Response of rapeseed (*Brassica campestris* var *toria*) varieties to sowing dates in middle Terai

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Abstract
A field experiment was conducted during the winter season at Tamsariya-7, Nawalparasi, Nepal to determine the effect of sowing dates on growth and yield of rapeseed varieties. Four varieties of rapeseed (Unnati, Preeti, Pragati and Local) were planted in four sowing dates; October 13th, October 28th, November 12th and November 27th. The experiment was laid out in split-plot design with sowing date in the main plot and varieties in the sub-plot. Significant variations due to sowing dates and varieties were observed in plant height, leaf area index, dry matter accumulation, branches per plant, number of siliqua per plant, siliqua length, number of seeds per siliqua, abortion percentage, test weight and the grain yield. Results showed that the highest grain yield (1.278 t/ha) was obtained from the October 28th sowing date and it was statistically different from the yield of all other dates of sowing. There were 17.05%, 40% and 62.18% reduction in grain yield for October 13th, November 12th and November 27th sowing dates compared to October 28th sowing date. Variety Preeti was the highest yielding variety for October sowing while variety Unnati was the highest yielding variety for November sowing. So, variety Preeti sown on October 28th is recommended to the farmers of the area and similar locations for obtaining optimum yield but under late sown condition, variety Unnati is preferred to Preeti for obtaining the optimum yield.

Key words**:** Grain yield, rapeseed, sowing date, variety

Introduction
Oil seed crops are the third important crops of Nepal after cereals and legumes both in area and production. Oil seeds occupy about 5.867% of the total cultivated land (30,91,000 ha) of the country with a total production of 1,35,494 mt and their average productivity is about 0.747 t/ha (MoAC, 2009). The average productivity of oilseed crops in Nepal is very low as compared to that of the world average of 1.28 t/ha (NORP, 2007/08). There are many crops being cultivated for oil seed purpose in Nepal, among them tori (*Brassica campestris* var. *toria*) is particularly important and cultivated from Terai (60 masl) to high hill (2500 masl). Agro-ecologically, Terai and inner Terai occupy 77% area of the total oil crops followed by hills with 20.6% (NORP, 2007/08). Among *Brassica* oil seed crops, rapeseed (*Brassica campestris* var. *toria*) occupies 80% of the total area under oilseed crops. Nepal was a rapeseed exporting country during 1970's, but at present the country is spending a huge amount of precious foreign exchange by importing it to bridge the wide gap between production and consumption (Ghimire, 2001). The import of rapeseed oil from the overseas countries was NRs. 26,536,637 (MoAC, 2009). The productivity of rapeseed has been declining for last many years as reported from various parts of the country (Chaudhary *et al.,* 1993). The growing condition changed due to climate change, nominal or no use of fertilizers, micronutrient deficiency, little attention in terms of maintaining the plant population, crop management with proper protection measures could be the major factors associated with the yield decline of rapeseed (Ghimire and Awasthi, 2000).

There is a great scope of increasing yield of rapeseed by selecting high yielding varieties and improving management practices. Time of sowing is very important for rapeseed production (Mondal and Islam, 1993). Sowing at proper time allows sufficient growth and development of a crop to obtain a satisfactory yield. The grain yield and maturity of rapeseed are greatly influenced by environmental conditions regardless of genotypes. Different sowing times provide variable environmental conditions within the same location for growth and development of crop and yield stability (Pandey *et al*., 1981). Decreasing

crop yield in delayed sowing date has been reported by many workers (Degenhardt and Kandra, 1981; McDonald *et al*., 1983). National Seed Boardof Nepal has recommended a few high yield potential varieties of rapeseed. These varieties may differ in their response to sowing dates for yield and yield components. Therefore, the present study was undertaken to find out the response of different varieties of rapeseed on different sowing in the middle Terai condition of Nepal.

