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IMPROVED AGRONOMIC PRACTICES TO ENHANCE THE PRODUCTIVITY AND QUALITY OF CANOLA (*BRASSICA NAPUS* L.) UNDER THE ARID CLIMATE OF SOUTHERN PUNJAB, PAKISTAN

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Abstract

Canola is an oilseed crop with up to 48% oil content. The productivity of canola is affected by a lack of improved agronomic practices. For this purpose, a field trial with different agronomic practices was laid out to improve canola productivity in the arid climate of Southern Punjab. Treatments included the different sowing methods *i.e.* Conventional method (CM), Gap chat method (GM), Drill sowing (DS), Ridges sowing (RS), and Bed sowing (BS); and seed rates [S_0= recommended seed rate (2 kg per acre), S_1= reduced seed rate (1.5 kg per acre), S_2= highly reduced (1 kg per acre), S_3= very high reduced (500 g per acre)]. The experiment was laid out in randomized complete block design (RCBD) with split-plot arrangement and was repeated three times. Sowing methods were adjusted in the main plot, while seed rates were placed in the sub-plot. The results showed that different sowing methods and seed rates had a significant interactive effect on growth and yield attributes. The conventional method with a reduced seed rate (CM×S1) took a maximum number of days to pod formation versus (vs.) bed sowing with a recommended seed rate (75.7 vs. 61.7) and days for maturity (143.7 vs. 120.7). The maximum plant height (158.3 cm), number of pods per plant (76.3), number of seeds per pod (40.3), pod length (4.93 cm) and 1000-grain weight (6.41 g) was noted in the bed sowing with reduced seed rate (BS×S1). The bed sowing with a reduced seed rate (BS×S1) increased the grain yield and biological yield as compared to the conventional method with a very high reduced seed rate (CM×S3). The same result for canola oil contents was noted. It was concluded that bed sowing with reduced seed rate is the improved agronomic practice to enhance the productivity of canola under the arid climate of southern Punjab.

Key words: Canola, Conventional method, Agronomic practices, Grain yield, Oil quality.

Introduction

Canola (*Brassica napus* L.) is a major oilseed crop globally, cultivated on a large scale (Grant *et al*., 2016). Among the oilseed crops, Canola (*Brassica napus* L.) holds an important position in Pakistan's cropping system (Bano *et al*., 2010). In contrast to mono and polyunsaturated fatty acids, it is known for its low quantity of saturated fatty acids, making it a favorable choice in human and livestock diets (Iqbal *et al*., 2008). Canola residue after oil extraction is also a good feedstuff for dairy animals (Wanasundara *et al*., 2017). Edible oils are essential components of the human diet, providing the necessary energy and fulfilling daily calorie requirements (Anon., 2022). In the fiscal year 2023, spanning from July to March, a total of 2.681 million tonnes of edible oil, which includes oil extracted from imported oilseed, was imported. The estimated value of these imports amounted to Rs. 826.482 billion or approximately US$ 3.562 billion (Govt. of Pakistan, 2023). Although canola is cultivated in Pakistan over an area of 0.03 million hectares, the yield per unit area is far less in comparison to other countries (Anon., 2022).

There are many constraints to the low yield of canola in Pakistan. Conventional methods of sowing and optimal seed rate are the factors that are responsible for low productivity. Planting strategies not only ensure fitting adjustment and perfect plant populace in the field next to but also engage the plants to utilize the land and other valuable contributions all the more adequately and consistently quickly towards development and improvement (Gul *et al*., 2015). Tanveer *et al*., (2003) reasoned that planting strategy expects a basic part in the position of seed at fitting profundity, which finally impacts crop development. The decision of sensible planting strategies for a yield is subject to the planting season, soil water openness at planting time, and planting machine availability. Improved sowing methods not only help to maintain optimum plant population due to better germination but also enable the plants to utilize land, light, and other input resources uniformly and efficiently. Soomro *et al*., (2009) have reported a significant increase in wheat yield by adopting a new sowing technique. The planting method is one of the most important crop production factors that determines and influences the germination percentage as well as seedling establishment. Bed planting has been involved in improved drainage (Takeshima *et al*., 2023), reducing soil erosion (Garg *et al*., 2022), increased economic efficiency (Du *et al*., 2022), and nutrient management (Nkebiwe *et al*., 2016). Seed rate affects plant population, and it significantly influences the growth and yield of canola and is highly dependent on the spatial arrangement of plants (Rathke *et al*., 2006). The length of the main inflorescence is significantly reduced as plant density increases (Hosseini *et al*., 2006; Mobasser *et al*., 2008).

