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Enhancing Grain Yield and Improving Oil Quality of Canola Through the Application of Sulfur and Nitrogen in Agro-Climatic Condition of Peshawar, Pakistan

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Abstract | Canola is significant oil crop and Nitrogen and sulfur act as the key plant nutrients that promote the plant growth and also raise the quality of its oil. It is very crucial to find a suitable dose of N and S for the oil crops, so keeping in view this experiment was designed in RCB design with 4 replications (each has one control plot) in research area of agriculture university Peshawar. Two factor were studied in this experiment i.e. 5 N doses (40, 80, 120, 160, 200 kg ha^{-1}) and 3 S doses (20, 40, 60 kg ha^{-1}). Urea was used as source of Nitrogen and ammonium sulphate was used as a source of sulfur. After analysis of the data the results revealed that Fertilizer applied plots showed best performance in all measured parameters as compared to control plots. In the case of N in 160 kg N ha^{-1} treated plots, maximum protein content, glucosinolate content, and erucic acid (percent) as well as grain yield was recorded, except oil contents which was higher at 20 kg N ha^{-1} plots, while on other hand S application, whereas Sulfur applied @ 40 kg ha^{-1} produced maximum Grain yield, oil content, protein content, Glucosinolate contents and erucic acid. It was determined that applying N @ 120 to 160 kg ha^{-1} in association with 40 kg S ha^{-1} resulted high yield and better oil quality, and thus recommended for boosting grain productivity and in raising the standard of canola oil.

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1. Introduction

Rapeseed (*Brassica napus* L.) is an important oil seed after soybean and is the member of family cruciferae. This family is comprised of about 160 species among which the rapeseed is most famous (Przybylsk and Mag, 2011). Rapeseed is best fodder crop but nowadays it is cultivated for oil purposes (Lin *et al*., 2013). Rapeseed is grown on large area in Pakistan for oil production (Khan *et al*., 2004). According to ministry of national food security and research report 2021 not only the yield of canola low in Pakistan but also its oil quality is inferior in comparison to developed countries like Australia, USA and china, because of lack of suitable cultural practices and insufficient fertilizer application (Ma *et al*., 2015). Rapeseed contains sulfur (S) substances which are unsafe for humans and animals uses, breeders and scientist has decreased the levels of these substances and develop canola from the rapeseed (Ma *et al*., 2019). Canola crop is significant oil crop and its oil is use for cooking and so many other purposes. The remaining husk after the extraction of oil after oil acts as a good feed for animals as it is rich of amino acids and fats (Tesfamariam *et al*., 2010). Canola oil is free of cholesterol and thus good for health (Lin *et al*., 2013). Canola oil contains unsaturated fatty acid and linoleic which essential food constituents (Kostik *et al*., 2013). Linolenic acid is important amino acid in the oil of canola as it declines the cholesterol level in the blood (Beyzi *et al*., 2019).

Nitrogen is an integral part of chlorophyll and play vital role in plant growth and development (Constantin *et al*., 2010). Nitrogen enhances light capturing ability of plants as it enhances the vegetative canopy of the crop plants (Giller, 2004). Correct level, time and method of N application are most important to harvest greater yield (Shahrokhnia *et al*., 2017). N is mobile nutrient and always prone to leaching in soil, so its application to soil for each crop is most nutrients. Canola crop require high level of N as compared to other crops (Jan *et al*., 2010). Insufficient nitrogen application and incorrect method result in poor crop development and yields. (Mohammadi *et al*., 2011). Ma and Herath (2016) testified that high doses of N to canola may lead to decrease in oil and protein contents in the seed (Al-Doori, 2013). It's critical to figure out what dose of nitrogen boosts productivity while simultaneously improving oil quality in canola (Koocheki *et al*., 2013). The quantity and quality of canola is positive correlated with levels of N (Rathke *et al*., 2005). Canola uptake of nitrogen was found to be more significant at levels ranging from 120 to 180 kg N ha^{-1}, similar its crop yield was also found greater (Cheema *et al*., 2010).

Sulfur (S) has significant importance in plant growth as it enhance chlorophyll production, starch production and also increase oil contents and vitamins compound in plants (Duncan *et al*., 2018). The deficiency of S decrease crop yield and also lead to un-availability of other nutrients to the plants (Jafarnejadi *et al*., 2015). It is estimated that is 70% of the soil all over the world is facing S deficiency as due to its minute quantity and lack of fertilizer application to the soil (Ma *et al*., 2015). Sulfur is a fundamental and vital plant nutrient that play vital role in plant growth and improve the quality of the crop as it's the part of amino acids (Ma *et al*., 2020; Grant *et al*., 2012). S application is important in increasing canola yield and improving its quality. Therefore, its most important to find out suitable time, level and method of S application for crop like canola (Bahmanyar *et al*., 2010). The soil of Pakistan is always facing S deficiency and its recommended to our farmer apply S to the crops (Amanullah *et al*., 2011). Malhi and Leach (2007) reported that oil, protein and glucosinolate level was enhanced with the S fertilization.

