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Effect of Foliar Application of Sulphur and Integrated Nutrient Management on Yield, Quality and Economics of Bed Transplanted Canola (*Brassica napus* L.)

L. Singh, R. Sharma, N. Singh

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ABSTRACT

Background: Canola is an important oilseed crop throughout the world which is grown in more than 53 countries. Proper nutrient management plays a key role in its production. Use of unbalanced and inadequate fertilizers accompanied by restricted use of organic manures resulting in a decline in crop yield and quality. Little information is available on the response of canola to these factors. Therefore, this study is focused on to evaluate effect of foliar application of sulphur and integrated nutrient management on canola.

Methods: A field experiment was conducted on sandy loam soil during winter (*Rabi*) season of 2017-18 and 2018-19 at Student's Research Farm, Khalsa college, Amritsar to study the effect of foliar application of sulphur and integrated nutrient management on yield, quality and economics of bed transplanted canola (*Brassica napus* L.). Canola variety GSC 7 was sown by transplanting method on beds at spacing of 30 cm × 10 cm under Randomized Complete Block Design (RCBD) with 6 treatment combinations of organic (Vermicompost and pressmud), inorganic and foliar fertilizer were used under three replications.

Result: The results revealed that treatment containing 100% RDF + 40 kgha^{-1} sulphur + 1% foliar sulphur spray (T_2) led to maximum siliqua length (8.5 cm), no. of siliqua plant^{-1} (547.5), no. of seed siliqua^{-1} (28.8), test weight (4.64 g), seed yield (24.92 q ha^{-1}) and stover yield (78.53 q ha^{-1}) whereas treatment consisting 100% N through vermicompost + 40 kgha^{-1} sulphur + 1% foliar sulphur spray (T_3) led to highest quality attributes *i.e.* oil content (43.73%), protein content (30.8%) in seed which was at par with 100% N through pressmud + 40 kgha^{-1} S + 1% foliar sulphur spray (T_4) which also resulted highest sulphur content (0.48%) in seed. The maximum gross return (Rs. 104664 ha^{-1}), net return (Rs. 59049 ha^{-1}) and benefit cost rato (1.29) obtained from treatment containing 100% RDF + 40 kgh^{-1} sulphur + 1% foliar sulphur spray (T_2). It was observed that foliar application of sulphur enhanced the yield whereas application of organic manures improved the quality of canola.

Key words: Canola, Economics, Foliar, Oilseed rape, Pressmud, Quality, Vermicompost, Yield.

INTRODUCTION

Rapeseed-Mustard is an important oilseed crop throughout the world. It ranks third among the oilseed crops after soybean and oil palm in production of vegetable oils. Rapeseed-mustard contributes around 26.1% of the total oilseed production and contributes about 85% of the total rapeseed-mustard produced in India (Meena *et al.,* 2013). India accounts for 10% of total global edible oil consumption. Canola (*Brassica napus* L.) is a species of Brassicaceae family having commercial importance with high oil content.

In Punjab state, the area under this crop is very low with low productivity due to sub-optimal application of fertilizers. Intensive cultivation and use of unbalanced and inadequate fertilizers accompanied by restricted use of organic manures have made the soils not only deficient in nutrients but also deteriorated the soil health resulting in a decline in crop response to the recommended dose of NPK fertilizers in the region. Canola is particularly sensitive to sulphur deficiency or limitation, which reduce both seed quality (De Pascal *et al.,* 2008) and yield by 40% (Scherer 2001). The method of foliar fertilizer application of sulphur may results in better nutrients absorption by the plants and thus can be used for increasing fertilizer use efficiency. Chemical fertilizers/organic manures alone cannot sustain the desired levels of crop production under continuous farming. Integration of chemical and organic sources and their efficient management have shown promising results not only in sustaining production but also maintaining the soil health (Babu *et al.,* 2007).

Little information is available on the response of different yield, quality and economics parameters of *Brassica napus* L. to foliar application of sulphur with other organic and inorganic nutrients at Punjab. Therefore, the study is focused on to evaluate the effect of foliar application of sulphur and

Department of Agronomy (Agriculture), Khalsa College, Amritsar-143 001, Punjab, India.

Corresponding Author: L. Singh, Department of Agronomy (Agriculture), Khalsa College, Amritsar-143 001, Punjab, India. Email: lovejosan03@gmail.com

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integrated nutrient management on yield, quality and economics of bed transplanted canola (*Brassica napus* L.).

