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EFFECT OF SULPHUR AND SOWING DATE ON GROWTH AND YIELD OF RAPESEED (*BRASSICA CAMPESTRIS* L.)

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ABSTRACT

The present study was conducted during *Rabi* season of 2023-24 at the Crop Research Farm, Department of Agronomy, Tantia University, Sri Ganganagar, Rajasthan, India. The experiment was conducted in Factorial Randomized Block Design (FRBD) with five sulphur management practices and two date of sowing. Results revealed that sulphur fertilization significantly enhanced rapeseed growth parameters, including plant height, and dry matter accumulation. The optimal sulphur dose for maximum growth varied depending on the sowing date. Early sowing (10 October) generally responded better to higher sulphur rates, while later sowing (20 October) benefited from moderate sulphur applications. Sulphur application also positively influenced rapeseed yield attributes, such as seed yield and harvest index. The highest seed yield was obtained with a sulphur application rate of 40 kg/ha for early sowing. This study demonstrates the significant benefits of sulphur fertilization for rapeseed production. By optimizing sulphur application rates and sowing dates, farmers can enhance rapeseed germination, growth and yield.

***Key words*:** FRBD, Dry matter, Sulphur, Yield, Rapeseed.

Introduction

Rapeseed (*Brassica campestris*) also called turnip rape, field mustard, lahi, sarson and tori. It is considered as one of the most important species in the genus *Brassica* providing edible oils, leafy vegetables as well as used as fodder for animals. Rapeseed is an economically important species and oldest cultivated plants by the (Koch *et al.*, 2018). The harvested seeds and oil are used as condiment in the preparation of pickles, curries, vegetables, hair oils, edible oil, medicines, while after the oil extraction, oil cake is use for animal feed, manure, tanning industry as well as mustard oil is used for leather softening. India stands fourth largest oilseed growing country which accounts for nearly 25.60% in total oilseed production of world. After palm oil and soybean, mustard and/or rapeseed oil is the third most important oil seed in the world. The major oilseed-growing countries of the world include India, Canada, America, Bangladesh, Iran, China, Nepal and Afghanistan (Staff, 2019).

Depending on climatic conditions, altitude and mode of pollinations the bright yellow flowers clustered at stem tops with four petals in racemes at the end of branches, elongating in fruit to 40 cm long, two-parted capsule that opening at the base to release the seeds at the stage of seed maturity **(**Rahman *et al.*, 2018). Both organic and inorganic fertilizers provide nutrients needed healthy and strong plants growth plants with producing plant yield; on the other hand, each contains different component and supplies these nutrients in dissimilar ways (Baghdadi *et al.*, 2018). Organic fertilizers work over time to generate a healthy growing environment, whereas inorganic fertilizers provide rapid plant growth and development. Organic fertilizers also referred to as synthetic fertilizer is contain only plant or animal-based resources that are either by product or end product of naturally occurring processes, it is mined form mineral or manufactured from synthetic compounds (Phibunwatthanwong and Riddech, 2019).

Since the crop is grown under varied ecosystems and climatic conditions in the country, hence the nutritional requirement of crop is regional and location based (Joshi and Rana, 1991). Plant nutrients are the chemical elements and/or chemical compounds necessary for growth and development of plants, their metabolism and also determined the yield of crops. In its absence the plant is unable to complete a life cycle, or that the element is part of some essential plant constituent or metabolite (Allen *et al.*, 2010). The foundation of organic farming lies in the health of the soil, a fertile soil provides essential (micro and macro) nutrients to the growing plants and helps support a diverse and active biotic community (Yadav *et al.*, 2018).