In the realm of agriculture, the need for continuous improvement in agronomic practices cannot be overstated. Enhanced practices, such as optimizing seed rates and refining sowing methods, hold the promise of substantially boosting crop yields and, subsequently, food security. Recognizing the importance of these advancements, this study embarks on a novel journey aimed at optimizing agronomic practices for the cultivation of canola within the challenging arid climate of south Punjab. While previous research has made significant strides, there remains a noticeable knowledge gap in the application of these practices in such a unique ecological context. The primary aims of this research endeavor include augmenting both the productivity and quality of canola crops under these specific conditions. It is hypothesized that by fine-tuning seed rates and sowing techniques tailored to the arid climate, we can achieve a substantial increase in canola yields, ultimately benefiting both farmers and consumers while addressing crucial agricultural challenges.

Material and Method

Experimental site, treatment, and design: A field experiment was conducted at the Agronomic Research Area, Department of Agronomy, Bahauddin Zakariya University, Multan, Pakistan. The experiments included the two factors, Factor A: different sowing methods, and Factor B: different seed rates. Different sowing methods included the *i.e.* Conventional method (CM), Gap chat method (GM), Drill sowing (DS), Ridges sowing (RS), and Bed sowing (BS); and different seed rates included the S_0= recommended seed rate (2 kg per acre), S_1=reduced seed rate (1.5 kg per acre), S_2= highly reduced (1 kg per acre), S_3= very high reduced (500 g per acre). The experiment was laid out in randomized complete block design (RCBD) with split-plot arrangement and was repeated three times. Sowing methods were adjusted in the main plot, while seed rates were placed in the sub-plot.

Experimental soil and environmental condition: The soil was sandy clay loam in texture with 1.3% organic matter (O.M), pH 7.7, and EC 2.8 dSm^{-1}. Total available nitrogen (0.04%), phosphorous (9.50 mg kg^{-1} and potassium (125 mg kg^{-1}). The environmental condition of the experimental area is given in (Fig. 1).

