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Research Article

Effect of Plant Geometry on Different Rapeseed Varieties under Rainfed Upland Condition in Nepal

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Abstract

The field experiment was carried out during winter of 2018/19 with two varieties (Unnati and Surkhet-Local) and three plant geometry (15cm × 10 cm, 30cm × 10 cm, 45cm × 10cm) in Randomized complete block design (RCBD) with four replications. Statistically there was no difference between two varieties while differences were found on different spacing and interaction between variety and spacing on final seed yield. High significant differences on seed yield was due to spacing and yield of rapeseed were higher at the 30 cm inter row spacing as compared to the 15 cm and 45 cm inter row spacing. Statistically significant effect was found on mean values of seed yield for interaction which showed that Unnati cultivar in 30 cm x 10 cm plant geometry had the highest seed yield (969.86 kg/ha) followed by Surkhet-local with spacing of 15 cm × 10 cm (843.75 kg/ha) and 30 cm × 10 cm (823.76 kg/ha). Yield of these varieties decreased as spacing is increased, thus sowing of Unnati should be done at cropping geometry of 30 cm × 10 cm and for Surkhet-local it should not be done beyond 30 cm inter row spacing to get the maximum potential yield.

Introduction

Oilseed Brassicas are rabi crops produced and marketed for oil and meal. As compared to other vegetable oils the oil from these crops is one of the best edible oils having lowest amount of saturated fatty acid and provide both essential fatty acid as well as high quality protein rich meal having well balanced aminogram. Rapeseed (*Brassica campestris* var *toria*) belongs to the family Brassicaceae or Cruciferae, genus Brassica, tribe Brassiceae and sub tribe Brassicinae with 20 chromosomes number. The name rape is derived from latin word 'rapum' meaning turnip. Vavilov (1926) and Sinskaia (1928) regarded central Asia, Afghanistan and adjoining north-west India as one of the independent centre of origin of rapeseed (Bhajan, 2015). Rapeseeds have been mentioned in ancient Sanskrit records from 2000-1500 B.C (Rathore, 2014).

Oilseed crops are major cash crop of Nepal with area coverage of 217867 ha, production 208291 Mt and yield of 956 kg/ha (MoAD, 2017). Toria (*Brassica campestries var.* black/yellow toria) and mustard (*Brassica juncea*) are the major oilseed crops of Nepal. Among which rapeseed (*Brassica campestris* var *toria*) is a dominant crop of Nepal. Its cultivation has occupied about 85 % of the total oilseed area in the country (Basnet, 2005). It is mostly grown after monsoon maize in upland condition and after early rice in lowland of terai, inner terai and mid-hills (Ghimire *et al*., 2000). In Nepal, the area under rapeseed cultivation is 169769 ha, production 171499 Mt and productivity 1.01 Mt/ha. It is cultivated in all 75 districts but the districts with higher area of cultivation are Kailali, Bardia, Dang, Chitwan and Surkhet respectively (MoAD, 2017). In 2016 Nepal has imported 46 tonnes of oil, rapeseed worth of 51000 US dollar and exported only 4 tonnes worth of just 8000 US dollar indicating negative balance of trade (FAOSTAT, 2017). Rapeseed is a cross-pollinated crop. It requires sufficient pollinating agents for better pollination and seed production (Pudasaini and Thapa, 2014). It is a photosensitive as well as thermosensitive crop (Ghosh and Chatterjee, 1988). It requires cool, dry and clear weather with temperature of 18-25ºC for its growth and development. If temperature falls below 3ºC and above 35-40ºC the growth of crop ceases. Long day with adequate sunshine and light loamy soil with pH 6.5-7.5 are ideal for its good production. The ideal RH is 85 % but high rainfall, high humidity and cloudy atmosphere at flowering increases incidence of aphids and other diseases and also adversely affects the pollination.

