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Influence of crop management practices on late sown toria (*Brassica campestries* var. toria) under rainfed rice-fallow situation of Assam

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Abstract

A field experiment was conducted under rainfed condition during the *rabi* season of the year 2014-2015 and 2015-2016 at the Instructional-cum-Research farm, Assam Agricultural University, Jorhat, India to study the performance of recently developed late sown *toria* var. JT-90-1 (*Jeuti*) under different dates of sowing, seed rates and method of sowing in medium land rice-fallow situation. The experiment was conducted in split plot design with three replications keeping the dates of sowing in the main plots and combination of seed rates and method of sowing in the sub plots. The treatments consisted of 4 sowing dates, *viz*. 1st, 8th, 15th and 22nd December; 3 seed rates, *viz*. 6, 8 and 10 kg/ha and 2 methods of sowing *viz.* line sowing at 25 cm apart and broadcasting. The highest seed yield of 724.3 and 742.1 kg/ha, stover yield of 2268.4 and 2296.5 kg/ha and seed oil content of 35.1 and 35.2% were recorded in 1st December sown crop which were significantly higher over other dates of sowing in first and second year, respectively. The extent of decrease in seed yield was 9.2 to 34.6% and 6.8 to 32.6% for 7 and 21 days delay in sowing from 1st December (D_1) during the first and second year, respectively. The seed rate of 10 kg/ha (S_3) recorded significantly higher yield of seed, stover, seed oil content over that of 6 and 8 kg/ha. In case of sowing method line sowing was found to be better than broadcasting in all growth and yield attributing characters. The crop recorded highest gross return (50,223.4 ₹/ha), net return (33,013.4 /ha) and benefit-cost ratio (2.9) when sown on 1st December with seed rate of 10 kg/ha in lines made at 25 cm apart.

Key words **:** *Crop management, late sown toria, rice-fallow*

Introduction

Rapeseed-mustard (*Brassica* spp.) is the third largest vegetable oilseed crop in the world after soybean (*Glycine max*) and palm oil (*Elaeis guineensis*). In Assam, *toria* is the only popular and predominant oilseed crop because of the prevailing climatic conditions and early duration of the crop, which enable the farmers to go for the summer crop after harvest of *toria.* However, the productivity of the crop is much lower than national average productivity. This low productivity is accounted for various factors like lack of moisture during crop growth period, untimely and unscientific method of sowing and poor crop husbandry resulted from inadequate or excess seed rate. About 90% of the crop is cultivated under rainfed condition so its performance depends upon the amount and distribution pattern of rainfall during the crop season. Sowing time, seed rate and method of sowing are the most important non-monetary input which influence to great extent on both the productivity of seed and oil. Rapeseed-mustard is considerably sensitive to weather as evidenced from the variable response to different date of sowing (Kumar *et al*., 2007). Optimum sowing time, seed rate and method of sowing play an important role to fully exploit the genetic potential of variety as it provides optimum growth conditions such as temperature, light, humidity and rainfall *etc*. Processes of yield formation are highly variable and depend on genetic, environmental and agronomic factors as well as interactions between them (Sidlauskas and Bernotas, 2003). The optimum sowing time of rapeseed-mustard in Assam condition is middle of

October to middle of November. But due to delayed monsoon rain or delayed harvesting of *kharif* rice it may extend up to December. JT-90-1(Jeuti) is a newly developed rapeseed variety of Assam Agricultural University especially for late sown rice-fallow situation whose performance at different date of sowing, seed rate and method of sowing is yet to be studied under late sown rice-fallow situation. Hence the present study was conducted to find out the extent of delay in sowing date, optimum seed rate and best method of sowing under late sown rice-fallow condition.

