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Effect of sowing methods on different varieties of rapeseed under rainfed condition

Efecto de los métodos de siembra en diferentes variedades de colza en condiciones de temporal

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Abstract

The most crucial variables affecting the yield of rapeseed are the sowing method and varieties, each of which is influenced by the production system, farmers' knowledge, and the innovative use of technologies. The aim of this study is to determine how rapeseed production potential is affected by sowing technique and variety. Three varieties (Pragati, Unnati, and Chitwan-Local) and two planting techniques (Broadcasting and Line Sowing) were used in the field trial in Fulbari, Dang, during the winter of 2021, with four replications. The experimental design used was Randomized Complete Block Design. Differences between the varieties, sowing techniques, and their interaction on eventual seed production were found to be statistically highly significant. The yield of rapeseed was highest when Chitwan Local was line sown (2.17 t.ha^{-1}) and lowest when Pragati was broadcasted (1.56 t.ha^{-1}). Statistically significant effect was found on mean values of seed yield when seed were line sown rather than broadcasted i.e. 1.85 t.ha^{-1} compared to 1.71 t.ha^{-1} respectively. Among the varieties the economical yield was found to be maximum in Chitwan Local (1.88 t.ha^{-1}) followed by Unnati (1.81 t.ha^{-1}) whereas lowest in Pragati (1.65 t.ha^{-1}). Line sowing of Chitwan Local variety produces better outcomes under rainfed condition. For better rapeseed yield performance under a rainfed condition, this study will be helpful in the selection of varieties and sowing techniques.
keywords: *branches per plant, harvest index, plant height, seeds per siliqua, yield*

Resumen

Las variables más cruciales que afectan el rendimiento de la colza son el método de siembra y las variedades, cada uno de los cuales está influenciado por el sistema de producción, el conocimiento de los agricultores y el uso innovador de las tecnologías. El propósito de este estudio es determinar cómo el potencial de producción de colza se ve afectado por la técnica y la variedad de siembra. En la prueba de campo en Fulbari, Dang, durante el invierno de 2021, se utilizaron tres variedades (Pragati, Unnati y Chitwan-Local) y dos técnicas de plantación (difusión y siembra en línea), con un total de cuatro repeticiones. El diseño experimental utilizado fue el Diseño de Bloques Completos al Azar. Se encontró que las diferencias entre las variedades, las técnicas de siembra y su interacción en la eventual producción de semillas eran estadísticamente muy significativas. El rendimiento de semilla de colza fue más alto cuando se sembró en línea Chitwan Local (2.17 t.ha^{-1}) y más bajo cuando se sembró Pragati (1.56 t.ha^{-1}). Se encontró un efecto estadísticamente significativo en los valores medios del rendimiento de semillas cuando las semillas se sembraron en línea en lugar de al voleo, es decir, 1.85 t.ha^{-1}en comparación con 1.71 t.ha^{-1} respectivamente. Entre las variedades, se encontró que el rendimiento económico era máximo en Chitwan Local (1.88 t.ha^{-1}), seguido de Unnati (1.81 t.ha^{-1}), mientras que el más bajo en Pragati (1.65 t.ha^{-1}). La siembra en línea de la variedad Chitwan Local produce mejores resultados en condiciones de secano. Para mejorar el rendimiento de la colza en condiciones de secano, este estudio será útil en la selección de variedades y técnicas de siembra.
Palabras clave: *ramas por planta, índice de cosecha, altura de planta, semillas por siliqua, rendimiento*

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Introduction

Brassica campestris var. Toria, also known as rapeseed, is a member of the Cruciferae or Brassicaceae family. From 2000 to 1500 B.C., rapeseeds are mentioned in ancient Sanskrit writings (Tofanica, 2019). Both tropical and subtropical nations grow rapeseed. It is primarily cultivated in Canada, the European Union, and China (Jannat et al., 2022). In Asia, it is mainly produced in India, Pakistan, Bangladesh, and Nepal. With an area of 217 867 ha, a production of 208 291 t, and a yield of 956 $kg.ha^{-1}$, oilseed crops are Nepal's main source of foreign exchange (Ministry of Agriculture & Livestock Development [MoALD], 2016). The two main oilseed crops in Nepal are tori (*Brassica campestris* var. Toria) and mustard (*Brassica juncea*). Rapeseed (*Brassica campestris* var. Toria) is one of those, and it is the main crop in Nepal. Rapeseed is grown on 169 769 ha in Nepal, producing 171 499 t, with a productivity of 1.01 $t.ha^{-1}$. It is grown in all 75 districts; however, Kailali, Bardiya, Dang, Chitwan, and Surkhet have the highest areas of cultivation (MoALD, 2016). In 2016, Nepal had a negative trade balance as it imported 46 t of oil and rapeseed for $ 51 000 and only exported 4 t worth only $ 8000 in 2016 (Adhikari et al., 2021). However, recently almost 80 % of total rapeseed production is from Nepal. Out of total rapeseed produced in Nepal, 21 % is produced in the eastern and central region of the country each, and similarly 29 %, 17 %, and 9 % of total rapeseed production in Nepal is from the eastern, mid-western, and far-western regions respectively (U.S. Department of Agriculture [USDA], 2024).