Maintaining optimum plant population is important to realize higher yields. Spacing fluctuates with growth habit of variety, date of sowing, manuring and irrigation. In general rapeseed may be sown at row to row spacing of 30 cm and plant to plant spacing of 10-15 cm (Rathore, 2014). Al-Barzinjy *et al*. (1999) studied the effects of different plant densities varying from 20 to 130 plants per square meter in rapeseed. In this study, pods per plant, seed weights and dry matter per plant was found to be decreased as plant density increased. Similar response was seen in case of seed weight and dry matter per square meter to varying plant density for the two cultivars. Leach *et al*., (1999) reported that plants grown at high density had fewer pod bearing branches per plant. Similarly, Brar (2014) reported that the plant density above optimum have negative effect on growth and yield due to competition for light, nutrients and space whereas plant density below optimum affects the growth and yield due to less utilization of nutrients, space and light. Kler (1988) stated that the planting pattern has effect on crop yield through its influence on light interception, rooting pattern and moisture extraction. The density of plants per unit area and soil fertility status greatly affects the competitive ability of a rapeseed-mustard plant (Shekhawat *et al.*, 2012). The production of rapeseed in Nepal is low as compared to other countries. The major reasons for much poor yield are mainly due to use of indigenous variety, inappropriate plant density and poor management as practiced at farmer's field. Different researchers have emphasized that plant spacing is responsible for better vegetative and productive phases. Spacing is a non-monetary input, but it plays a vital role by changing the magnitude of competition. In wider row spacing, solar radiation falling within the rows gets wasted particularly during the early stages of crop growth whereas in closer row spacing upper part of the crop canopy may be well above the light saturation capacity but the lower leaves remain starved of light and contribute negatively towards yield. Thus, optimum row spacing is necessary for interception of sunlight to each strata of leaves. This will enhance the rate of photosynthesis and consequently, the dry matter production which can ultimately increase the crop yield.

Materials and Methods

The experiment was carried out in Agronomy farm of Campus of Live Sciences under rainfed upland condition of Dang, Nepal. The area lies within the subtropical agro-ecological belt, between Latitude 28° 07' 24.00" N and Longitude 82° 17' 26.40" E with an altitude of 725masl.

Climate and Soil

Dang district lies in sub-tropical region. The average temperature is generally 25.2ºC and average rainfall in a year is 425 mm. Most of the precipitation here falls in August averaging 132 mm. The cultivation of rapeseed is practiced in wide range of soil light to heavy soil well drained and well aerated. Soil of Fulbari, Dang is clay to clay loam soil which is also suited for rapeseed cultivation. The driest month is April with 3mm precipitation. June is the warmest month with an average temperature of 34.3℃ and January is the coolest month with temperature averaging 14.1℃. Average air humidity is 74%.

Experimental Details

Treatments

The field experiment was carried out on factorial RCBD with two factors, four replications and 24 treatments in total land area of 225.5 m² (20.5 m × 11 m) at Fulbari, Dang. Each replication consists of six treatments plot each of area 3.0 m² ($2m \times$ 1.5m) that were placed through randomization. The distance of 1m and 0.5m was maintained between replications and plots respectively. Two varieties i.e. Unnati (V1) and surkhet local (V2) were assigned as Factor I. Three spacing i.e. (S1: 15 x 10 cm), (S2: 30 x 10 cm) and (S3: 45 x 10 cm) were assigned as Factor II (Table 1). Temperature pattern in Tulsipur is shown in Fig. 1.