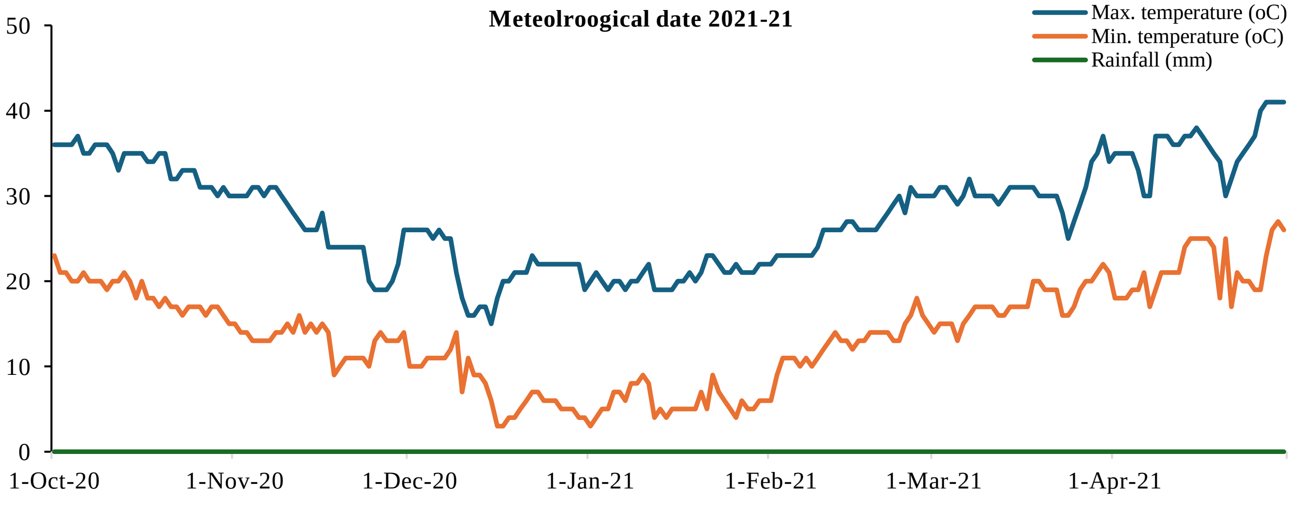

Fig. 1. Meteorological data for the crop growing session.

Crop husbandry: A registered variety of canola, "Canzola" was collected from an authorized dealer of Punjab Seed Corporation. A fine seedbed was prepared as per the experiment, and the seed was planted as per treatment. The conventional method (CM) of sowing is the broadcast method. Sowing of seed in the broadcast way in standing water is the Gap Shat method (GM). In drill sowing (DS), the seed was drilled by the manual drill at a distance of 24 inches. In ridges sowing (RS), ridges were raised at a distance of 24 inches, and seed was sown on the top of the ridges. In bed sowing (BS), the seed was planted on a raised bed in a broadcast method. The size of each experimental unit was 3×4 m^2. A recommended dose of N:P:K was applied at 35:34:25 kg per acre. Urea (46% N) fertilizer was used as a source of nitrogen, Di-ammonium phosphate (DAP) fertilizer (46% P and 18% N) was used as a source of phosphorus, and Murate of potash (MOP) fertilizer (60% K) was used as a source of potassium. The total dose of P and K was applied at the time of sowing, while nitrogen was applied in two splits. Half was applied at the time of sowing, and half of the remaining was applied at the second irrigation at the flowering stage. The crop was irrigated when needed. Thiophanate Methyl" was used as a fungicide for seed treatment. All other plant protection measures, like weed control and insect pest control, were kept constants for all the experiment units. Ten plants from each experimental unit were tagged for data collection. The crop was harvested at its physiological maturity.

Statistical analysis

Data recorded was analyzed statistically using the least significant difference (LSD) test at 5% probability (Steel *et al*., 1960). Graphs were prepared in Microsoft Excel software.

Results

Analysis of variance showed that different sowing methods, seed rate, and their interactive effect significantly affected the growth and yield attributes of canola (Table 1). Phonological attributes like the number of days to pod formation and the number of days to maturity are significantly affected by the different sowing methods and seed rates. The maximum number of days to pod formation (75.7 vs. 61.7 days) was counted in the conventional method with the reduced seed rate (CM×S1) vs. the bed sowing with the reduced seed rate (BS×S1). Concerning the number of days to maturity, the maximum number of days to maturity (143.7 vs. 120.7 days) was counted in the conventional method with a reduced seed rate (CM×S1) versus the bed sowing with the recommended seed rate (BS×S0). The conventional method with a reduced seed rate increased the 14 days for pod formation as compared to the bed sowing with the recommended seed rate. Hence, bed sowing with the recommended seed rate was delayed 23 days for its maturity.

Growth attributes of canola were also significantly affected by the different sowing methods and seed rates. The maximum plant height (158.3 cm) was measured in the bed sowing with the reduced seed rate (BS×S1). The minimum plant height (104.7 cm) was measured in the conventional method with the very high reduced seed rate (CM×S3). The interactive effect of different methods and seed rate for the number of leaves per plant was found to be non-significant. Results for the number of branches per plant showed that bed sowing with the reduced seed rate (BS×S1) attained the maximum number of branches per plant (10.7 vs. 4.3) versus conventional methods with reduced seed rate (CM×S1). The number of pods per plant, number of seeds per pod, pod length, and 1000-grain weight are yield attributes that are important for the yield of canola crops. The maximum number of pods per plant and number of seeds per pod (76.3 and 40.3) were counted in the bed sowing with the reduced seed rate (BS×S1), while the minimum values (42. 0 and 16.3) were noted in the conventional method with highly reduced seed rate (CM×S3), respectively. The same results for pod length and 1000-grain weight were noted. Bed sowing with reduced seed rate (BS×S1) attained the maximum pod length (4.93 cm) and 1000-grain weight (6.41 g). The minimum pod length (3.10 cm) and 1000-grain weight (3.31g) were observed in the conventional method with a very high reduced seed rate (CM×S3) and recommended seed rate (CM×S0).