Compared to cereals and legumes, rapeseed is a notable source of lipids, protein, and vitamins in the diet of Nepalese people. Rapeseed is also significant from the perspective of income creation. Rapeseed is used to make vegetables from the green, fragile plant, and the whole seed is used to make pickles to flavor veggies and curries. Because of the presence of glucoside sinigrin, which gives seed and oil its distinctive pungent smell, animals can only eat a limited amount of it, and it has low palatability (Tofanica, 2019). Eight rapeseed cultivars have so far been made available: Type-9, Pragati, Unnati, Vikas, Preeti, Lumle Tori-1, Morang-2, and Surkhet local; however, there is currently no Type- 9 being grown (MoALD, 2016). Rapeseed is a cross-pollinated crop. For improved pollination and seed production, there must be enough pollinating agents (Pudasaini & Thapa, 2014). For its growth and development, it needs cold, dry, and clear weather with temperatures between 18 °C and 25 °C. Crop growth stops if the temperature rises over 35 °C and falls below 3 °C. The best conditions for its good production are long days with enough sunlight and light loamy soil with a pH of 6.5–7.5. It is both a thermosensitive and photosensitive crop. Flowering and anthesis is affected if the temperature rises over 35 °C and falls below 3 °C (Butkevičienė et al., 2021).

Plant density has a significant impact on rapeseed productivity. It controls yield quality, and subsequently, how much each plant will produce (Kaiqin et al., 2024). Rapeseed can often be planted with a plant to plant spacing of 10 cm - 15 cm and a row to row spacing of 30 cm. The yield starts to decrease when the row spacing is narrower than 15 cm (Kuai et al., 2015). Increased grain output requires the establishment of an ideal population density per unit area. Therefore, population density affects yield and characteristics of rapeseed that contribute to yield. The planting pattern affects roots growth, moisture extraction, and light absorption which ultimately impact crop output. The requirement for yield stability is consistent plant spacing per unit area (Kaiqin et al., 2024).

Almost all the rapeseeds grown in Nepal is still planted using the ancient sowing system, or broadcasting (Devkota et al., 2018). Because of this, it is challenging to maintain the desired plant population per unit area, which is necessary to get a greater yield. In order to unlock the crop's yield potential, research in plantation methods including sowing in ridges, furrows, or lines has not been conducted. The factors that affect the components of yield and the yield of individual plants are the sowing method and variety (Dinç & Ünay, 2021). Rapeseed planting often involves line planting and broadcasting. In line sowing, seeds are sown in distinct lines while maintaining plant-to-plant spacing,

guaranteeing the maximum plant population per unit area and boosting rapeseed production. One of the key elements to ensure a better transfer of photosynthates through spatial distribution of light and its usage that offer greater yield is the establishment of an optimal plant population by maintaining correct row spacing (Kuai et al., 2015). The establishment, growth, beginning of flowering, maturity days, productivity, and vigor of plant establishment in relation to a given ecological situation are all significantly influenced by varieties. In addition to promoting the growth of viable seedlings, choosing the right variety for an environment will also promote the development of robust crops, reduce adaptability issues, increase productivity, and be more profitable (Ahmadzadeh et al., 2019), all of which are essential for improving the socioeconomic standing of farmers in upland and rainfed rural areas. As a result, this study evaluated how three rapeseed varieties—Pragati, Unnati, and Chitwan Local—grow and yield under rainfed conditions in response to two sowing techniques—line sowing and broadcasting.