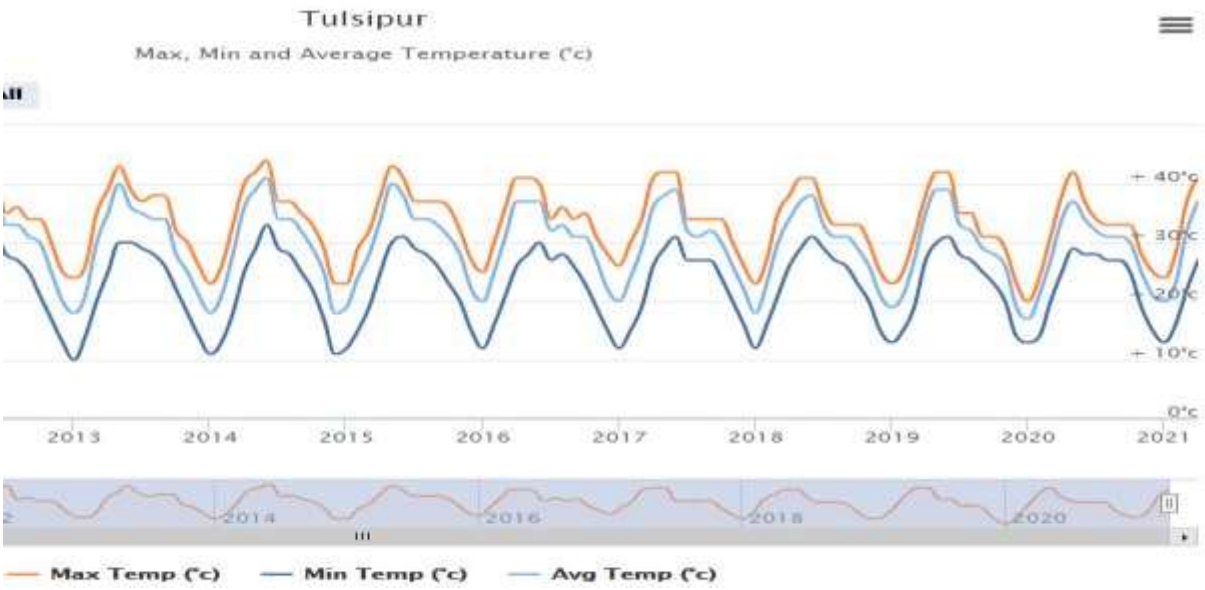

Fig. 1: Temperature pattern in Tulsipur (Source: https://www.worldweatheronline.com)

Table 1: Treatment Combination

Treatments	Symbols	Combinations
T_1	V_1S_1	Unnati + 15 cm x 10 cm
T_2	V_1S_2	Unnati + 30 cm x 10 cm
T_3	V_1S_3	Unnati + 45 cm x 10 cm
T_4	V_2S_1	Surkhet Local+ 15cm x 10cm
T_5	V_2S_2	Surkhet Local+ 30cmx 10 cm
T_6	V_2S_3	Surkhet Local+ 45cmx 10 cm

Details of Crop Raising

Land preparation:

The field was ploughed twice and the layout of the field was done first before final field preparation. Thereafter, at field condition one deep ploughing with 2 harrowing each followed by planking were done to prepare a fine and compact seedbed for proper seed germination. Then stubble and debris from the previous crop was removed from the field as these can harbor the pathogen that can cause disease.

Manure and fertilizers:

After preparation of the field, the experiment was laid out. The recommended doses of nitrogen (60 Kg N/ha), phosphorus (40 Kg P_2O_5/ha) and potassium (20 kg k_2O/ha) were applied. Full dose of phosphorus, potassium and half dose of nitrogen were applied at the time of sowing and the remaining half dose of nitrogen was applied twice as top dressing coinciding with rainfall. The source of nitrogen and phosphorus was urea (46 % N) and DAP (46% P_2O_5 and 18% N), respectively and source of potassium was murate of potash.

Method of sowing:

The rapeseed crop was sown in lines on 8th Oct, 2018 having crop geometry of 45 cm x 10 cm, 30 cm x 10 cm, 15 cm x 10 cm (as per treatments) drawn by hoe using a seed rate of 8 kg/ha. Sowing depth of 2-3 cm from the soil surface was maintained at the time of sowing.

Gap filling and thinning:

After emergence, gaps within plants were filled to maintain the required plant population in each plot**.** Thereafter the thinning operation was done and optimum plant population was maintained. The plant to plant spacing of 10 cm after thinning the crop at 20 days after sowing was obtained.

Plant protection:

The crop was not affected by any insect-pest and diseases during the entire growing period of the crop. Therefore, no plant protection measures were adopted in the rapeseed crop. However, few *Orobanche* and *Cynodon dactylon* were seen in the field which was removed manually with the help of hoe.