METHODS AND MATERIALS

A field experiment was conducted on sandy loam soil during winter (*Rabi*) season 2017-18 and 2018-19 at Student's Research Farm, Khalsa College, Amritsar, Punjab, India (31.63°N latitude and 74.83°E longitude and at an altitude of about 234 m from sea level). During the crop growing period, maximum and minimum temperature were 30.4°C and 1.6°C. The total rainfall received during the crop growing season was 144.2 mm. The soil of the experimental field was alkaline pH (8.24), medium electrical conductivity (0.34 dSm^{-1}), low organic carbon (0.41%), low available N (180.2 kgh^{-1}), medium available P (16.4 kgh^{-1}), medium available K (253.8 kgh^{-1}) and medium available S (8.71 kgh^{-1}). Canola variety GSC 7 was sown by transplanting method on beds at spacing of 30 cm × 10 cm under randomized complete block design (RCBD) with 6 treatments (three replications each) comprising of T_1: 100% Recommended dose of NPK fertilizers (RDF), T_2: 100% RDF + 40 $kgha^{-1}$ sulphur (S) + 1% foliar sulphur spray (SS), T_3: 100% Nitrogen (N) through vermicompost (VC) + 40 $kgha^{-1}$ S + 1% SS, T_4: 100% Nitrogen through pressmud (PM) + 40 $kgha^{-1}$ S + 1% SS, T_5: 75% RDF + 25% N through VC + 40 $kgha^{-1}$ S + 1% SS, T_6: 75% RDF + 25% N through PM + 40 $kgha^{-1}$ S + 1% SS.

Recommended dose of nutrients for Canola (GSC 7) was 100 kg nitrogen, 30 kg phosphorous and 15 kg potassium per hectare. Full amount of P_2O_5, K_2O and sulphur (S) along with 50% of nitrogen as per the treatment was applied as basal dose and remaining 50% of N was top dressed after 30 days after transplanting at second irrigation. The N, P, K and S concentration in organic manures used was 1.84, 0.90, 1.43 and 0.57% in VC, 0.67, 2.11, 0.81 and 0.31% in PM, respectively and required quantity as per the treatments was applied in the field before last tillage operation on dry weight basis. The net plot size was 3m × 2.8m. Ridges were made by wheat bed planter in main field and one month old nursery was transplanted. Foliar application of elemental sulphur was done @ 1% concentration before the flower initiation stage (45 DAT) with the help of knapsack sprayer. Only water spray was also done to those plots that lacked foliar application of sulphur to minimize the errors. All other standard agronomic practices were followed as per the schedule. Economics of different treatments was worked out on the basis of results of seed yield of canola in term of gross and net returns ha^{-1} and B:C considering the prevailing minimum support price (MSP) of the produce and cost of cultivation. The data of the trail obtained were subjected to statistical analyses and the results were documented, analyzed and presented (as pooled over two year) in tabular form.

RESULTS AND DISCUSSION

Yield and Yield Attributes

Length of siliqua (cm)

The data presented in Table 1 showed that the maximum siliqua length were observed with the treatment T_2 in which application of foliar sulphur helps to increases (7.59%) of the siliqua length from T_1 but statistically it was unaffected with all other treatments. Similar results were reported by Piri *et al.,* (2011).

Number of seed siliqua^{-1}

The data in Table 1 showed that among the all treatment, maximum number of seed siliqua^{-1} was observed with T_2 was significantly higher than all other treatments as 9.92% from T_1, 20.50% from T_3, 19.50% from T_4, 17.55% from T_5 and 11.62% from T_6. Canola is an oilseed crop response very well to the higher rate of sulphur application which resulted in increased grains $pods^{-1}$. (Sattar *et al.,* 2011). Results were agreed with the study of Anjum *et al.,* (2017).

Number of siliquae plant^{-1}

The data showed in Table 1 revealed that among all treatments maximum number of siliqua plant^{-1} was observed under T_2 was significantly higher from all other treatments as 5.43% from T_1, 46.66% from T_3, 41.03% from T_4, 9.93% from T_5 and 7.14% from T_6. The increase in productive pod might be due to the sulfur application because it is mainly responsible for enhancing the reproductive growth and the proportion of the reproductive tissues (inflorescences and pods) in total dry matter (Ngezimana and Agenbag (2013). The result was also in agreement with the findings of Ahmad *et al.,* (2011).