Materials and Methods

A field experiment was conducted at Tamsariya-7, Nawalparasi, Nepal during October 2009 to February 2010. The soil analysis of the experimental field at a depth of 0-20 cm was sandy loam in texture with strongly acidic in reaction (pH 4.6) and medium in total nitrogen (0.19%), available phosphorus (50.4 kg/ha) and available potassium (259 kg/ha). Four varieties (Unnati, Preeti, Pragati and Local) were used to assess their performance on four sowing dates (October 13th, October 28th, November 12th and November 27th). The experimental design was split-plot design with three replications assigning sowing dates as main-plot factor and varieties as sub-plot factor. The unit plot size was 2.5 x 2.4 m^2 and the crop was planted in the rows spaced 25cm with 5cm plant to plant distance. FYM (farm yard manure) was applied at the rate of 6 t/ha two weeks before sowing. The chemical fertilizer dose used for the experiment was 60, 40, 20, 25, 5 and 1 kg/ha of N, P_2O_5, K_2O, S, Zn and B in the form of urea, DAP, murate of potash, gypsum, $ZnSO_4$ and boric acid, respectively. Half of the urea and whole amount of other chemical fertilizers were applied as a basal dose in all the treatments and were applied in the furrows opened at a depth of 8-10 cm at the time sowing. The remaining 50% of the total dose of nitrogen was splitted in two equal halves and first halve was applied before first irrigation at initiation of flowering stage and the second halve applied before second irrigation stage at grain filling stage. Bevisteen (Carbendazim 50% WP) at the rate of 2 g/litre of water and Roger (Dimethoate) at the rate of 2 ml/litre of water were sprayed at an interval of 10 days starting from 25 DAS-70 DAS to control alternaria blight and aphid of rapeseed. All other recommended practices were followed and kept uniform for all treatments. Plant height was measured at 15 days interval from 25 to 70 DAS of crop as an average of 10 randomly selected plants per plot from the ground level to the top of the plant.

Plant height and dry matter were measured at 15 days interval from 25 to 70 DAS. For plant height, an average of 10 randomly selected plants per plot was measured from the ground level to the top of the plant. For dry matter accumulation, five plants from four destructive rows were continuously uprooted and all leaves was detached from the main stem and packed in the envelope and placed in the electronic oven. Similarly, the shoot of the rapeseed plant of each plot after detaching the whole leaves was put in an envelope separately and placed in the oven for complete drying. Temperature was maintained at 70 ^oC for 72 hours for complete drying of leaves and stems. After complete drying, dry weight of the leaves and stem was taken and calculated for the individual plants.

Number of primary branches, number of siliqua per plant, number of grains per siliqua, siliqua length, abortion percentage, thousand grain weight and grain yield were calculated at physiological maturity of the crop as an average of 10 randomly selected plants from net harvested rows per plot. Data collected were statistically analysed by M-STATC 1997 computer program. All the analysed data were subjected to DMRT for mean comparison at 5% level of significance.

Results and Discussions

Physiological attributes

Plant height

The highest plant height was observed on October 28th sowing date at 70 DAS and it was at par with October 13th sowing date. Significantly the lowest plant height was observed on November 27th sowing followed by November 12th sowing (Table 1). Murdock *et al.*, (2007) reported that the best growth of canola takes place when minimum temperature is higher than 12.22 ^oC and maximum temperature is

below 30 ^{o}C. The maximum and minimum temperature for October 13th, October 28th, November 12th and November 27th were (31.25 and 19.08 ^{o}C); (28.33 and 16.46 ^{o}C); (25.89 and 12.61^{o}C) and (24.5 and 17.74 ^{o}C) respectively for the first 25 days after sowing. Thus, the temperature range suitable for the best growth of rapeseed crop was observed on October 28th sowing date. Therefore, at the optimum temperature, high growth rate of the plant is accompanied by the high activity of auxins, gibberellins and cytokinins and lower activity of abscissic acid but reverse occurs at low temperature (Reddy and Reddi, 2005). So, plants of October 28th sowing date were taller than those of October 13th sowing date. This finding was fully supported by Mondal *et al.,* (1999) who found significantly the highest plant height (124.1 cm) on November 1st sowing date when the rapeseed crop was sown from October 1st to December 1st at 15 days' interval in Bangaladesh. Decrease in plant height in late sowing was mainly attributed to the decreasing minimum temperature. Plant height was significantly influenced by varietal characteristics at 70 DAS. Variety Preeti had the highest plant height compared to other three varieties and it was followed by variety Unnati and Pragati. Variety Local had the lowest plant height compared to other three varieties (Table 1).