Harvesting and Threshing:

The crop was harvested manually with sickle when plants turned golden yellow and maximum number of pods turned yellowish. The harvesting of Unnati and Surkhet local was done on different dates when the pods turned yellow in color. Before harvesting, 10 plants already tagged (leaving border plants) were pulled out from every plot to record post-harvest observations. The crop in net plots was harvested separately and left in the respective plots for sun drying. The bundles of individual net plot were weighed just before threshing to record biological yield. Thereafter the crop was threshed by manual laborers using sticks and was weighed to get seed yield, stover or biomass yield kg/plot. The produce was winnowed, cleaned and weighed plot wise. Thereafter, these yields were converted into kg/ha.

Result and Discussion

Pre-harvest Observation

Plant Height

Wider row spacing of 45 cm recorded significantly taller plants than narrow row spacing of 15 cm and it was at par with 30 cm row spacing. Pandey *et al*., (2015) had also reported that the plant height was significantly higher with crop geometry of 45cm x 15cm as compared to other crop geometries. The plant height was not significantly influenced by varieties and interaction of varieties and plant geometry.

Primary Branches Per Plant

The primary branches per plant was highest in row spacing of 45 cm followed by row spacing of 30 cm. Row spacing of 15 cm produced significantly lesser number of primary branches per plant. Increased spacing between rows increased primary branches per plant from 1.675 (15cm) to 3.625 (45cm). Meiti *et al*., (2000) had also reported that the highest number of primary branches per plant was obtained at wider row spacing of 45 cm as compared to other row spacings. Among varieties primary branches per plant were significantly more in Surkhet local as compared with Unnati. The interaction effect of plant geometry and varieties on primary branches per plant was found to be non-significant.

Secondary Branches Per Plant

Significant differences in secondary branches per plant occurred between the various rows spacing between rows. An increase in row spacing led to significant increase in the secondary branches per plant, was found highest in 45 cm row spacing which was at par with 30 cm row spacing. The lowest secondary branches per plant were found in 15 cm row spacing. Pandey *et al*., (2015) in a field experiment had also reported that the number of secondary branches was recorded significantly higher with crop geometry of 45cm x 15cm as compared to other crop geometries. Varieties and the interaction effect of plant geometry and varieties on primary branches per plant were found to be non-significant.

There was a significant positive linear relationship between number of primary branches per plant, secondary branches per plant and cropping geometry. Cropping geometry S3 had highest mean PBN and SBN value and S1 had lowest mean PBN and SBN. Both primary and secondary branches per plant are increasing from S1 to S3. At S1, PBN was found to be 1.625 per plant and it increases to 3.625 at S3. Likewise, SBN was found 0.835 at S1and increased up to 1.593 at S3 (Table 2)..