Materials and Methods

A field experiment was conducted under rainfed condition during *Rabi* season of the year 2014-2015 and 2015-2016 at the Instructional-cum-research farm of the Assam Agricultural University, Jorhat (26Ú472 N, 94Ú122 E and 86.6 m above mean sea level), Assam, India. Climate of study site is sub-tropical humid with hot summer and cold winter. Soil of the experimental site was sandy loam in texture, acidic in reaction (pH 5.2), medium in organic carbon (0.69%), low in available N (125.4 kg/ha), available P_2O_5 (15.9 kg/ha) and medium in available K_2O (188.2 kg/ha). A range of mean minimum temperatures of 8.3-17.5ÚC and 8.2-16.9ÚC and mean maximum temperature of 23.9-30.5ÚC and 20.2-28.3ÚC were recorded during 2014-15 and 2015-16, respectively. The amount of rainfall received during the crop growing period were 30.5 and 101.6 mm in the respective years of experimentation. The mean relative humidity in morning and evening varied from 90-98% and 52-67%, respectively during 2014-15. The corresponding values during 2015-16 were 90-100% and 53- 80%, respectively. Treatments consisting of 4 different dates of sowing *i.e.* D_1 -1st December, D_2 - 8th December, D_3- 15th December and D_4 - 22nd December in main plots and the combinations of 3 different seed rates i.e. S_1 - 6 kg/ha, S_2 - 8 kg/ha, S_3 - 10 kg/ha and 2 methods of sowing i.e. M_1 - line sowing and M_2 – broadcasting in sub-plots were tested in a split plot design and replicated thrice. The expremental field was prepared by ploughing with disc plough immediately after the harvest of transplanted *kharif* rice followed by application of compost @ 2 t/ha and harrowing twice. The final land preparation was done by running a rotavator. Recommended dose of N, P_2O_5 and K_2O @ 40, 35 and 15 kg /ha in the form of urea, single super phosphate (SSP) and muriate of potash (MOP) was applied one day ahead of sowing. Borax was applied @ 10 kg per ha in each plot along with other fertilizer. In this experiment recently developed late sown toria var. 'JT-90-1'(Jeuti) was used. The crop was sown in two methods one by placing the seeds in the furrows of 3-4 cm depth opened at 25 cm apart and other by broadcasting and was covered with thin layer of soil. The seeds were weighted out separately for each plot according to different seed rates. One weeding with garden hoe was done at 20 days after of sowing. Insect-pest was effectively controlled by spraying Malathion 50 EC @ 2 ml/lit.

Observations of growth and yield-attributing characters were recorded at 30 and 60 days after sowing and at harvesting of the crop. Plant height was recorded from each plot at 10 randomly selected plant. Leaf area was measured with leaf area meter and leaf area index was calculated by dividing the leaf area per plant by land area occupied by the plant. Data on dry matter were recorded on 10 random plant sample in each plot. Numbers of primary branches and siliquae per plant were counted for ten randomly selected plants from each plot at the time of maturity and their average was taken for statistical analysis. Ten siliquae were selected at random from each plot to measure the length of siliqua and number of seeds per siliqua. For test weight, 1000 grains were randomly counted from each treatment, dried to 12% moisture and then their weight was recorded. The crop which sown on 1st, 8th, 15th, and 22nd December of both the years 2014 and 2015 was harvested on 28th February, 5th, 12th and 18th March, 2015 and 2016, respectively. Seed and stover yields/ha were worked out based on yield records in each plot. Seed oil content was determined with the help of "Soc-Plus" apparatus as per method described by AOAC (1960) by taking 5g seed samples from each plot. The results were analysed using standard statistical procedure given by Panse and Sukhatme (1985). Critical differences (CD) at 5% probability level was calculated only when the F value has been found to be significant.The cost of cultivation and returns were calculated by taking into account the prevailing cost of inputs and prices of output.