Leaf area index

LAI decreased significantly with delay in sowing from October 28th to November 27th at 70 DAS (Table 1). The LAI recorded on October 28th sowing date was higher than October 13th sowing date. This might be one of the reason for getting significantly higher yield attributes and final grain yield (Table 2) on October 28th sowing date as compared to October 13th sowing date. Singh *et al.,* (2002) reported higher LAI on October 30th (1.34) and October 10th (1.28) sowing dates as compared to November 20th and December 10th sowing dates. Variety Preeti had significantly higher LAI at 70 DAS compared to variety Pragati and Local. Variety Preeti and Unnati were at par for LAI at 70 DAS. Similarly, LAI for variety Pragati and Local were also at par at 70 DAS (Table 2).

Table 1. Physiological attributes as influenced by different date of sowing and varieties

	Plant height (cm)	Leaf area index	Dry matter (g/plant)	Braches/plant
Treatments	70 DAS	70 DAS	70 DAS	
Sowing dates				
October 13th	72.23^{a}	0.33^{a}	10.51^{b}	2.80^{b}
October 28th	73.68^{a}	0.37^{a}	12.75^{a}	3.58^{a}
November 12th	51.37^{b}	0.24^{b}	8.11^{c}	2.13^{c}
November 27th	47.84^{c}	0.21^{b}	5.76^{d}	1.4^{d}
LSD(<0.05)	1.56*	0.05**	2.23**	0.65*
SEm±	0.45	0.01	0.64	0.18
Varieties				
Unnati	64.60^{b}	0.33^{a}	7.77^{b}	2.63^{b}
Preeti	71.86^{a}	0.34^{a}	8.75^{a}	3.01^{a}
Pragati	57.30^{c}	0.26^{b}	6.80^{c}	2.27^{c}
Local	50.00^{d}	0.23^{b}	5.81^{d}	2.00^{d}
LSD(<0.05)	7.21**	0.02**	0.96**	0.25**
SEm±	2.47	0.009	0.33	0.08
CV%	14.04	9.63	15.76	12.19

Note: *DAS= Days after sowing. Treatments means followed by the common letter (s) within a column are non-significantly different based on DMRT at 5% level of significance.*

Dry matter accumulation

Total dry matter production per plant was significantly higher on October 28th sowing date compared to other sowing dates at 70 DAS. CCC (2011) reported that at full flower in canola, stems become the major

photosynthetic structure although leaves are still important. At the beginning of ripening, pod walls and stems account for the majority of photosynthesis while leaves make only a small contribution. Higher dry matter production at 70 DAS on October 28th sowing date compared to other dates of sowing may be due to the higher plant height and more number of siliqua per plant (Table 1). Total dry matter production was significantly affected by varieties at 70 DAS of rapeseed. Variety Preeti produced significantly higher dry matter compared to other three varieties. The lowest dry matter per plant was produced by variety Local (Table 1). Higher plant height, LAI and higher number of branches per plant, might be the reasons for attaining higher total dry matter of variety Preeti compared to other varieties.

Number of branches per plant

Number of branches per plant was significantly influenced by sowing dates (Table 2). The highest number of branches per plant was produced on October 28th sowing date and the lowest number on November 27th sowing date. This finding was in conformity with the findings of Shahidullah *et al.*, (1997) who stated that crop sown on October 27th recorded higher number of primary and secondary branches per plant as compared to November 6th and November 16th sowing dates. Varieties were characteristically different in producing branches per plant. Variety Preeti produced significantly the highest number of branches per plant which was followed by variety Unnati and Pragati. Similarly, variety Local produced significantly the lowest number of branches compared to other varieties.