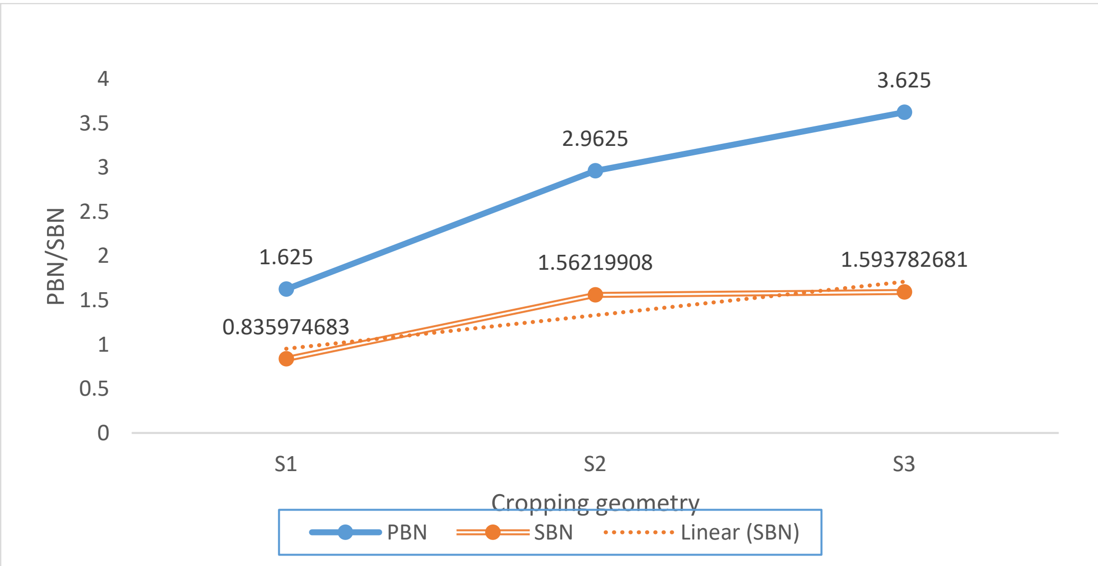

Fig. 2: Graph showing trendline of PBN and SBN and their relationships with cropping geometry in rapeseed.

[Note: S1=15cm×10cm, S2=30cm×10cm, S3=45cm×10cm, PBN= Primary Branch Number Plant-1 and SBN= Secondary Branch Number Plant-1].

Table 2: Effect of varieties, spacing and their interaction on different biometric characters of rapeseed in Nepal

Treatments	Plant height(cm)	Primary branches per plant	Secondary branches per plant
Varieties			
Unnati (V1)	68.699	2.467[b]	1.175
Surkhet Local(V2)	67.018	3.033[a]	1.817
LSD (0.05)	NS	0.345**	NS
Spacing between rows (cm)			
15 (S1)	62.325[b]	1.675[c]	0.263[b]
30 (S2)	69.491[a]	2.950[b]	2.05[a]
45 (S3)	71.755[a]	3.625[a]	2.175[a]
LSD (0.05)	6.172*	0.423***	1.036*
Interactions			
V1 × S1	61.8	1.3	0.71
V1 × S2	72.9	2.8	1.8
V1 × S3	71.5	3.3	1.7
V2 × S1	62.9	2.1	0.5
V2 × S2	66.1	3.1	2.3
V2 × S3	72.0	3.9	2.6
LSD (0.05)	NS	NS	NS
Mean	67.859	2.750	1.496
CV	8.535	14.434	65.018
Sem(±)	5.792	0.397	0.973

Note: CV: Coefficient of variation, LSD: Least significant difference, Sem: Standard error. Mean separated by LSD and columns represented with same letter are non-significant at 5% level of significance, * significant, ***Highly significant, NS-non significant.

Post- Harvest Observation

Siliqua per plant

Maximum number of siliqua per plant was recorded with S3 (45cm) followed by S2 (30cm) which were statistically at par and were significantly superior to S3 (15cm). There was significant difference in number of siliqua per plant at different row spacing. With close spacing these parameters gradually decline as the plants per unit area increase (Hasanuzzaman and Karim, 2007). Surajbhan *et al*., (1980) also reported that the rapeseed crop sown at the spacing of 45 cm produced maximum number of siliqua per plant. The effect of varieties and interaction effect of V×S did not show any response to this parameter (Table 3).

Seeds per silique

Data in respect of seeds per siliqua were statistically analysed and the result depicted that the spacing (S), varieties (V) and the interaction effect of V×S did not show any response to this parameter and were found non-significant (Table 3)..

Aborted siliqua per plant

The higher number of aborted silliqua per plant (3.088) was found in inter row spacing of 45cm followed by 2.525 in inter row spacing of 30 cm which were statistically at par. Significantly lowest number of aborted siliqua per plant was found in inter row spacing of 15cm. However, the difference in aborted silique per plant due to varieties and interaction effect of V×S were non-significant (Table 3).

Biological Yield (kg/ha)

Among varieties, significantly higher biological yield of 2261.112 kg/ha was recorded in Surkhet-local with significantly lower yield of 1763.888 kg/ha in Unnati. The biological yield among crop geometries and interaction effect of V×S on biological yield were found non-significant (Table 4)..