Statistical results for grain yield and biological yield were also significant for different sowing methods and seed rates (Fig. 2). Results showed that different sowing methods and seed rates influenced the grain yield and biological yield of canola significantly. The maximum grain yield and biological yield were attained in bed sowing with a reduced seed rate (BS×S1), while the minimum grain yield and biological yield were attained in the conventional method with a very high reduced seed rate (CM×S3).

Quality attributes: Results for quality attributes like oil contents and protein contents of canola were significantly affected by the different sowing methods and seed rate. The interactive effect of different sowing methods and seed rate was also found to be significant except for protein contents, which showed a non-significant effect (Fig. 3). The bed sowing with a reduced seed rate (BS×S1) produced the maximum oil contents when it was compared with the conventional method with a high reduced seed rate (CM×S2). The same trend for protein contents was noticed, but their interactive effect was non-significant (Fig. 3).

Table 1. Influence of different sowing methods and seed rate on phenology, growth and yield attributes of canola.

Treatments		No. of days to pod formation	No. of days to maturity	Plant height (cm)	Number of leaves plant^{-1}	Number of branches plant^{-1}	Number of pods plant^{-1}	Number of seeds pod^{-1}	Pod length (cm)	1000-grain weight (g)
CM	S_0	75.0 a	136.7 c	122.7 h	8.7	7.0 de	46.7 hi	18.7 hi	2.57 m	3.31 m
	S_1	75.7 a	143.7 a	126.0 gh	11.5	4.3 h	50.3 g	23.3 fg	3.53 i-k	4.59 ij
	S_2	73.7 a-c	140.3 b	112.3 j	10.0	5.3 gh	44.3 ij	20.7 gh	3.67 l	3.99 j
	S_3	74.3 ab	141.3 b	104.7 k	10.7	6.3 efg	42.0 j	16.3 i	3.10 l	4.04 kl
GM	S_0	72.3 a-d	130.7 de	132.3 ef	10.3	7.7 cd	49.0 gh	22.3 g	3.70 h-j	4.87 hi
	S_1	68.3 a-g	140.0 b	136.7 d	14.4	5.3 gh	53.7 ef	26.7 e	4.07 e-g	5.29 e-g
	S_2	72.7 a-d	135.0 c	126.3 g	11.7	6.3 efg	50.2 g	21.0 gh	3.43 jk	4.46 i-k
	S_3	72.0 a-e	136.7 c	116.0 i	12.7	5.7 fg	51.0 fg	21.3 gh	3.01 l	3.97 l
DS	S_0	66.0 b-g	126.0 fg	135.3 de	12.0	8.3 c	55.7 e	26.7 e	3.77 g-i	4.90 g-i
	S_1	72.3 a-d	136.3 c	143.7 c	15.3	6.0 efg	60.4 d	30.3 d	4.17 d-f	5.41 d-f
	S_2	68.7 a-g	132.3 d	130.7 f	14.0	6.7 def	54.7 e	26.3 e	3.73 h-j	4.85 hi
	S_3	70.7 a-f	132.3 d	122.7 h	12.7	5.7 fg	58.7 d	25.3 ef	3.33 kl	4.33 j-l
RS	S_0	64.3 d-g	1227 h	141.3 c	15.3	9.7 ab	64.7 e	30.3 d	3.73 h-j	4.84 hi
	S_1	69.0 a-g	135.0 c	148.7 b	16.3	6.7 def	68.7 b	35.3 c	4.37 c-e	5.68 c-e
	S_2	65.0 d-g	127.0 f	137.3 d	14.0	7.7 cd	64.7 c	30.7 d	3.92 f-h	5.08 f-h
	S_3	67.3 a-g	130.0 e	135.0 de	14.3	6.3 efg	64.7 c	31.7 d	3.97 f-h	4.16 f-h
BS	S_0	61.7 g	120.7 i	149.7 b	16.3	6.3 efg	71.0 b	35.3 c	4.43 b-d	5.77 b-d
	S_1	65.3 c-g	132.0 de	158.3 a	18.3	10.7 a	76.3 a	40.3 a	4.93 a	6.41 a
	S_2	63.7 efg	126.3 f	143.7 c	15.0	8.7 bc	69.7 b	38.3 ab	4.73 ab	6.16 ab
	S_3	63.3 fg	124.0 gh	141.7 c	15.7	7.7 cd	68.7 b	35.7 bc	4.56 bc	5.94 bc