Materials and Methods

Study site

In the rainfed upland environment of Dang, Nepal, the experiment was conducted in the agronomy farm of the Campus of Live Sciences. The region is located in the subtropical agro-ecological tract at an altitude of 725 masl and between Latitude 28°07'24" N and Longitude 82°17'26.40" E. The typical annual rainfall is 425 mm, and the average temperature is 25 °C. The month of August receives an average of 132 mm of precipitation. Rapeseed is grown on a variety of well-drained, aerated soil types, ranging from light to heavy. The experimental site›s soil is clay to clay loam, which is also suitable for growing rapeseed.

Design of experiment and treatments

The experiment was laid out in Randomized Complete Block Design with 6 treatments comprising of two factors *viz.,* three varieties (Pragati, Unnati and Chitwan Local) and two sowing methods (Line sowing and broadcasting). With 6 treatment combinations each replicated four times, there were a total of 24 plots. The dimension of the field was 10 m^2 × 9.5 m^2. Each plot has the size of 1.5 m^2 × 1 m^2 and 1 m gap was left at all borders of each plot. Two plots were spaced at 0.5 m length wise and 1m breadth wise.

Land preparation and sowing

Before finishing the final field preparation, the field was laid out and twice-plowed. The field was prepared by one deep plowing, two harrowings, and planking. According to the allocation of the treatments, seeds were sown in each plot. Hoe lines were created with 30 cm line spacing and seeds were sown at a depth of 3 cm from the soil surface.

Management practices

Potassium (20 kg.ha^{-1} K_2O), phosphorus (40 kg.ha^{-1} P_2O_5), and nitrogen (60 kg.ha^{-1} N) were applied in the appropriate levels. Half of the nitrogen dose was supplied twice as top dressing in conjunction with irrigation after the full doses of phosphorus, potassium, and nitrogen were applied at the time of sowing. To maintain the necessary plant population in each plot after emergence, gaps within plants were filled. The thinning operation was then completed, and the ideal plant population was kept. When the majority of the pods turned yellowish and the plants turned golden yellow, the crop was physically uprooted and harvested. Threshing was carried out manually with sticks.

Data collection

The height of ten randomly selected plants in each plot was measured from the ground surface (point of root-shoot interaction) to the tip of the main shoot with the help of measuring tape at harvest. The average height was calculated and expressed as plant height in cm. The number of branches was counted separately from ten selected plants drawn for measuring height, and their average was worked out. Total number of siliqua per plant were counted on the same ten selected plants for plant height and then converted into the average number of siliqua per plant. Ten siliqua were drawn randomly from ten

selected plants and were threshed manually and cleaned. The number of seeds in each siliqua was counted, and then the average number of seeds per siliqua was calculated. The crop harvested from net plot area of 1 m x 1.5 m = 1.5 m² was threshed. After 4-5 days of sun drying. Seed yield was then converted into t/ha. Before threshing, the sun-dried whole plant samples (biological yield) were weighed and then converted into t/ha. Finally, harvest index (HI) was calculated as per formula given below:

Harvest Index (HI) = Seed yield (t/ha)/Biological yield (t/ha)

Statistical Analysis

MS Excel was used for data entry, tables and graphs. Data were tabulated treatment wise in MS-Excel. Statistical analysis was done in MS-Excel. Descriptive statistics like mean, standard error of mean and coefficient of variation were calculated. The output will be significant if $p < 0.05$ (Cesana, 2018). The significant difference between the treatment's means were compared by calculating the least significant difference at 5 % significance level.

Results and Discussion

Plant height

The height of rapeseed is significantly different for different varieties. Pragati showed the highest height (89.24 cm) and Unnati showed the lowest height (82.25 cm) (Table 1). Likewise, plant height differed significantly for different sowing methods (Table 2). The highest height was found under line sowing (90.72 cm). There was a significant difference in plant height as resulted by the interaction of genotypes and sowing methods. Pragati variety under line sowing had the maximum height (100.51 cm) and Pragati variety under broadcasting had the minimum height (77.99 cm) (Table 3). Sowing method had significant effect on plant height and line sowing produced the tallest plant and the shortest one was found at broadcast method (Hossain et al., 2013). Plant height is shorter when sown with broadcasting method (Khan et al., 2000). Ali & Rahman (1986) found significant variation on plant height due to varieties of rapeseed. Mondal et al. (1992) also observed significant variation in plant height among different genotypes of *Brassica* which was similar to our findings.