Yield attributing characters

Siliqua per plant

Sowing date had a great influence on the number of siliqua per plant, which may have apparent impact on seed yield (Table 2). The highest number of siliqua per plant was attained on October 28th sowing date. A serious reduction of siliqua per plant was noted with earlier as well as later sowing dates viz. October 13th, November 12th, and November 27th. This finding was in conformity with the findings of Bhuiyan *et al.,* (2008) who stated that the highest number of siliqua per plant was obtained in October 30th sowing date and the lowest on November 30th sowing date. Siliqua per plant was significantly influenced by varietal characteristics. Variety Preeti produced the highest number of siliqua per plant followed by Unnati and Pragati. Similarly, variety Local produced the lowest number of siliqua per plant.

Siliqua length

Siliqua length was significantly influenced by sowing dates (Table 2). The highest length of siliqua was obtained on October 28th sowing date followed by October 13th and November 12th sowing dates. The lowest length of siliqua was obtained on November 27th sowing date. Afroz *et al.,* (2011) found the highest siliqua length from November 10th sown crop and the lowest siliqua length from the plants of November 30th sowing date when the mustard crop was sown at 10 days interval from November 10th to November 30th. Variety Preeti had significantly the highest length of siliqua followed by Unnati and Pragati . The lowest length of siliqua was observed in variety Local.

Number of seed per siliqua

Number of seeds per siliqua was significantly influenced by sowing dates. The highest number of seeds per siliqua was obtained on October 28th sowing date and the lowest seeds per siliqua were found on November 27th sowing date (Table 2). The result of the present investigation with respect to seed per siliqua fairly agreed with the findings of Ghose and Chatterjee (1998). They reported that delay in sowing resulted decrease in the number of seeds per siliqua in rapeseed and mustard. Seeds per siliqua were significantly influenced by varietal characteristics. Variety Preeti produced the highest number of seed per siliqua followed by Unnati and Pragati. Similarly, variety Local gave the lowest seeds per siliqua compared to other varieties. Highest number of seeds per siliqua with variety Preeti might be attributed to the higher number of branches per plant, higher number of siliqua per plant and higher length of siliqua compared to other three varieties.

Table 2. Yield attributing characters as influenced by different date of sowing and varieties

Treatments	SPP[1]	SL[2]	SPS[3]	Abortion[4]%	TW[5]	Yield (t/ha)
Sowing dates						
October 13th	54.79[b]	5.57[b]	10.08[b]	21.34[bc]	2.60[b]	1.06[b]
October 28th	59.64[a]	6.09[a]	14.89[a]	19.18[c]	2.83[a]	1.27[a]
November 12th	50.14[c]	5.26[c]	8.26[c]	23.52[ab]	2.16[c]	0.76[c]
November 27th	45.49[d]	4.19[d]	6.12[d]	26.85[a]	1.91[d]	0.48[d]
LSD(<0.05)	4.64**	0.27**	1.01**	3.50**	0.044**	0.12**
SEm±	1.59	0.08	0.29	1.01	0.012	0.03
Varieties						
Unnati	54.95[b]	5.69[b]	5.69[b]	24.45[a]	2.68[b]	1.01[b]
Preeti	72.38[a]	6.2[a]	6.21[a]	21.55[b]	2.9[a]	1.16[a]
Pragati	47.56[c]	4.99[c]	4.99[c]	25.71[a]	2.12[c]	0.76[c]
Local	35.16[d]	4.21[d]	4.21[d]	19.19[b]	1.76[d]	0.64[d]
LSD(<0.05)	4.64**	0.50**	0.50**	2.66**	0.23**	0.07**
SEm±	1.59	0.17	0.17	0.91	0.08	0.027
CV%	10.49	11.37	10.79	13.91	11.75	10.81

Note: *1. Siliqua/plant 2. Siliqua length 3. Seeds/siliqua 4. Abortion 5. Test weight; Treatments means followed by the common letter (s) within a column are non-significantly different based on DMRT at 5% level of significance.*

Thousand grain weight

Thousand grain weight was significantly influenced by sowing dates. The highest thousand grain weight was obtained on October 28th sowing date and the lowest thousand grain weight was obtained on November 27th sowing date which was statistically lower than other dates of sowings indicating that thousand grain weight reduced with delay in sowing (Table 4). Bhuiyan *et al.*, (2008) recorded that the highest thousand grain weight in rapeseed was recorded on October 30th compared to October 20th and November 10th sowings. Thousand grain weight was significantly influenced by varietal characteristics. Preeti had the highest thousand grain weight which was followed by Unnati and Pragati. The lowest thousand grain weight was observed on Local.