CM= Conventional method, GM= Gap chat method, DS= Drill sowing, RS= Ridges sowing, BS= Bed sowing, S_0= Recommended seed rate, S_1= Reduced seed rate (1.5 kg per acre), S_2= Highly reduced (1 kg per acre), S_3= Very high reduced (500 g per acre)

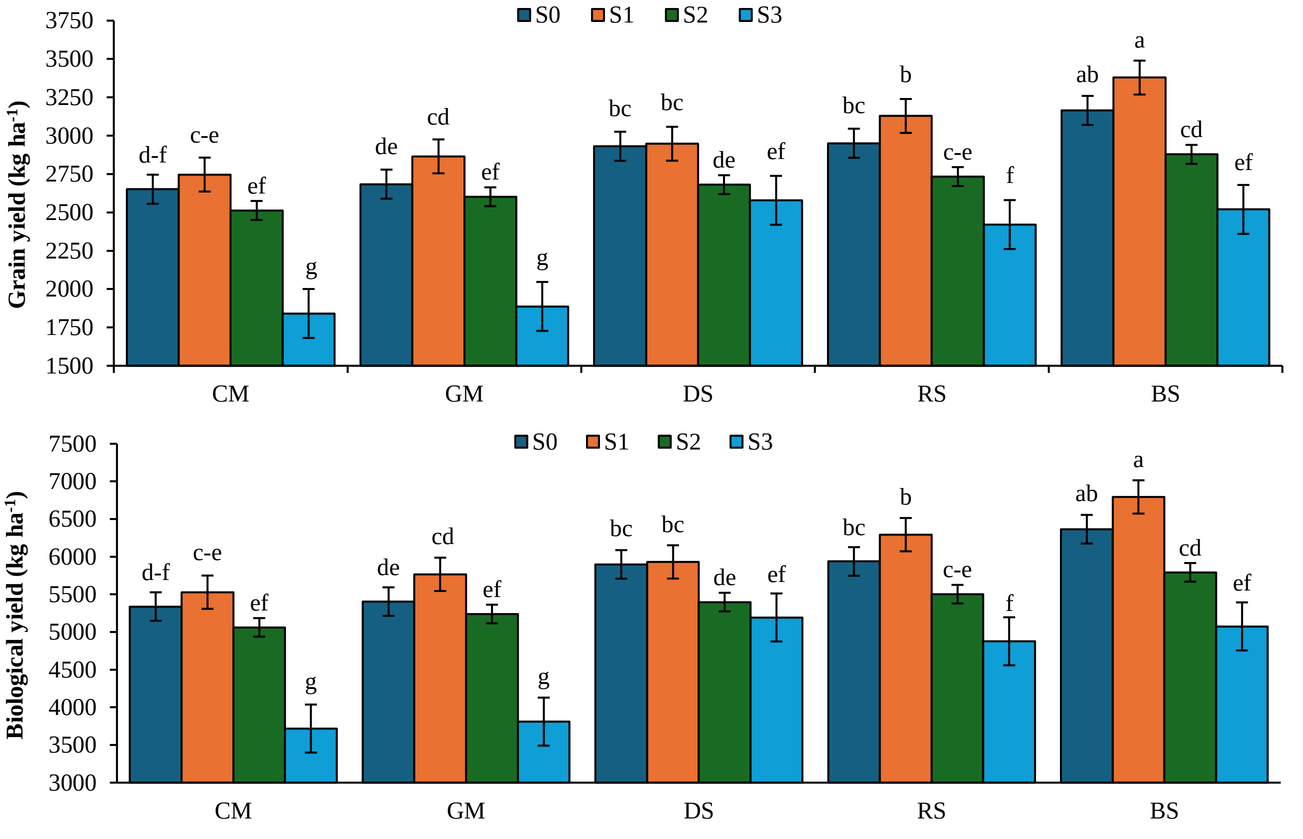

Fig. 2. Influence of different sowing methods and seed rate on grain yield and biological yield of canola.
CM= Conventional method, GM=Gap chat method, DS=Drill sowing, RS=Ridges sowing, BS=Bed sowing, S_0= Recommended seed rate, S_1= Reduced seed rate (1.5 kg per acre), S_2= Highly reduced (1 kg per acre), S_3= Very high reduced (500 g per acre)