Seed Yield (kg/ha)

High significant differences occurred in seed yield (kg/ha) due to crop geometries. Among different crop geometries 30 cm × 10 cm produced significantly higher yield of 896.82 kg/ha. The yield was found lowest in crop geometry of 45 cm × 10 cm (584.60 kg/ha) which was at par with crop geometry of 15 cm × 10 cm (700.58 kg/ha). Sahoo *et al*., (2000) found that higher seed yield was found in the spacing of 30 cm (669 kg/ha) compared to wider spacing. Chaniyara *et al*., (2000) found that row spacing of 30 cm produce higher seed yield compared to the spacing of 40 and 50 cm. The effect of varieties on this parameter was found to be non-significant. The interaction effect of V× S on seed yield was found significant. The significantly higher seed yield was observed in variety Unnati under 30 cm inter row spacing, which was at par with Surkhet-local under 15 cm and 30 cm inter row spacing. The lowest seed yield was obtained in variety Unnati with inter row spacing of 45 cm which was at par with Unnati with 15 cm and Surkhet-local with 45 cm inter row spacing (Table 4).

Stover Yield (kg/ha)

Significant differences in stover yield occurred between two varieties. Among two varieties Surkhet-local produced significantly higher stover yield (14.73 qtl/ha) as compared with Unnati (10.98 qtl/ha). Increase in row spacing and the interaction effect of V×S do not led to significant effect on stover yield (Table 4).

Table 3: Effect of varieties, spacing and their interaction on different yield attributing characters of rapeseed in Nepal

Treatments	Siliqua per plant	Seeds per silique	Aborted siliqua per plant
Varieties			
Unnati (V1)	65.375	14.853	1.825
Surkhet-local (V2)	79.233	13.938	2.575
LSD (0.05)	NS	NS	NS
Spacing between rows (cm)			
15 (S1)	32.675[b]	12.458	0.988[b]
30 (S2)	82.700[a]	15.233	2.525[a]
45 (S3)	101.538[a]	15.498	3.088[a]
LSD (0.05)	26.168***	NS	0.942***
Interactions			
V1 × S1	23.3	11.9	0.6
V1 × S2	77.5	17.1	2.0
V1 × S3	95.4	15.6	3.0
V2 × S1	42.1	13.0	1.4
V2 × S2	87.9	13.4	3.1
V2 × S3	107.7	15.4	3.2
LSD (0.05)	NS	NS	NS
Mean	72.304	14.396	2.200
CV	33.959	14.486	40.164
Sem (±)	24.554	2.085	0.884

Note: CV: Coefficient of variation, LSD: Least significant difference, Sem: Standard error. Mean separated by LSD and columns represented with same letter are non-significant at 5% level of significance,* significant, *** Highly significant, NS-non significant.

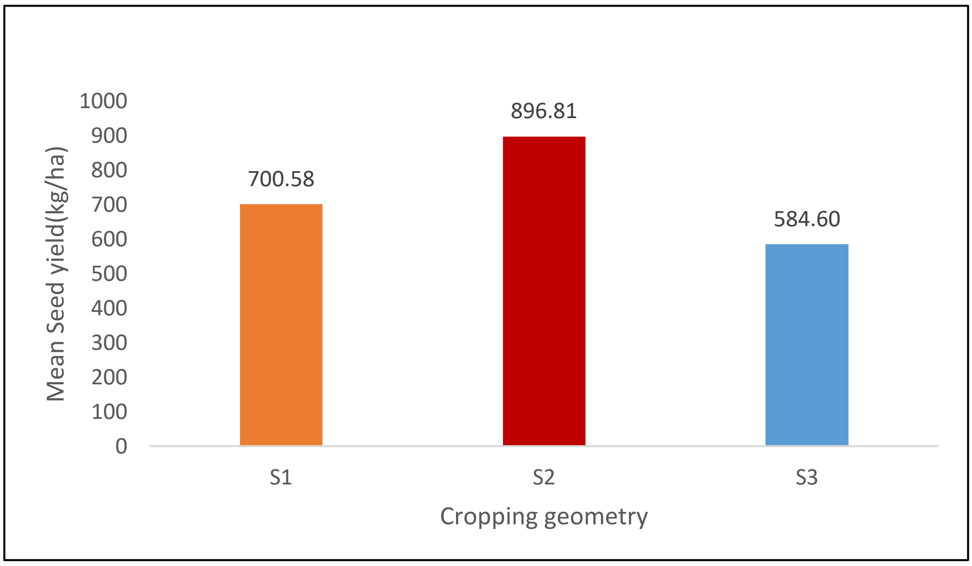

Fig. 3: Graph showing mean seed yield (Kg/ha) against cropping geometry in rapeseed.