Grain yield

Grain yield in rapeseed and mustard is a function of number of siliqua per plant, number of seeds per siliqua and seed size. Grain yield was significantly influenced by sowing dates. The highest grain yield was obtained on October 28th sowing date (Table 2). This might be due to higher number of branches per plant, higher number of siliqua per plant, higher number of seeds per siliqua and higher thousand grain weights of the crop sown on October 28th sowing date. There were 17.05%, 40% and 62.18% reduction in grain yield for October 13th, November 12th and November 28th sowing dates compared to October 28th sowing date. Accumulation of higher dry matter per plant might have attributed to higher yield of October 28th sowing date compared to October 13th sowing date. Yield depression recorded from October 28th sowing date to November 27th sowing date may be due to the dominance of vegetative growth over the reproductive one as described by Mendham *et al.*, (1990). This finding was supported by Bhuiyan *et al.*, (2008) who noted significantly higher yield on October 30th sowing date compared to October 20th, November 10th and November 30th sowing dates. Grain yield was also significantly influenced by varietal characteristics. Variety Preeti produced significantly the highest grain yield followed by Unnati and

Pragati. Variety Local produced the lowest grain yield. The yield difference of variety Unnati, Pragati and Local compared to Preeti were 12.63%, 34.14% and 44.78%, respectively (Table 2).

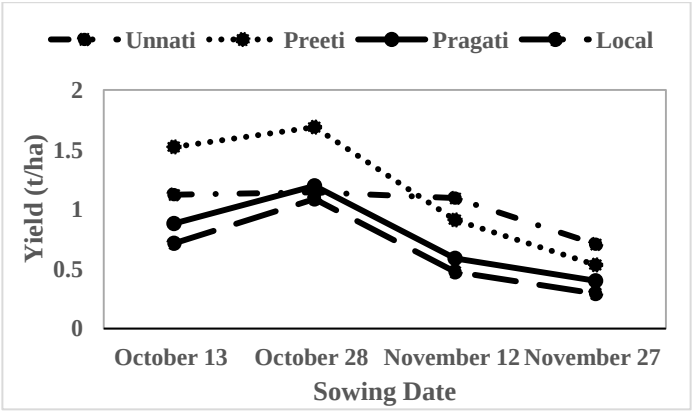

Fig. 1: Interaction effect as influenced by different date of sowing date and varieties on grain yield per hectare

The interaction effect of sowing time and variety on grain yield per hectare was found significant (Figure 1). The highest grain yield of each of the variety was obtained on October 28th compared to other dates of sowing. Sowing of Preeti on October 28th produced significantly the highest seed yield. This yield was significantly higher than those obtained from Unnati, Pragati and Local. But one important aspect was noted that in November sowing dates, grain yield was significantly higher for variety Unnati compared to variety Preeti. Thus, variety Preeti was the best yielding variety for October sowing dates while variety Unnati was the best suitable for November sowing dates. The higher yield with variety Unnati with latter sowing might be attributed to higher number of branches per plant compared to other varieties. Variety Local produced the lowest seed yield in all the dates of sowing followed by the variety Pragati. Though the grain yield of each variety was declined either before or after sowing of October 28th, the rate of grain yield decline was higher from October 28th sowing date onwards to November 27th sowing date.

Conclusion

It is concluded from this study that October 28th sowing date was the best sowing date of rapeseed for obtaining maximum yield. The late planting of rapeseed adversely affected the yield and yield components. Among varieties Preeti appeared to the high yielding variety for October sowing whereas variety Unnati was the best yielding variety for November sowing. So, it is suggested to the farmers of the area and locations with similar climatic conditions that they should plant variety Preeti on October 28th sowing for obtaining maximum yield but under late sown condition they should give preference to variety Unnati to Preeti for producing maximum yield.

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