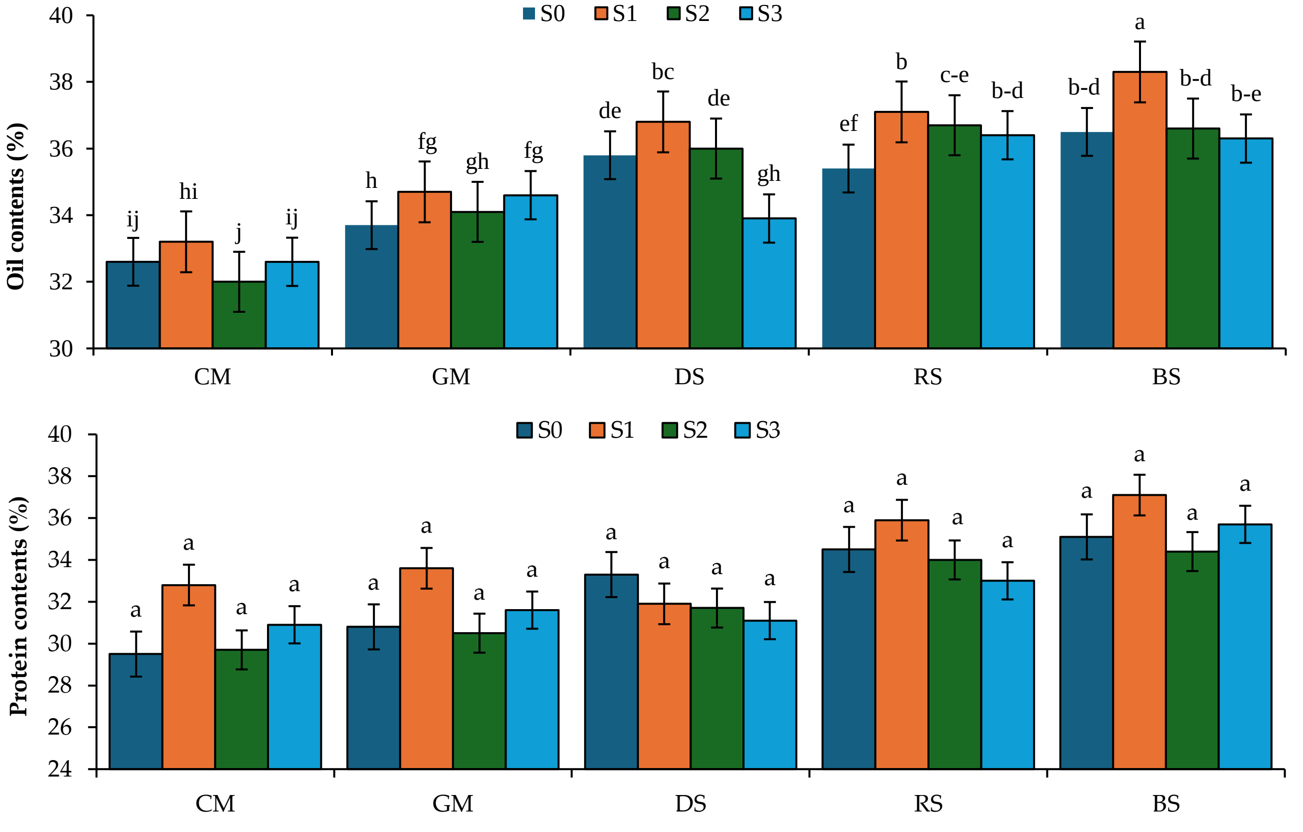

Fig. 3. Influence of different sowing methods and seed rate on oil contents and protein contents of canola
CM= Conventional method, GM=Gap chat method, DS=Drill sowing, RS=Ridges sowing, BS=Bed sowing, S_0= Recommended seed rate, S_1= Reduced seed rate (1.5 kg per acre), S_2= Highly reduced (1 kg per acre), S_3= Very high reduced (500 g per acre).