[Cropping geometry S2 had highest mean seed yield and S3 had lowest mean seed yield. Note: S1=15cm×10cm, S2=30cm×10cm, S3=45cm×10cm]

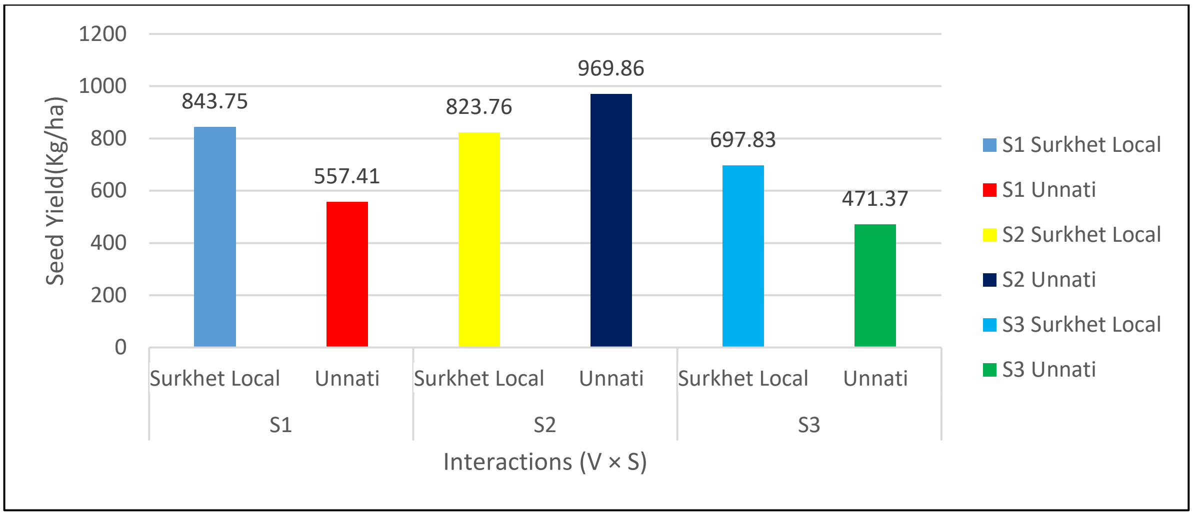

Fig.4: Graph showing mean seed yield value against interactions (V×S) in rapeseed.
[Interaction Unnati × S2 had highest mean seed yield and interaction Unnati × S3 had lowest mean seed yield. Note: V= Variety, S= Spacing, S1=15cm×10cm, S2=30cm×10cm, S3=45cm×10cm.]

Table 4: Effect of varieties, spacing and their interaction on different biometric characters of rapeseed in Nepal

Treatments	**Biological yield (kg/ha)**	**Seed yield (kg/ha)**	**Stover yield (kg/ha)**
Varieties			
Unnati (V1)	1763.888[b]	666.219	1097.669[b]
Surkhet-local (V2)	2261.112[a]	788.450	1472.662[a]
LSD (0.05)	426.034*	NS	328.556*
Spacing between rows (cm)			
15 (S1)	2145.83	700.58[b]	1445.25
30 (S2)	2237.5	896.82[a]	1340.68
45 (S3)	1654.17	584.60[b]	1069.56
LSD (0.05)	NS	165.141**	NS
Interactions			
V1 × S1	1691.7	557.41[c]	1134.3
V1 × S2	2258.3	969.86[a]	1288.5
V1 × S3	1341.7	471.37[c]	870.3
`V2 × S1	2600.0	843.75[ab]	1756.3
V2 × S2	2216.7	823.76[ab]	1392.9
V2 × S3	1966.7	697.83[bc]	1268.8
LSD (0.05)	NS	239.98*	NS
Mean	2012.5	727.34	1285.17
CV	24.328	21.305	29.380
Sem (±)	489.604	154.956	377.581

Note: CV: Coefficient of variation, LSD: Least significant difference, Sem: Standard error. Mean separated by LSD and columns represented with same letter are non-significant at 5% level of significance, *significant, ***Highly significant, NS-non significant.