Important physiological attributes (*i.e.* growth and yield attributes) also affected by the date and time of sowing and can address various constraints of a variety for increasing its productivity (Tandale and Ubale, 2007). Selection of suitable date of sowing for Rapeseed is most important as well as suitable agronomic practise to batter performance of crop in respect to production and strong plant growth. It is quite imperative to study the effect of integrated sulphur management and sowing date on soil fertility, growth and yield of Rapeseed. Therefore, keeping in view the importance of fertilizers and date of sowing characteristics with a set of tools to collect data pertaining to estimation of different parameters with objective to study the effect of Sulphur and date of sowing on growth and yield attributes parameters of rapeseed.

Materials and Method

The experiment was conducted in *Rabi* Season of 2023-24 at Crop Research Farm, Department of Agronomy, Tantia University, Sri Ganganagar, Rajasthan, India. This located at 28.4° N latitude, 72.2° E longitude and 178 m above mean sea level. The experiment was conducted in Factorial Randomized Block Design (FRBD) using two factors and each factor having three levels and replicated thrice of Variety (PSC-601). Several growth and yield attributing traits studied where, Germination%, Numbers of plant m^2, Plant height (cm), Dry matter accumulation, Numbers of seed silique^{-1} and 1000 seed weight. Yield and its attributing traits are Harvest Index, economic yield, biological yield. Details of treatments combinations along with their symbols are presented in Table 1.

Table 1: Treatment combinations.

TS	TC	TD
T_1	S_1D_1	Control + 10 October
T_2	S_1D_2	Control + 20 October
T_3	S_2D_1	NPK nutrient only + 10 October
T_4	S_2D_2	NPK nutrient only + 20 October
T_5	S_3D_1	NPK + 20 kg sulphur/ha + 10 October
T_6	S_3D_2	NPK + 20 kg sulphur/ha + 20 October
T_7	S_4D_1	NPK + 40 kg sulphur/ha + 10 October
T_8	S_4D_2	NPK + 40 kg sulphur/ha + 20 October
T_9	S_5D_1	NPK + 60 kg sulphur/ha + 10 October
T_{10}	S_5D_2	NPK + 60 kg sulphur/ha + 20 October

TS: Treatment Symbol; **TC:** Treatment Combination; **TD:** Treatment Description

Statistical analysis

Experimental data were processed in Microsoft Excel-2019 and analyzed with the help of analysis of variance (ANOVA) technique for Factorial Randomized Block Design (FRBD) (Gomez and Gomez, 1984). The significance of the treatments was tested using F test at 5% level of significance ($P \leq 0.05$) and means were compared using the critical difference (CD) test at $\alpha \leq 0.05$.

Results and Discussion

Effect of different Sulphur and sowing date on germination% and plant population

The data on germination count and plant population m^2 revealed that the highest germination% and plant population was recorded under S_4 treatments (Table 2). It might be due to the selection of healthy and vigorous seeds, proper seed treatment, carefully sowing of seed at proper depth which brought significant germination and acquire highest plant population. Similar finding was also reported by Yadav (2018). Data further revealed that that higher germination count and plant population m^2 in S_4 could be attributed to better nutrient absorption. This result was closely confirmed with the result of Singh *et al.*, (2015)

Table 2: Effect of sulphur management and sowing dates on germination count and plant population m^2 of Rapeseed.

Treatment	Germination %	Plant population (m^2)
Sulphur level		
S_1) Control	85.75	31.54
S_2) NPK nutrient only	86.23	32.22
S_3) NPK + 20 kg sulphur/ha	86.44	33.76
S_4) NPK + 40 kg sulphur/ha	86.56	33.90
S_5) NPK + 60 kg sulphur/ha	85.07	31.30
Sem ±	**4.14**	**2.32**
C.D. (5%)	**NS**	**NS**
Sowing date		
D_1) 10 October	85.97	33.68
D_2) 20 October	83.48	32.96
Sem ±	**3.18**	**2.16**
C.D. (5%)	**NS**	**NS**

Table 3: Effect of sulphur management and sowing dates on plant height and dry matter accumulation of Rapeseed.