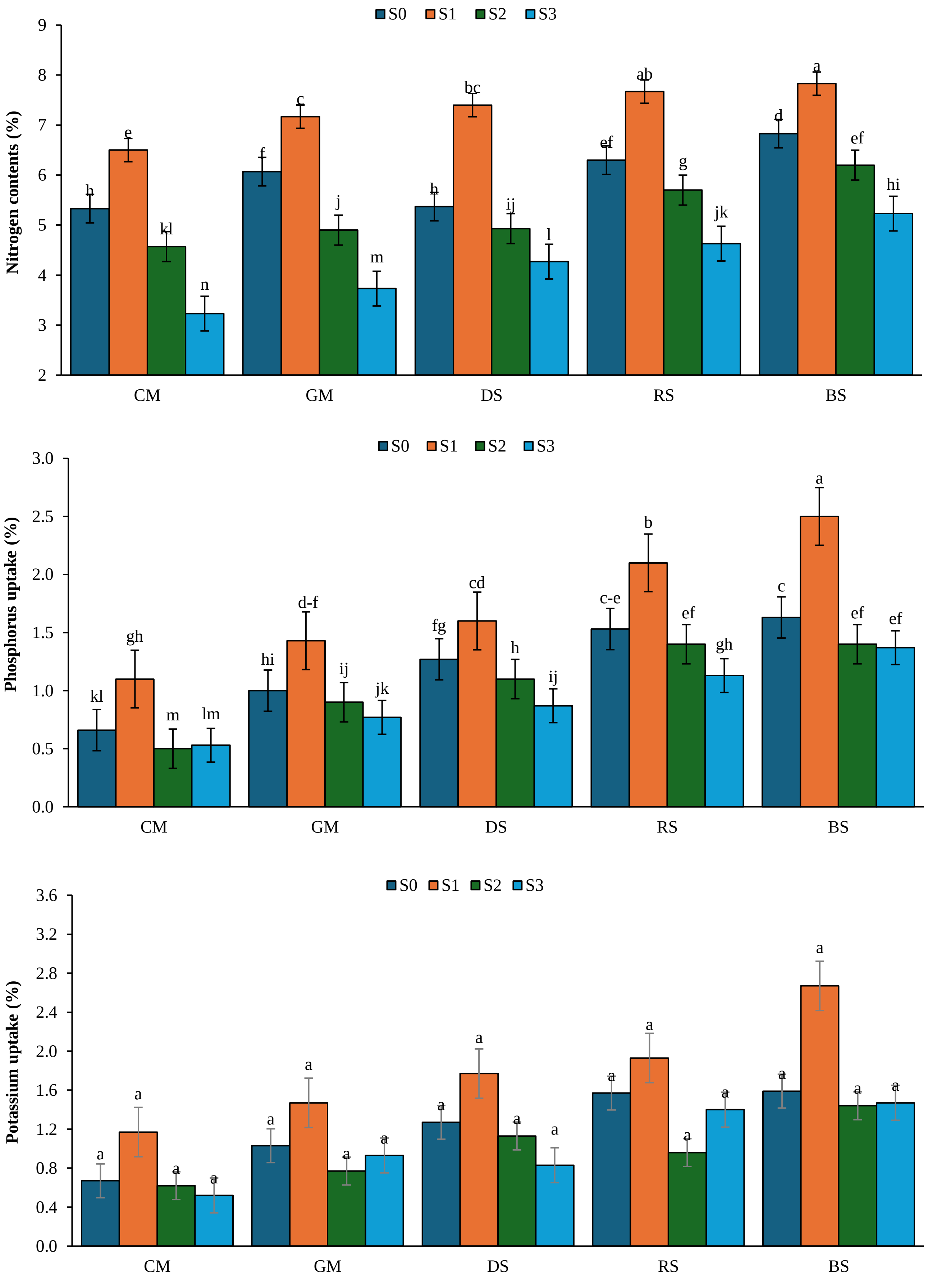

Fig. 4. Influence of different sowing methods and seed rate on nitrogen, phosphorus, and potassium uptake contents of canola, CM= Conventional method, GM=Gap chat method, DS=Drill sowing, RS=Ridges sowing, BS=Bed sowing, S_0= recommended seed rate, S_1= reduced seed rate (1.5 kg per acre), S_2= highly reduced (1 kg per acre), S_3= very high reduced (500 g per acre)

Mineral uptake: Minerals like nitrogen, phosphorus, and potassium uptake showed a significant response towards the different sowing methods and seed rates. The interactive effect of different sowing methods and seed rates was significant for nitrogen and phosphorus while was non-significant for potassium uptake (Fig. 4). Results for the nitrogen and potassium uptake showed that bed sowing with a reduced seed rate (BS×S1) uptake the maximum nitrogen when it was compared with the conventional method with a very high reduced seed rate (CM×S3). The same results for phosphorus uptake were noted. The maximum phosphorus uptake was noted with bed sowing and reduced seed rate (BS×S1), and the minimum phosphorus uptake was noted in the conventional method with a high reduced seed rate (CM×S2) followed by (CM×S3). The interactive effect for potassium uptake was non-significant (Fig. 4).

Discussion

Our results showed that canola showed maximum growth at bed sowing with a reduced seed rate. Crop yield and yield attributes were significantly affected by different sowing methods and seed rates (Table 1).

Sowing methods play an important role in crop production. Each sowing method has a different role in crop production. Our results revealed that bed sowing was an improved sowing method when compared with others. Bed planting systems increased the soil porosity and reduced crop lodging and disease attack, thereby increasing the production per unit area (Fahong *et al*., 2004). Bed planting of canola can significantly enhance yield potential through a combination of physiological and environmental factors. The raised bed structure fosters improved soil drainage, thereby mitigating