Test weight (g)

The data pertaining that the test weight affected by different treatments as shown in Table 1. Among all treatment, highest

Table 1: Effect of foliar application of sulphur and integrated nutrient management on different yield attributes of bed transplanted canola (Data pooled over two year).

Treatments		Length of siliqua (cm)	No. of seed per siliqua	No. of siliquae per plant	Test weight (g)
100% Recommended dose of NPK fertilizers	T_1	7.9	26.2	519.3	4.40
100% RDF + 40 $kgha^{-1}$ S + 1% foliar sulphur spray (SS)	T_2	8.5	28.8	547.5	4.64
100% N through vermicompost (VC) + 40 $kgha^{-1}$ S + 1% SS	T_3	7.4	23.9	373.3	4.08
100% N through pressmud (PM) + 40 $kgha^{-1}$ S + 1% SS	T_4	7.5	24.1	388.2	4.05
75% RDF + 25% N through VC + 40 $kgha^{-1}$ S + 1% SS	T_5	7.7	24.5	498.0	4.32
75% RDF + 25% N through PM + 40 $kgha^{-1}$ S + 1% SS	T_6	7.8	25.8	511.0	4.37
CD (p = 0.05)		0.6	2.1	22.5	0.15

test weight was observed under $T_2$was significantly higher than other treatments as 5.45% fromT_1, 13.72% from T_3, 14.56% from T_4, 7.40% from T_5 and 6.17% from T_6. Increase in test weight could be also ascribed to the overall improvement in plant growth and vigour with sulphur fertilization that favoured both the grain formation and grain development which resulted into increase in test weight of mustard seed (Mehriya and Khangarot 2000). Similar results were founded by Dhruw *et al.,* (2017).

Seed yield (qha^{-1})

The data represented in Table 2 showed that among all the treatments, the maximum seed yield was recorded with T_3 which was statistically higher than all other treatments as 13.58% fromT_1, 84.72% from T_3, 76.36% from T_4, 24.10% from T_5 and 19.63% from T_6 (Fig 1). Sulphur nutrition enhances cell multiplication, elongation, expansion and imparts a deep green colour to leaves due to better chlorophyll synthesis, which in turn increases the effective area for photosynthesis, resulting in a relatively greater amount of dry matter accumulation in comparison to sulphur deficient plants (Mehriya and Khangarot, 2000). Yield from organic nutrient sources was low may be because organic sources are not able to release the nutrients synchronizing with the peak crop requirement because of their slow mineralization rate at low temperature during winter. The result is also in agreement with the findings of Sharifi (2012).

Stover yield (qha^{-1})

The maximum stover yield (Table 2) were recorded from T_2which was significantly higher among all the treatments as 8.91% from T_1, 71.95% from T_3, 65.18% T_4, 18.14% from

Table 2: Effect of foliar application of sulphur and integrated nutrient management on seed yield, stover yield, oil content, protein content and sulphur content of bed transplanted canola (Data pooled over two year).

Treatments		Seed yield (qha^{-1})	Stover yield (qha^{-1})	Oil content (%)	Protein content (%)	Sulphur content (%)
100% Recommended dose of NPK fertilizers	T_1	21.94	72.10	37.63	26.3	0.28
100% RDF + 40 kghs^{-1} S + 1% foliar sulphur spray (SS)	T_2	24.92	78.53	42.33	29.4	0.41
100% N through vermicompost (VC) + 40 kgha^{-1} S + 1% SS	T_3	13.49	45.67	43.37	30.8	0.45
100% N through press-mud (PM) + 40 kgha^{-1} S + 1% SS	T_4	14.13	47.54	43.13	30.1	0.48
75% RDF + 25% N through VC + 40 kgha^{-1} S + 1% SS	T_5	20.08	66.47	42.73	29.7	0.40
75% RDF + 25% N through PM + 40 kgha^{-1} S + 1% SS	T_6	20.83	68.61	42.07	29.1	0.43
CD (p = 0.05)		1.61	6.21	1.69	1.1	0.05

Table 3: Effect of foliar application of sulphur and integrated nutrient management on economics of bed transplanted canola (Data pooled over two year).