Treatment	Plant height (cm)	Dry matter Accumulation
Sulphur level		
S_1) Control	114.78	140.66
S_2) NPK nutrient only	119.84	155.65
S_3) NPK + 20 kg sulphur/ha	122.81	160.67
S_4) NPK + 40 kg sulphur/ha	124.30	165.56
S_5) NPK + 60 kg sulphur/ha	119.69	158.05
Sem ±	**2.85**	**4.22**
C.D. (5%)	**7.33**	**12.09**
Sowing date		
D_1) 10 October	122.42	165.45
D_2) 20 October	114.24	148.98
Sem ±	**2.73**	**4.06**
C.D. (5%)	**6.50**	**11.22**

In case of sowing dates, the highest germination % and plant population recorded with D_2 date of sowing (Table 2). The similar observation had been reported by Kumar *et al.,* (2018), Singh *et al.,* (2017) and Aziz *et al.,* (2011). The delayed sowing reduces the production due to poor performance of the crop as the result of reduced germination count and lower plant population, has tens maturity and ultimately causes the reduction in yield.

Effect of different Sulphur and sowing date on growth attributes

The significantly higher plant height was recorded with S4 treatment and among different sowing dates the significantly higher plant height recorded with D1 over D2 treatment (Table 3). Effect of sulphur management showed significant effect on plant height (Keivanrad and Zandi, 2012), plant dry weight (Yadav *et al.,* 2018). S_4 (NPK + 40 kg Sulphur) showed significant superiority to other sulphur management treatments. Higher plant height, and plant dry weight recorded in S_4 treatment could be attributed to better nutrient uptake (Meena *et al.,* (2013), beside to increased uptake of nitrogen and phosphorus by the plants, which was made available through organic sources which provide plant to grow its potential and attain maximum plant height and more plant dry weight. However, the response of different treatment was differing on the plant at early stages of growth. This may have been due to the slower rate of mineralization of nutrients, but at later stages the availability of nutrients increases and gave maximum growth attributes. The result correlated with those of (Keivanrad and Zandi, 2012).

Perusal of mean data on sowing date showed treatment D_1 sowing date gave significantly higher plant height over D_2 sowing date. Similar finding was also reported by Kumari *et al.,* (2012). This could be ascribed due to prolonged vegetative growth period because of congenial environmental conditions, especially atmospheric temperature which formed a basis for rapid cell division in the meristematic tissues of the experimental crop which led to better growth attributes under normal sowing. The late sown crop experienced sub-optimal temperature regime, especially second fortnight of October which retarded their growth as compared to those sown either normal date.

Table 4: Effect of sulphur management and sowing dates on growth traits of Rapeseed.

Treatment	No. of Seed Silique^{-1}	1000 seed weight (g)
Sulphur level		
S_1) Control	11.20	3.56
S_2) NPK nutrient only	13.08	5.08
S_3) NPK + 20 kg sulphur/ha	13.80	5.67
S_4) NPK + 40 kg sulphur/ha	14.11	5.75
S_5) NPK + 60 kg sulphur/ha	13.20	5.20
Sem ±	**0.60**	**0.35**
C.D. (5%)	**1.60**	**0.85**
Sowing date		
D_1) 10 October	13.82	5.77
D_2) 20 October	11.02	4.25
Sem ±	**0.50**	**0.32**
C.D. (5%)	**1.30**	**0.83**

Effect of sulphur management and sowing date on yield attributes

The yield contributing characters *viz*. numbers of seed

Table 5: Effect of sulphur management and sowing dates on yield attributes of Rapeseed.