waterlogging-induced stress (Du *et al*., 2022). Low productivity was observed with the conventional method of sowing. Conventional soil preparation methods have caused a loss of soil moisture content and soil health (Taghinazhad *et al*., 2012). Our results showed that plant growth and yield attributes decreased with increasing plant spatial arrangement (Plant-to-plant and row-to-row distance) in the conventional method.

Concerning the effect of different seed rates, maximum growth and productivity were observed with the reduced seed rate when it was compared with the recommended and other rates. Seed rate is an important factor in attaining the maximum plant population for high productivity. Plants compete for nutrients, light, and space. Hosseini *et al*., (2006) and Mobasser *et al*., (2008) found that plant height, number of pods per plant, and grain yield decreased with increasing the plant population. The same results were also reported by Li *et al*., (2014) and Kazemeini *et al*., (2010). Improved agronomic practices with spatial management is the strategy to enhance the canola productivity because it affects the phenology, like the number of branches per plant and yield of canola (Yantai *et al*., 2016; Rondanini *et al*., 2017). The findings prove our results that the number of branches per plant, the number of pods per plant, the number of seeds per plant, and pod length increased with the reducing seed rate but decreased when it reduced very high.

Conclusion

Canola crop is significantly affected by the different sowing methods and seed rates. Among the different sowing methods, bed sowing is more affected than other sowing methods, and among the different seed rates, it resulted that 1.5 kg per acre of seed rate gave the more grain yield. It was concluded that canola productivity can be increased with the bed sowing method with a seed rate of 1.5 kg per acre. Seed yield and quality of canola can be increased with maximum nutrient uptake of improved agronomic practice of bed sowing and reduced seed rate of 1.5 kg per acre.

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