Treatments	Symbol	Total cost of production (Rs.)	Gross return (Rs.)	Net return (Rs.)	B:C (%)
100% Recommended dose of NPK fertilizers	T_1	43830	92148	48318	1.10
100% RDF + 40 kgha^{-1} S + 1% foliar sulphur spray (SS)	T_3	45615	104664	59049	1.29
100% N through vermicompost (VC) + 40 kgha^{-1} S + 1% SS	T_5	64145	56658	-7487	-0.12
100% N through press-mud (PM) + 40 kgha^{-1} S + 1% SS	T_7	52645	59346	6701	0.13
75% RDF + 25% N through VC + 40 kgha^{-1} S + 1% SS	T_9	50247	84336	34089	0.68
75% RDF + 25% N through PM + 40 kgha^{-1} S+ 1% SS	T_{11}	47372	87486	40114	0.85

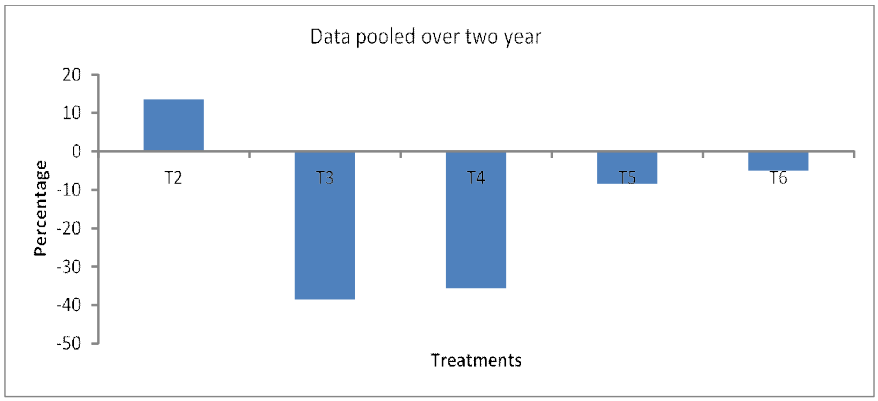

Fig 1: Percentage changed in seed yield of different treatments as compared to 100% recommended dose of NPK fertilizers (T_1).

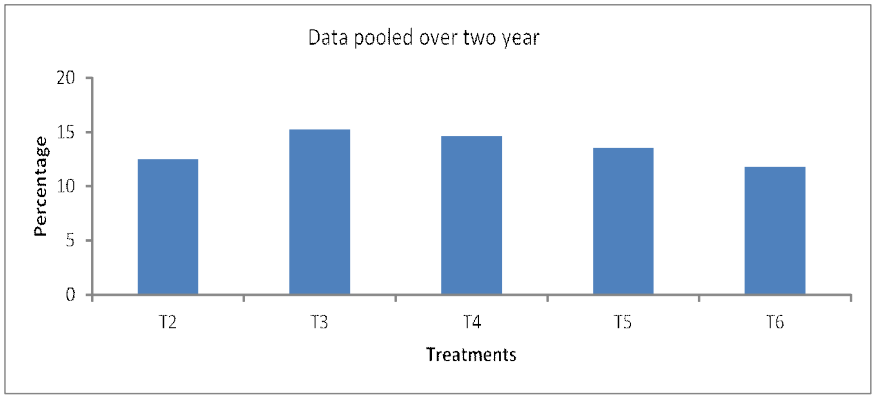

Fig 2: Percentage changed in oil content of different treatments as compared to 100% recommended dose of NPK fertilizers (T_1).

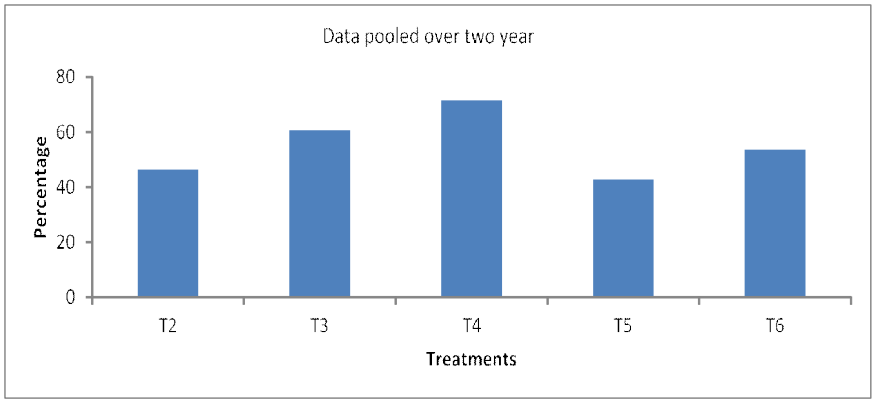

Fig 3: Percentage changed in Sulphur content in seed of different treatments as compared to 100% recommended dose of NPK fertilizers (T_1).