Treatment	Seed yield	Stover yield	Biological yield	Harvest index
Sulphur level				
S_1) Control	12.99	31.14	43.13	28.18
S_2) NPK nutrient only	13.02	32.69	45.77	28.39
S_3) NPK + 20 kg sulphur/ha	13.09	32.93	46.03	28.45
S_4) NPK + 40 kg sulphur/ha	13.60	33.19	46.79	29.13
S_5) NPK + 60 kg sulphur/ha	13.27	32.75	45.95	28.90
Sem ±	**0.03**	**0.04**	**0.05**	**0.03**
C.D. (5%)	**0.07**	**0.09**	**0.10**	**0.06**
Sowing date				
D_1) 10 October	12.55	32.32	44.87	28.54
D_2) 20 October	12.51	31.75	44.26	27.89
Sem ±	**0.02**	**0.02**	**0.03**	**0.01**
C.D. (5%)	**0.03**	**0.04**	**0.05**	**0.03**

silique^{-1} and test weight among different sulphur management (Table 4). Maximum Numbers of seed silique^{-1} (No.) and test weight (g) was recorded with S_4 treatment. Similar finding was also reported by Mishra *et al.,* (2017) and Singh *et al.,* (2014). This may be attributed to facilitate in increasing the availability of nutrient, ensure better plant establishment and better growth attributes in S_4 treatment. Pramanik and Bera (2012) also reported similar result.

In case of sowing date, the highest numbers of seed silique^{-1} and test weight recorded with D_1 treatment over D_2 treatment. late sowing restricted the crop growth duration and induced early flowering. It is also reduced pod initiation and seed setting to a great extant as compared to 10 October. This might be due to the fact that low temperature during last October not only restricted the crop growth but also induced lower rate of pollination and flower abortion. Similar results were also observed by Singh and Singh (2002).

Effect of sulphur and sowing date on grain and stover yield and harvest index

Yield is a complex character resulting from the interaction from primary inherited character of the plant and with the environment and management. For top crop yields, the trio-complex of ecological situation, the genetic potential and the agronomic management systems are of utmost importance. If the previous two requirements are commonly shared, the fate of the crop will naturally by determined by agronomic manipulation.

Rapeseed seed yield, stover yield and biological yield exhibited a significant increase under S_4 (Table 5). The higher grain yield recorded with S_4 might be due to optimum utilization of nutrients. While, at later stage of crop the availability of nutrients increases and gave maximum growth attributes, the plant growth and ultimately yield may increase (Singh *et al.*, 2015). These results in straw yield could be attributed to the significant increase in plant height and dry matter production under S_4 treatment. This result collaborated with the result of Mishra *et al.,* (2023). For grain crops harvest index is the ratio of harvested grain to total shoot dry matter. This can be used as a measure of reproductive efficiency. This index can also be used to estimate crop carbon balance by applying it to grain yield statistics to determine total shoot dry matter and then calculating crop residue as the difference between shoot carbon and grain carbon. The highest harvest index recorded with S_4 treatment might be due to highest grain yield.

Sowing date exerted significant variation among grain yield, stover yield, harvest index and biological yield and treatment D_1 date of sowing. The similar observation had been reported by Kumar *et al.,* (2018), Singh *et al.,* (2017) and Aziz *et al.,* (2011). The late sowing causes the mortality of tender seedling due to low temperature. However delayed sowing also reduces the production due to poor performance of the crop as the result of reduced growth parameters, has tens maturity and ultimately causes the reduction in yield.

Conclusion

Based on the findings of the present investigation, it may be concluded that the rapeseed performed well when sown on 10 October with application of NPK + 40 kg sulphur per hectare in terms of better growth, yield attributes and yield of rapeseed. Based on the above findings it can recommended that Rapeseed sown on 10 October with application of NPK + 40 kg sulphur per hectare can successfully sustain the productivity of rapeseed. S4 nutrient treatment significantly enhanced plant growth, yield components, and overall productivity compared to S1. Similarly, early sowing (D1) resulted in superior plant height, dry matter accumulation, grain yield, and harvest index compared to late sowing (D2). These findings highlight the crucial role of optimized nutrient management and timely sowing in maximizing crop performance. Adopting these agronomic practices can significantly improve yield potential and resource efficiency.

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