Results and Discussion

Growth attributes

The growth attributing characters, viz. plant height, leaf area index, dry matter accumulation per plant, number of primary branches per plant showed a decreasing trend for every 7 days delay in sowing of the crop (Table 1) which ultimately reflected in seed and stover yield. Delay in sowing caused a significant reduction in growth characters. The late sown crop was subjected to relatively less time span available for plant growth and development. Crop sown on 1st December (D_1) produced significantly taller plant, higher LAI, number of primary branches per plant and dry matter accumulation over 22nd December (D_4) sowing (Table 1) due to prolonged vegetative growth period because of congenial environmental condition, especially atmospheric temperature, availability of adequate soil moisture through rainfall and more sunshine hours during its growth period which formed a basis for rapid cell division in meristematic tissues of the crop which led to better growth attributes. On the contrary, 22nd December (D_4) sowing crop experienced lower temperature and soil moisture content available during this period which retarded their growth. Height of the plant, number of primary branches per plant showed a decreasing trend with increase in seed rate. But leaf area index, dry weight per plant showed an increasing trend with increase in seed rate which ultimately reflected in seed and stover yield. Influence of seed rate was significant in case of number of primary branches per plant (Table 1). Afroz *et al*. (2011) also found that plant height decreased with increasing seed rate. Leaf area per plant, leaf area index and dry weight per plant increased with increase seed rate. Higher leaf area index enhanced photosynthetic activity of plants which eventually contribute to higher yield (Helal *et al*., 2016). Number of branches per plant significantly decreased with the increase in level of seed rate. This would seem to indicate that at higher

Table 1. Growth parameters of late sown toria as influenced by date of sowing,seed rate and method of sowing

Treatment	Plant height at maturity (cm)		LAI at 60 DAS		Dry matter accumulation at 60 DAS (g/plant)		No. of primary branches/plant	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
Date of sowing (D)								
D_{1--} – 1 December	86.12	102.03	0.62	0.64	4.88	5.04	4.01	4.58
D_2 – 8 December	83.23	97.16	0.59	0.61	4.67	4.79	3.37	3.53
D_3 – 15 December	80.94	91.69	0.57	0.59	4.33	4.36	2.92	2.92
D_4 – 22 December	78.76	88.63	0.54	0.56	3.98	4.15	2.44	2.69
S.Em (±)	0.56	0.75	0.01	0.01	0.05	0.05	0.10	0.17
CD (P=0.05)	1.93	2.59	0.02	0.02	0.19	0.19	0.35	0.60
Seed Rate (S)								
S_1 – 6 kg/ha	83.04	95.97	0.58	0.60	4.45	4.57	3.45	3.80
S_2 – 8 kg/ha	82.05	94.94	0.58	0.60	4.47	4.59	3.19	3.43
S_3 – 10 kg/ha	81.70	93.72	0.58	0.61	4.48	4.60	2.92	3.05
S.Em(±)	1.31	1.03	0.02	0.01	0.09	0.09	0.08	0.12
CD (P=0.05)	NS	NS	NS	NS	NS	NS	0.23	0.36
Method of sowing (M)								
M_1 – Line Sowing	82.64	95.33	0.58	0.60	4.47	4.59	3.38	3.74
M_2 – Broadcasting	81.88	94.42	0.58	0.60	4.46	4.58	3.00	3.11
S.Em(±)	1.07	0.84	0.01	0.01	0.08	0.07	0.07	0.10
CD (P=0.05)	NS	NS	NS	NS	NS	NS	0.19	0.29

population density there was reduction in total number of branches per plant. This might be attributed to inadequate space and limited availability of resources like essential plant nutrients, soil moisture and solar radiation per plant for growth and development. These results are in agreement with the findings of Borthakur and Barthakur (1980) and Kurmi and Kalita (1992). Line sowing was found to produce better result in all growth attributing characters than broadcasting. Growth attributing characters like plant height, leaf area index, dry weight per plant, were produce non significant effect on method of sowing in both the years. However number of branches per plant was significantly higher in case of line sowing than that of broadcasting (Table 1). These results might be attributable to better environmental conditions offered by line sowing which helped individual plants to exploit soil moisture, plant nutrients, space and solar radiation uniformly in better manner. Another possible reason may be synchronized germination due to uniform seeding depth in line sowing. These results are in conformity with the findings of Hossain *et al*. (2013). The interaction effect on growth attributing characters like plant height, leaf area index, dry weight per plant and number of primary branches per plant were found to be statistically non significant.