T_5 and 14.45% from T_6. The increase in stover yield due to sulphur (S) fertilization was mainly because of the stimulatory effect of applied S in the synthesis of chloroplast and activation of ferridoxin photosynthetic process its involvement in metabolic processes and its role in protein and hormone synthesis (Mishra 2001). These results corroborated with the findings of Dharuv (2017).

Quality attributes

Oil content (%)

The analysis of data presented in Table 2 showed that among the all treatments, maximum oil content was obtained from T_3. Results showed that T_3 was statistically higher as 15.25% from T_1, 2.45% from T_2, 0.55% from T_4, 1.49% from T_5 and 3.09% from T_6 (Fig 2). Such an increase in oil content may be ascribed to the enhanced protein synthesis (acetyl-CoA carboxylase) and increased oil accumulation in the developing seeds (Rathore *et al* 2015) by the S application. Vermicompost is effective as organic fertilizer and bio-control agents that have organic nutrition role and increase plant growth (Simsek 2011). The result is also in agreement with the findings of Kansotia *et al.,* (2013).

Seed protein content (%)

The analysis of data presented in Table 2 revealed that among all treatments, maximumprotein content in seed was obtained from T_3. Results showed that T_3 was statistically higher as 17.11% from T_1, 4.76% from T_2, 2.32% from T_4, 3.70% from T_5 and 5.84% from T_6. Sulphur promotes oil synthesis and it is an important constituent of seed protein, amino acid, enzymes and glucosinolate (Shekhawat *et al.,* 2012). Similar results were founded by Ali *et al.,* (2016).

Sulphur content in seed (%)

The data regarding grain sulphur (%) in canola presented in Table 2 showed that the maximum sulphur content was obtained from T_4. Results showed that T_4 was statistically higher as 71.42% from T_1, 17.07% from T_2, 6.66% from T_3, 20.00% from T_5 and 11.62% from T_6 (Fig 3). Application of sulphur increases the availability of sulphur for crop which results in higher sulphur content in seed. Results agreed with the study of Parihar *et al.,* (2016).

Economics

The data presented in Table 3 revealed that among the all treatments, maximum cost of production was resulted from T_3 due to economic implication in case of higher dose of vermicompost whereas T_1 had economically viable with lowest cost of production. Maximum gross return was founded in T_2 due to higher yield of canola whereas least from T_3 because of lower yield and higher cost of vermicompost manure. The highest net return obtained from

T_2 followed by T_1 and lowest as negative net returns from T_3. The B:C best from T_2 (1.29%) followed by T_1 (1.10%) and was lowest in T_3 (-0.12%) followed by T_7 (0.13) where 100% nitrogen was applied through vermicompost and press mud. These results are in agreement with those of Daury and Ghosh (2013) and Singh *et al.,* (2014).

CONCLUSION

The findings of the present investigation revealed that among different treatment combinations, 100% RDF + 40 kgha^{-1} S + 1% foliar sulphur spray (T_2) registered the maximum in yield parameters like siliqua length (7.59%), no. of siliqua plant^{-1} (5.43%), no. of seed siliqua^{-1} (9.92%), test weight (5.45%), seed yield (13.58%) and stover yield (8.91%) over 100% Recommended dose of NPK fertilizers (T_1). The maximum oil content (16.21%) and protein content (17.11%) in canola were found where treatment containing 100% N through vermicompost + 40 kgha^{-1} S + 1% SS (T_3) while maximum sulphur content in seed (71.41%) was observed where we apply 100% N through pressmud + 40 kgha^{-1} S + 1% SS (T_4) over 100% Recommended dose of NPK fertilizers (T_1) which indicated that the organic manure is helpful for the good quality of canola. 100% RDF + 40 kgha^{-1} S + 1% foliar sulphur spray (T_2) also registered the maximum net return and benefit cost ratio (B:C).

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