It is determining from the above passage that N and S are highly important and play vital role in harvesting greater yield and obtaining high quality of canola oil, so as a consequence, this study was conducted to investigate an optimal amount of N and S that would boost canola productivity while simultaneously improving oil quality.

2. Materials and Methods

This study was initiated at Agriculture University of Peshawar's research unit with the objective of determining an optimal dose of N and S that would not only boost canola yield but also optimize the oil quality.

The detail of the experimental factors and their different doses are as bellow:
Factor A: N Doses (kg ha^{-1}): N1= 40; N2= 80; N3= 120; N4= 160; N5= 200.
Factor B: S Doses (kg ha^{-1}): S1= 20; S2= 40; S3= 60
Control: No N and No S

This experiment was tested in RCB design during the second week of October. The Seeds of canola were sown @ 10 kg ha^{-1} in 4 replications. Each plot area was 12 m^2 which consist of 8 rows apart 40 cm from each other's. Urea was used as sources of N and ammonium-sulphate was used as source of S. All S doses were applied at the time of sowing, while all doses of N was applied with 1st and 2nd irrigation. Hoeing, thinning, irrigation and weeding etc such cultural practices were done for all experimental plots uniformly. For distillation and discovering quality ingredients, random samples of seed were obtained from each plot and analyzed using Gunning and Hibbard's method and micro Kjeldahl's method (Anon, 1990).

2.1 Statistical analysis

The data was randomly collected from the experimental units and statistically analysed using the RCB design methodology. For determining the difference between the means and comparing the means, the LSD test was applied (Jan *et al*., 2010).

3. Results and Discussion

3.1 Grain yield (kg ha^{-1})

N and S application was positive correlated with grain yield of canola as shown in Figures 1 and 2. All the treated plots produce higher seed yield when compared with control plots. The plot receiving 120 kg ha^{-1} of nitrogen produced the highest grain yields, while the plot receiving 40 kg ha^{-1} of nitrogen produced the lowest seed yield. In the case of S application, plots receiving 40 kg S ha^{-1} yielded more seeds than the other treatments. The interactive effect between S and N was positive correlated for grain yield of canola. It might be due that N and S are the main plant nutrient and enhance the growth of the plant and ultimately higher grain yield was achieved. Our results confirmed those of Jan *et al*. (2010), Cheema *et al*. (2016), and Ma *et al*. (2015), who found that applying N and S to crop plants increases vegetative growth and income of the farmers.

3.2 Oil content (%)

Figures 3 and 4 depict data related to canola oil content. The application of N and S increased the oil content of canola, according to the findings. The planned mean comparison of the control and rest plots demonstrated that the control plots had lower oil content than the nutrients applied plots. The plots fertilised with 40 kg N ha-1 had the highest oil content, while plots fertilised with 200 kg N ha-1 had the lowest oil content. The amount of sulphur in the soil has a big impact on the amount of oil in the air. The plots that received 40 kg S ha-1 had higher oil content, while the plots that received 20 kg S ha-1 reported lower oil content. The amounts of N and S demonstrated a negative relationship with the oil content of canola seeds. Cheema *et al*. (2010); Aminpanah (2013) stated that protein content increases with N application but oil content is decreases. In contrast to N applications, S applications boosted the oil content of canola, with higher oil content recorded in plots treated with 40 or 60 kg S ha^{-1}. Increased S treatment increases the oil concentration of canola, according to Subhani *et al*. (2003); Kutcher *et al*. (2005); whose supported our findings.

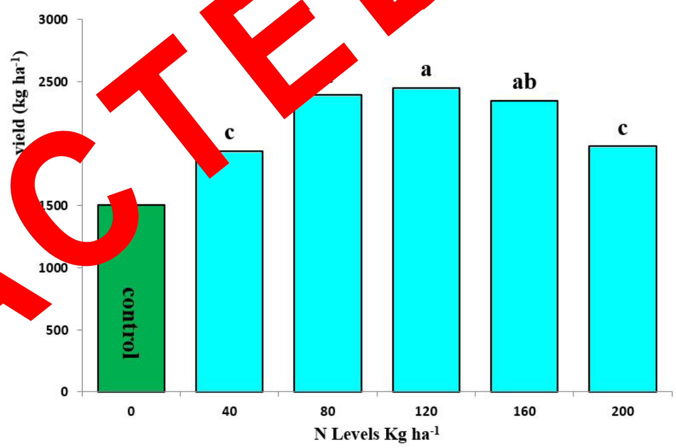

Figure 1: Grain yield (kg ha-1) as affected by different N levels. Different letters over the vertical bars represent means significant difference within each category.