Yield attributes

Sowing dates significantly influenced yield attributes. Number of siliquae per plant, length of siliqua, number of seeds per siliqua and 1000-seed weight were successively decreased with delay in sowing from 1st December (D_1) to 22nd December (D_4) (Table 2). Late sowing (22nd December) restricted the growth duration and induced early flowering, delayed pod initiation and seed setting to great extent as compared to 1st December and 22nd December. Chandrakar and Urkurkar (1993) observed reduction in number of siliquae per plant and 1000-seed weight of Indian mustard due to delay in sowing beyond 23rd November. Choudhary and Thakuria (1994),

Table 2. Yield attributing parameters of late sown toria as influenced by date of sowing, seed rate and method of sowing

Treatment	No. of siliquae/plant		Length of siliqua (cm)		Number of seeds/siliqua		1000-seed weight (g)	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
Date of sowing (D)								
D_{1--} – 1 December	39.69	42.45	5.8	5.84	21.24	23.04	3.06	3.15
D_2 – 8 December	36.97	40.14	5.5	5.50	19.73	21.39	2.93	3.05
D_3 – 15 December	34.58	37.04	5.3	5.31	17.47	20.36	2.81	2.97
D_4 – 22 December	32.80	34.69	5.0	4.99	16.34	18.98	2.69	2.88
S.Em(±)	0.40	0.37	0.0	0.04	0.11	0.28	0.02	0.02
CD (P=0.05)	1.39	1.29	0.2	0.15	0.36	0.96	0.08	0.07
Seed rate (S)								
S_1– 6 kg/ha	36.20	39.10	5.0	5.04	17.45	19.98	2.79	2.96
S_2 – 8 kg/ha	35.96	38.44	5.4	5.44	18.79	20.89	2.88	3.00
S_3 – 10 kg/ha	35.88	38.21	5.8	5.75	19.85	21.95	2.94	3.07
S.Em(±)	0.81	0.98	0.1	0.07	0.28	0.30	0.04	0.03
CD (P=0.05)	NS	NS	0.2	0.19	0.80	0.86	NS	NS
Method of sowing (M)								
M_1 – Line Sowing	36.43	39.54	5.5	5.50	19.11	21.39	2.90	3.05
M_2 – Broadcasting	35.59	37.62	5.3	5.32	18.29	20.49	2.83	2.98
S.Em(±)	0.66	0.80	0.1	0.06	0.23	0.24	0.03	0.02
CD (P=0.05)	NS	NS	0.2	0.16	0.65	0.70	NS	NS

Table 3. Yield performance of late sown toria as influenced by date of sowing, seed rate and method of sowing

Treatment	Seed yield (kg/ha)			Stover yield (kg/ha)			Harvest Index (%)		Seed oil content (%)		
	2014-15	2015-16	Pooled mean	2014-15	2015-16	Pooled mean	2014-15	2015-16	2014-15	2015-16	Pooled mean
Date of sowing (D)											
D_{1--} – 1 December	724.3	742.1	733.2	2268.4	2296.5	2282.4	24.2	24.5	35.13	35.17	35.15
D_2 – 8 December	657.6	691.4	674.5	2083.2	2149.0	2116.1	24.0	24.3	34.36	34.39	34.38
D_3 – 15 December	592.5	564.4	578.5	1962.5	1873.0	1917.7	23.2	23.2	33.10	33.14	33.12
D_4 – 22 December	474.0	499.9	486.9	1723.5	1746.7	1736.6	21.6	22.2	32.46	32.46	32.46
S.Em(±)	8.6	9.2	8.6	21.5	25.9	18.2	0.1	0.3	0.19	0.19	0.13
CD (P=0.05)	29.7	31.6	29.7	74.1	89.2	62.7	0.5	1.0	0.64	0.65	0.46
Seed rate (S)											
S_1 – 6 kg/ha	556.4	566.4	561.4	1876.5	1877.2	1876.8	22.8	23.1	33.71	33.74	33.73
S_2 – 8 kg/ha	606.6	611.3	608.9	1965.1	1928.5	1946.8	23.5	23.7	33.80	33.83	33.82
S_3 – 10 kg/ha	673.3	695.7	684.5	2186.6	2245.4	2216.0	23.5	23.9	33.77	33.80	33.79
S.Em (±)	7.0	9.7	6.6	12.6	26.1	19.1	0.4	0.4	0.43	0.41	0.30
CD (P=0.05)	20.0	27.8	19.0	36.0	74.5	54.6	NS	NS	NS	NS	NS
Method of sowing (M)											
M_1 – Line Sowing	647.3	658.3	652.80	2111.02	2106.74	2108.88	23.33	23.71	33.77	33.80	33.78
M_2 – Broadcasting	576.9	590.6	583.75	1907.75	1927.32	1917.54	23.13	23.41	33.75	33.78	33.77
S.Em(±)	5.7	7.9	5.42	10.28	21.29	15.61	0.29	0.31	0.35	0.34	0.25
CD (P=0.05)	16.3	22.7	15.50	29.38	60.85	44.62	NS	NS	NS	NS	NS

