

Application of sulphur increased nitrogen content and uptake in plants as well as in seeds. However, the maximum response was at 50 kg S ha^{-1} during both years. The increase in nitrogen content may be attributed to the increased supply of suplhur to plants, which in turn resulted in to profused vegetative and root growth, thereby activating greater absorption of nitrogen from soil (Singh) 1995, Patel and Rathore, 2008). Similarly, the total uptake of nitrogen by the crop and seeds at harvest was also increased significantly with sulphur fertilization in comparison to no sulpuhr application during both the years. This increase in total uptake of nitrogen might be the outcome of increased nitrogen content as well as increased seed and stover yields as a result of sulphur application. Similar findings were also reported by Aulakh et al. (2004) and Rathore (2008)

The uptake of sulphur increased significantly at highest doses of sulphur fertilization i.e. upto 50 kg S ha^{-1} during both the years. The increase in seed and stover yields due to sulphur application might have resulted in greater uptake of sulphur. Similarly, the total sulphur uptake in seeds and stover at harvest increased mainly because of more sulphur content. Singh (1995) also obtained similar results.

Oil content and oil yield of mustard increased significantly due to sulphur application. The percent increase in oil yield at 25 kg S ha^{-1} over control was 25.75 and 19.64 respectively during 2017-18 and 2018-19. The increase in oil content might be attributed to increased availability of sulphur. The oil yield also increased significantly due sulphur application upto 50 kg S ha^{-1} during both years. Similarly, protein yield also increased with higher levels of suphur fertilization. It may be noted that sulphur is an integral part of mustard oil and therefore , it played a significant role in the synthesis of oil. Sulphur supply seems to be involved in an increased conversion of primary fatty acid metabolites to end product of fatty acid. Similarly, increased oil and protein yields were due to higher seed yield and oil contrent on account of increased sulphur supply. Pasricha and Randhawa (1993), Pathak and Tripathi (2009), Aulakh et al. (2000), Dev et al (2001), Singh and Singh (2003), Singh and Saran (2007), Rathore (2008), Joshi et al (1991) and Singh et al (2000) also reported significant increase in oil content and oil yield of mustard with the application of sulphur.

1.5 Interaction effect

The interaction effect in respect of seed yield , dry matter production, total number of siliquae/ plant, and seed weight were observed. It therefore, appeared relevant to explain combined effects of nitrogen and sulphur fertilization on mustard

Interaction between different levels of nitrogen and sulphur fertilization on seed yield of mustard was found to be significant and the application of nitrogen upto 100 kg N ha^{-1} significantly increased the seed yield at different levels of sulphur during both years. This indicated the synergistic effect of nitrogen and sulphur application in improving the productivity of mustard. The increase in the seed yield is attributed with the concomitant increase in total dry matter production at harvest which significantly increased when nitrogen at 100 kg N ha^{-1} was applied during both years. The dry matter production at harvest also varied significantly with the higher doses of nitrogen and sulphur application. Similarly total number of siliquae and seed weight /plant responded significantly when nitrogen and sulphur were applied at higher doses .The positive and significant interaction between N and S for yield has also been reported by Aulakh et al (1997), Pathak and Tripathi (2009), Aulakh et al (2000), Raut and Ali (2005), Verma and Reddy (2005), Chaudhary and Sharma (2006), Singh and Tiwari (2006), Rathore (2008), Singh et al (2008) and Dubey et al (2015).

It may, therefore, be concluded that the expression of growth and productivity parameters of mustard are enhanced by sulphur application made in conjunction with optimum nitrogen rate. Conversely, mustard inadequately fertilized with nitrogen will not be physiologically capable of making fullest use of fertilizer sulphur. Thus , nitrogen and sulphur interaction noted in the present investigation appeared to be more promising to boost productivity of mustard. The response to nitrogen fertilization was linear so the highest dose of N tried be taken as economic optimum dose for nitrogen for both the years while that of sulphur were 48.56 and 48.53 kg ha^{-1} respectively during 2017-18 and 2018-19 the corresponding optimum expected seed yield obtained were 19.64 and 18.52 Q ha^{-1} for nitrogen and 16.1`5 and 15.54 Q ha^{-1} respectively for sulphur during 2017-18 and 2018-19.

1.6 CONCLUSION

It could therefore, be concluded that the seed yield and quality of mustard [*Brassica juncea* (L). Czern and Coss] can be increased significantly with the application of 100 kg N and 50 kg S per hectare. The optimum economic dose for nitrogen and sulphur were 100 kg N ha^{-1} and 48.56 kg S ha^{-1} during 2017-18 and 100 kg N ha^{-1} and 48.53 kg S ha^{-1} during 2018-19 with a corresponding optimum expected seed yield were 19.64 and 18.52 q ha^{-1} N and 16.15 and 15.54 Q ha^{-1} S during 2017-18 and 2018-19 respectively.