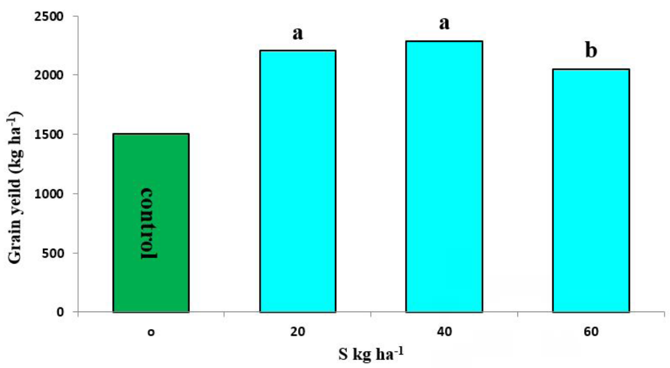

Figure 2: Grain yield (kg ha-1) as affected by different S levels. Different letters over the vertical bars represent means significant difference within each category.

3.3 Protein content (%)

Data regarding the protein content are presented in Figures 5 and 6. Protein content is positively affected by N and S levels, but there was also positive correlation between N and S for protein contents. Highest protein content was observed in treated plots with respect to control plot. Seed protein content was higher in plots treated with 160 kg N ha-1, but as the amount of nitrogen increased, the percentage of protein in the seeds decreased dramatically. In case of S application 40 kg S ha^{-1} dose has produce higher protein content, while lower protein content was recorded for 20 kg S ha^{-}1 dose. The levels of nitrogen and sulfur significantly influence the protein content of canola seeds because of N and S are the important constituent of protein and amino acids (Amanullah *et al*., 2011). Sulfur is a constituent of protein that assists in the biosynthesis of amino acids (Ur Rehman *et al*., 2013). These findings were verified by Kutcher *et al*. (2005); Hao *et al*. (2004) who found that increasing N and S levels increased the protein content of canola seeds considerably. Jan *et al*. (2010) also established that N and S are obligatory for protein synthesis.

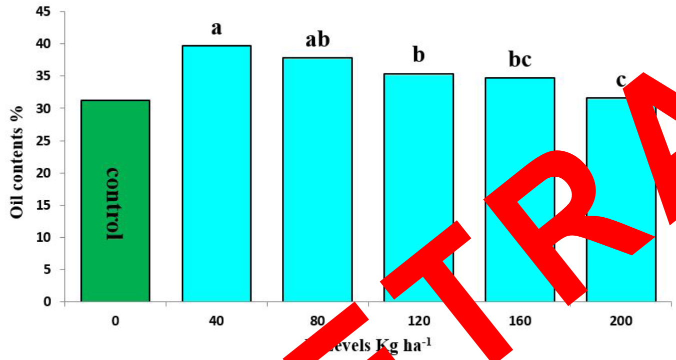

Figure 3: Oil contents (%) as affected by different N levels. Different letters over the Vertical bars represent means significant difference within each category.

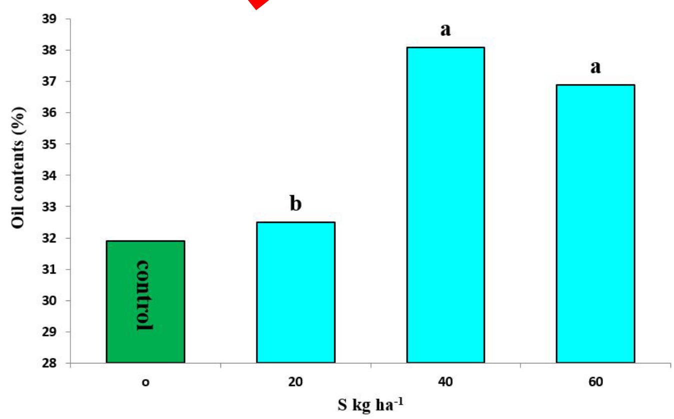

Figure 4: Oil contents (%) as affected by different S levels. Different letters over the vertical bars represent means significant difference within each category.