Number of branches per plant

The number of branches per plant differed significantly for different varieties. Chitwan Local and Pragati showed highest and the lowest number of branches per plant i.e. 9.44 and 5.41 respectively (Table 1). Likewise, there was a significant difference in number of branches per plant for different sowing methods (Table 2). The highest number of branches per plant was found under line sowing (8.17). There was a significant difference in number of branches per plant due to the interaction of genotypes and sowing methods. Chitwan Local variety under line sowing had the maximum number of branches per plant (10.68) and Pragati variety under broadcasting had the minimum number of branches per plant (5.05). Line sowing method produced the highest number of branches per plant while the lowest number of branches per plant was observed in the broadcast method (Hossain et al., 2013). Barick et al. (2020) also found that number of primary branches per plant was higher in line sowing followed by broadcasting. In contrast to our findings, Mondal et al. (1992) found that there was no significant effect of varieties on number of branches per plant. Zakaria & Jahan (1997)

Table 1: Growth and yield attributes of selected rapeseed varieties

Treatment	Plant height (cm)	Branches per plant	Siliqua per plant	Seeds per siliqua	Biological yield ($t.ha^{-1}$)	Seed yield ($t.ha^{-1}$)	Harvest Index
Pragati	89.24a	5.41c	79.01c	14.41b	11.38c	1.65c	0.11b
Unnati	82.25c	8.2b	105.96b	15.35ab	15.54a	1.81b	0.11b
Chitwan Local	85.94b	9.44a	116.65a	15.89a	12.86b	1.88a	0.14a
SEM	2.66	0.62	4.14	1.31	0.44	0.06	0.01
LSD (0.05)	2.83*	0.67**	4.41**	1.39*	0.47**	0.06**	0.01**
CV %	3.1	8.13	4.12	8.59	3.29	3.37	7.18
Grand mean	85.81	7.68	100.54	15.22	13.26	1.78	0.14

reported that the local varieties had a maximum number of branches per plant which is similar to our findings.

Siliqua per plant

The number of siliqua per plant is significantly different for different varieties. Chitwan Local variety had the maximum number of siliqua per plant (116.65) and Pragati variety had the minimum number of siliqua per plant (79.01) (Table 1). Likewise, siliqua per plant differed significantly for different sowing methods (Table 2). The maximum siliqua per plant was found under line sowing (110.51). There was a significant difference in the number of siliqua per plant as resulted by the interaction of genotypes and sowing methods. Chitwan Local variety under line sowing had the maximum siliqua per plant (137.53) and Pragati variety under broadcasting had the minimum siliqua per plant (69.23) (Table 3). Khan et al. (2000) studied the number of siliqua per plant play a major role in yield, which was significantly affected by sowing methods. Sarkees (2015) reported that individual plants of drill-row sowing produced a higher number of siliqua than those of broadcasting sowing. Siliqua per plant were significantly higher in line sowing as compared to broadcasting (Barick et al., 2020). Mamun et al. (2015) reported that the number of siliqua per plant significantly varied for rapeseed and mustard varieties. Hossain et al. (1996) also reported the significant variation of siliqua per plant due to varieties which is similar to our findings.

Seeds per siliqua

The number of seeds per siliqua differed significantly for different varieties. Chitwan Local and Pragati showed highest and the lowest number of seeds per siliqua i.e. 15.89 and 14.41 respectively (Table 1). Sowing methods do not significantly affect the seeds per siliqua (Table 2). There was a significant difference in the number of seeds per siliqua due to the interaction of genotypes and sowing methods. Chitwan Local variety under broadcasting had the maximum number of seeds per siliqua (17.56) and Pragati variety under broadcasting had the minimum number of seeds per siliqua (12.95) (Table 3). There was a significant effect of varieties on seeds per siliqua (Hossain et al., 1996) which is like our findings. According to Barick et al. (2020), there is a significant effect of sowing methods on seeds per siliqua.

Biological yield

Biological yield was significantly different for different varieties. Unnati showed the highest biological yield (15.54 $t.ha^{-1}$) and Pragati showed the least biological yield (11.38 $t.ha^{-1}$) (Table 1). Similarly, biological yield differed significantly for different sowing methods (Table 2). The maximum biological yield was found under line sowing (13.92 $t.ha^{-1}$). There was a significant difference in biological yield as resulted by the interaction of genotypes and sowing methods. Unnati variety under line sowing had the maximum biological yield (16.32 $t.ha^{-1}$) and Chitwan Local variety under broadcasting had the minimum biological yield (10.64 $t.ha^{-1}$) Hossain et al. (2013) found significant influence on biological yield due to sowing method. Maximum biological yield was observed in ridge sowing method which was at par to drill sowing method whereas the lowest biological yield was found in furrow and broadcast method (Khan et al., 2000). Biological yield was significantly influenced due to the varieties (Mendham et al., 1990).