Harvest Index (%)

The data pertaining to harvest index as influenced by varieties, crop geometries and their interaction were statistically analysed which were found non-significant.

1000 Seed Weight (g)

The data pertaining to 1000 seed weight as influenced by varieties, crop geometries and their interaction were statistically analysed and revealed that the effect of varieties on 1000 seed weight was observed highly significant. Among varieties Unnati produced significantly higher 1000 seed weight (4.050 g) as compared to Surkhet-local (3.792 g). Data reveals that an increase in inter row spacing from 15 cm to 45 cm and the interaction effect of V × S do not led to significant effect on 1000 seed weight. The result was also supported by research findings of Mamun *et al*., (2014). They reported that 1000 seed weight was highly significantly affected by different variety but non-significantly by plant densities. Mondal and Wahab (2001) had also reported that 1000 seed weight is the stable part of yield and it varies from variety to variety.

Table 5: Effect of varieties, spacing and their interaction on different biometric and yield attributing characters of rapeseed in Nepal

Treatments	Harvest Index (%)	1000 seed weight (g)
Varieties		
Unnati (V1)	38.424	4.050[a]
Surkhet-local (V2)	34.999	3.792[b]
LSD (0.05)	NS	0.190**
Spacing between rows (cm)		
15 (S1)	33.6	3.988
30 (S2)	41.1	3.900
45 (S3)	35.34	3.875
LSD (0.05)	NS	NS
Interactions		
V1 × S1	34.8	4.2
V1 × S2	45.4	4.0
V1 × S3	35.0	3.9
V2 × S1	32.5	3.8
V2 × S2	36.8	3.8
V2 × S3	35.6	3.9
LSD (0.05)	NS	NS
Mean	36.712	3.921
CV	17.611	5.580
Sem (±)	6.465	0.219

Note: CV: Coefficient of variation, LSD: Least significant difference, Sem: Standard error. Mean separated by LSD and columns represented with same letter are non-significant at 5% level of significance, *significant, ***Highly significant, NS-non significant.

Conclusion

The experimental findings reveled that, 30cm x 10cm registered significantly higher seed yield (kg/ha) over rest of the crop geometries. Crop geometries of 30cm x 10cm exhibited 12.29 % and 21.06 % higher seed yield over crop geometries of 15cm x 10cm and 45cm × 10cm respectively. Furthermore, the siliqua per plant was found to be significantly higher in inter row spacing of 45 cm which was at par with 30 cm inter row spacing and were significantly superior to 15 cm inter row spacing. However, the aborted siliqua per plant was significantly lower in 15 cm spacing as compared to 45 cm and 30 cm inter row spacing which was statistically at par.

It can be concluded that the maximum seed yield (kg/ha) of rapeseed could be obtained if Unnati variety is sown at spacing of 30cm × 10 cm and variety Surkhet-local at 15 cm × 10 cm and 30 cm × 10 cm spacing for higher seed. Yield of these varieties decreased as spacing is increased, thus sowing of Unnati should be done at cropping geometry of 30 cm × 10 cm and for Surkhet-local it should not be done beyond 30 cm inter row spacing to get the maximum potential yield.

Authors' Contribution

S. Adhikari, B. Thapa, L. Poudel, P. Paudel & U. Acharya designed the research plan; S. Adhikari, B. Thapa, L. Poudel, P. Paudel & U. Acharya performed experimental works & collected the required data. S. Adhikari, B. Thapa, L. Poudel, P. Paudel & U. Acharya analysed the data; S. Adhikari, B. Thapa, L. Poudel, P. Paudel, U. Acharya, B. Acharya & S.L. Bohora prepared the manuscript. All authors critically revised, finalized and approved the final form of manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest with present publication.

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