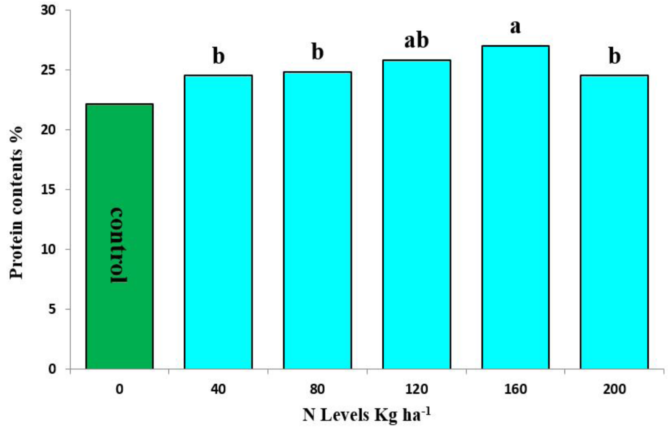

Figure 5: Protein contents (%) as affected by different N levels. Different letters over the vertical bars represent means significant difference within each category.

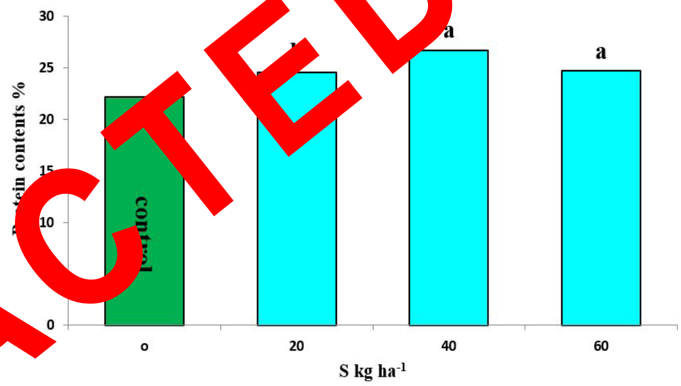

Figure 6: Protein contents (%) as affected by different S levels. Different letters over the vertical bars represent means significant difference within each category.

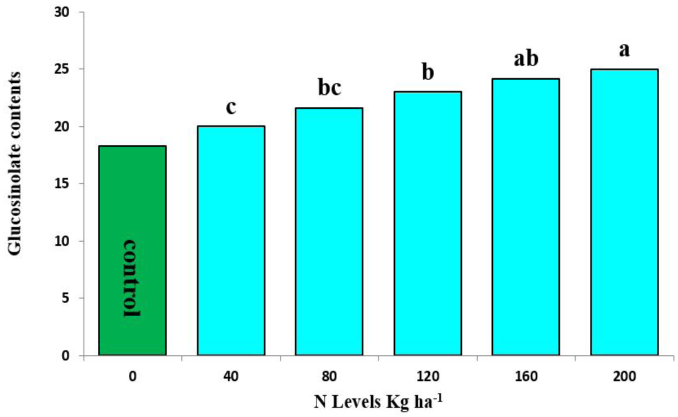

Figure 7: Glucosinolate content (µ mol g-1) as affected by different N levels. Different letters over the vertical bars represent means significant difference within each category.

3.4 Glucosinolate content (µ mol g^{-1})

The quantities of nitrogen and sulphur have a considerable impact on glucosinolate concentration, as seen in Figures 7 and 8. When comparing control and rest plots, it was discovered that the control plots had lower glucosinolate concentrations, but the fertilised plots had higher glucosinolate levels. At 200 kg N ha-1, the glucosinolate content was higher, whereas at 40 kg N ha^{-1}, the glucosinolate level was lower. In terms of S levels, the maximum glucosinolte content of canola was found at a dose of 60 kg S ha-1, whereas the lowest was found at a dose of 20 kg S ha^{-1}. Our findings are also supported by Ma *et al.* (2015) and Jan *et al.* (2010), who found that increasing the S and N rates increased the glucosinolate content. This could be because glucosinolate is a sulfur-containing molecule that increases with sulphur application.