Table 2: Growth and yield attributes of selected rapeseed varieties as affected by sowing methods

Treatment	Plant height (cm)	Branches per plant	Siliqua per plant	Seeds per siliqua	Biological yield ($t.ha^{-1}$)	Seed yield ($t.ha^{-1}$)	Harvest Index
Line sowing	90.72a	8.17a	110.51a	15.43a	13.92a	1.85a	0.131a
Broadcasting	80.90b	7.2b	90.56b	15a	12.59b	1.71b	0.138a
SEM	2.67	0.62	4.13	1.3	0.44	0.06	0.01
LSD (0.05)	2.31*	0.54**	3.6**	1.14	0.38**	0.052**	0.01
CV %	3.1	8.13	4.11	8.6	3.29	3.37	7.19
Grand mean	85.36	7.68	100.54	15.22	13.25	1.78	0.14

Seed Yield

There was a significant effect of varieties on seed yield. Chitwan Local had the maximum seed yield (1.88 t.ha^{-1}) and Pragati showed the least seed yield (1.65 t.ha^{-1}) (Table 1). Similarly, seed yield differed significantly for different sowing methods (Table 2). The maximum seed yield was found under line sowing (1.85 t.ha^{-1}). There was a significant difference in seed yield due to the interaction of genotypes and sowing methods. Chitwan Local variety under line sowing had the maximum seed yield (2.17 t.ha^{-1}) and Pragati variety under broadcasting had the minimum seed yield (1.56 t.ha^{-1}) (Table 3). Sowing method had significant effect on seed yield (Hossain et al., 2013). Seed yield is higher in line sowing than in broadcasting sowing (Barick et al., 2020). The drill-row sowing method produces significantly higher yield than the broadcasting method (Sarkees, 2015).

Harvest Index

Harvest index differed significantly with variation in genotypes. Chitwan Local had the maximum harvest index (0.14) whereas Pragati and Unnati showed the least harvest index (0.11) (Table 1). There was no significant effect of sowing methods as well as the interaction of genotypes and sowing methods on harvest index (Table 2, 3). There was a significant effect of varieties on harvest index (Islam et al., 1994). A low harvest index of rapeseed might be due to excessive loss of siliqua and seed during flowering (Mendham et al., 1981).

Conclusion

Chitwan Local variety under line sowing methods produced the highest yield under the rainfed condition. Line sowing method is found to be better than broadcasting method in terms of growth and yield attributes of rapeseed. In order to increase the yield of rapeseed under rainfed conditions, line sowing should be preferred. Line sowing method increases the yield by decreasing the plant to plant competition for resources.

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Conflict of interest

The authors declare no conflicts of interest.

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Authors contribution

SB: developed the project proposal, drafted the manuscript, analyzed the data; PG and TR: conducted the experiment, collected the data, edited the manuscript draft. All authors reviewed the final manuscript.

Table 3: Growth and yield attributes of selected rapeseed varieties due to the interaction between variety and sowing method

Treatment	Plant height (cm)	Branches per plant	Siliqua per plant	Seeds per siliqua	Biological yield (t.ha^{-1})	Seed yield (t.ha^{-1})	Harvest Index
Pragati × Line sowing	100.51a	5.76c	88.8d	15.88abc	11.94c	1.74c	0.15a
Unnati × Line sowing	84.14bc	8.35b	106.7b	14.46bcd	16.32a	1.99b	0.12a
Chitwan Local × Line sowing	87.51b	10.68a	137.53a	14.20cd	15.07b	2.17a	0.15a
Pragati × Broadcasting	77.99d	5.05c	69.23e	12.95d	10.82d	1.56d	0.14a
Unnati × Broadcasting	80.35cd	8.05b	105.22b	16.22ab	14.75b	1.65cd	0.11a
Chitwan Local × Broadcasting	84.38b	8.2b	95.77c	17.56a	10.64d	1.59d	0.15a
SEM	6.84	0.42	15.43	1.53	0.19	0.004	0.001
LSD (0.05)	3.90*	0.97	5.8	1.85	0.65**	0.098**	0.05
CV %	3.04	8.4**	3**	8.15**	3.3	3.1	25.24
Grand mean	85.81	7.68	100.54	15.21	13.26	1.78	0.13

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