On the basis of two years results it is concluded that variety Vardan produced 1785 and 1692 kg ha^{-1} seed yield during 2017-18 and 2018-19 respectively which was 16.51 and 12.66 percent more than Bio 902 and 52.56 and 53.05 percent more than RH 30 in respective years. Variety Vardan can thus safely be recommended for this locality. And for higher yields of mustard 100 kg N and 50 kg S ha^{-1} should be applied.

1. Variety RH 30 produced taller plants at all the crop growth stages during both years. However, significantly higher height was recorded at harvest stage only.

2. Significantly higher dry matter accumulation/ plant was recorded in variety RH 30 in 2017-18 and 2018-19 also.

3. Primary branches remained unaffected by varieties but secondary and total branches were higher in variety Vardan.

4. Yield attributing characters viz. number of siliquae / plant , length of siliqua, number of grains and weight of grains per plant were significantly higher in Variety Vardan while variety RH 30 proved significantly better in respect of 1000 grain weight in 2017-18 only.

5. Significantly higher seed yield was recorded in variety Vardan. Stover yield was also higher in this variety. Harvest index could not be influenced significantly by varieties in any of the years of study.

6. Dry matter production (kg ha^{-1}) was higher in variety Vardan as compared to Bio 902 and RH 30 during both years.

7. The content of N and S in seeds and stoven was higher in variety Vardan during both years except S content in seeds in 2018-19. Uptake of N and S followed almost the same trend.

11. The total dry matter accumulation at harvest increased significantly, with the application of 100 kg N/ha. Sulphur application at 50 kg S/ha produced significantly higher total dry matter accumulation

12. Number of siliquae per plant were significantly higher when higher dose of nitrogen was applied as in case of sulphur fertilization the sulphur application 50 kg S ha^{-1} recorded significant influence. The interaction between nitrogen and suphur dose was significant on number of siliquae/ plant during both the years.

13. The significantly higher seed weight per plant was recorded when nitrogen was applied at 100 kg ha^{-1}, while in case of sulphur fertilization 50 kg S ha^{-1} produced significantly more seed weight during both the years.

14. Nitrogen application at 100 N ha^{-1} influenced significantly the number of seeds per siliqua during both the years as compared to control . Application of sulphur could not exert its influence on the number of seeds per siliqua. during both the years.

15. Application of 100 kg N ha^{-1}, significantly increased the length of siliqua in comparison to control during both the years. Sulphur application failed to increase the length of siliqua significantly.

16. Nitrogen application at 100 kg N ha^{-1} had significantly more 1000-seed weight during 2018-19 while this significant increase was observed upto 50 kg N ha^{-1} in 2017-18

17. Significantly higher seed yield was recorded when nitrogen was applied @ 100 kg N ha^{-1} and the sulphur fertilization was made @ 50 kg S ha^{-1} during both the years. The percent increase in seed yield at 100 kg N ha^{-1} over control was 95.03 and 88.96 respectively for 199-96 and 2018-19 and at 50 kg S ha^{-1} the increase was 25.01 and 23.27 respectively during 2017-18 and 2018-19. Stover yield also had similar trend. Harvest index was not significantly affected by nitrogen or sulphur application and the varieties as well.

18. With the application of nitrogen @ 100 kg N ha^{-1} and sulphur @ 50 kg S ha^{-1}, the nitrogen content in seed and stover and nitrogen uptake increased significantly during both the years. Highest total N uptake at harvest was 85.47 and 80.13 at 100 kg N ha^{-1} and 69.36 and 95.36 kg ha^{-1} at 50 kg S ha^{-1} during 2017-18 and 2018-19 respectively.

19. Nitrogen application @ 100 kg N ha^{-1} and that of sulphur application @ 50 kg S ha^{-1} recorded significant increase in S content as well as S uptake in seed and stover during both the years.

20. With increasing rates of nitrogen application, the oil content decreased but non significantly and the maximum oil content was recorded with no nitrogen 39.96 and 39.87 percent, respectively during 2017-18 and 2018-19) , while with sulphur application the oil content in mustard increased significantly upto 25 kg S ha^{-1} and the maximum oil content was recorded at 50 kg S ha^{-1} during

both the years. The oil content at 50 kg S ha^{-1} was 40.07 and 40.16 percent compared with control 38.20 and 38.12 percent, respectively during 2017-18 and 2018-19.

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