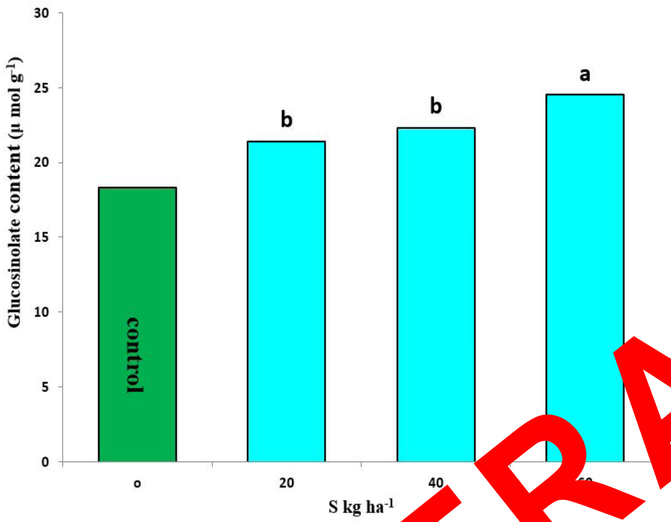

Figure 8: Glucosinolate content (μ mol g-1) as affected by different S levels. Different letters over the vertical bars represent means significant difference within each category.

3.5 Erucic acid (%)

As indicated in Figures 9 and 10, the amounts of nitrogen and sulphur had a beneficial impact on the results about erucic acid (percentage). When the control plots were compared to the remaining of the plots, the control plots had a lower content of erucic acid (percent) than the rest. The plots absorbing N @ 160 kg ha-1 had the highest erucic acid (percent), while the plots receiving 40 kg N ha-1 had the lowest erucic acid (percent). In the case of S, the plot getting S @ 40 kg ha-1 had the highest erucic acid (percent), while the plot absorbing S @ 20 kg ha-1 had the lowest. With the addition of S and N, the amount of erucic acid (percent) increases. Kutcher *et al.* (2005) also found that increasing N and S application increased the amount of erucic acid (percent) in canola. Malhi and Leach (2000) came to the same conclusion.

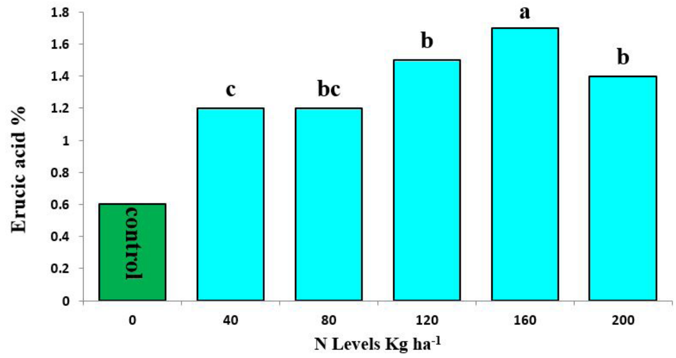

Figure 9: Erucic acid (%) as affected by different N levels. Different letters over the vertical bars represent means significant difference within each category.

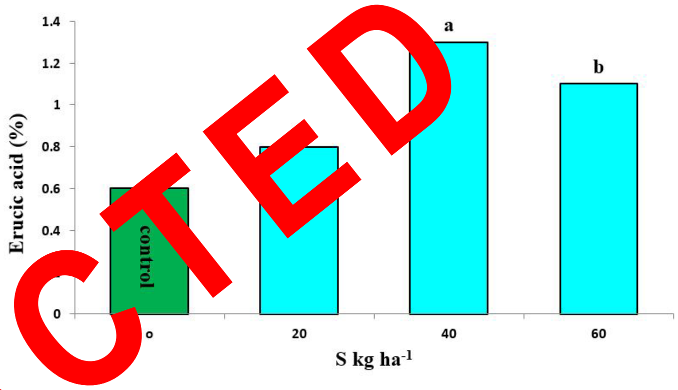

Figure 10: Erucic acid (%) as affected by different S levels. Different letters over the vertical bars represent means significant difference within each category.

Conclusion and Recommendations

The application of N @ 160 (kg ha-1) and S @ 40 (kg ha-1) enhanced the production and quality of canola oil, hence it is observed that the application of N @ 120 to 160 (kg ha-1) together with 40 kg S ha-1 is the ideal nutrients combination for attaining bigger grain yield and better canola oil quality.

Novelty Statement

This study on N and S application in canola highlights the usefulness of N and S in crop production, making it particularly useful for young scientists and researchers in plant sciences and agriculture who want to learn more about the role of N and S in the development of oil crops such as canola.

Author's Contribution

Muhmmad Bakhtiar: Paper composition and

Materials.
Fayaz Ali Niaz: Original draft.
Mamoona Munir: Result and Discussion.
Ghulam Yaseen and Muhammad Numan Khan: Analysis.
Wajiha Seerat: Reviewing and editing.
Sadiqullah Khan: Introduction.
Asma Bibi: Data collection.
Asim Muhammad: Supervisor.

Conflict of interest

The authors have declared no conflict of interest.

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