Sharma (2009) reported that delay in sowing of rapeseed beyond 15th November there was shortening of the crop growth period and resulted in significantly less number of branches, siliquae per plant and number of seeds per siliqua. Reduction in yield attributing characters like number of siliquae per plant, number of seeds per siliqua and 1000-seed weight due to delay in sowing of rapeseed was also reported by Siadat and Hemayati (2009) and Alam *et al*. (2014). Number of siliquae per plant at different seed rate was not statistically significant but more number of siliquae per plant was found in lower seed rate (6 kg/ha). Shahin and Valiollah (2009) also reported that number of siliquae per plant decreased 8.7% as the seeding rate increased from 4 to 6 kg/ha. Length of siliqua and number of seeds per siliqua were found to be significantly higher in higher seed rate (10 kg/ha). This might be due to the moderate competition and efficient nutrients availability to the plants due to the optimum level of seed rate. However, 1000 seed weight was not significantly influenced by the variation in seed rate. Higher seed rate produced comparatively more 1000 seed weight. Sowing method had non significant effect on number of siliquae per plant and 1000 seed weight. However length of siliqua and the production of seeds per siliqua was significantly higher in line sowing than that of broadcasting (Table 2). Line sowing method allows the plants to absorb more nutrients, moisture and light than broadcast method. Similar result was obtained by Hossain *et al.* (2013) who also reported that all the yield contributing characters except number of unfilled siliqua per plant were found best at line sowing method and consequently it produced the highest seed yield. The interaction effect on yield attributing characters like number of siliquae per plant, length of siliqua, number of seeds per siliqua and 1000 seed weight were found to be statistically non significant.

Seed and Stover yield

Experimental findings revealed that for every 7 days delay in sowing of the crop from 1st December lead to a significant reduction in the growth and yield attributing characters that consequently lead to yield reduction. The highest seed yield of 724.33 kg/ha and 742.06 kg/ha, stover yield of 2268.41 kg/ha and 2296.45 kg/ha and seed oil content of 35.13% and 35.17% were recorded in 1st December sown crop which were significantly higher over other dates of sowing in first and second year, respectively. The extent of decrease in seed yield was 9.20 to 34.56% and 6.82 to 32.63% for 7 and 21 days delay in sowing from 1st December (D_1) in first and second year, respectively. In case of stover yield the extent of reduction was 8.16 to 24.02% and 6.42 to 23.93%, respectively. The pooled mean of two years in respect of seed yield were also found to be higher in 1st December (D_1) sowing crop. Significant reduction in yield was also reported due to delay in sowing of the crop (October to December) in different parts of the country by several workers like Afroz *et al*. (2011), Bala *et al*. (2011), Alam *et al*. (2014), Akhter *et al*. (2015), Dinda *et al*. (2015). Significant differences in seed and stover yield were observed due to variation in seed rate. The seed yield under the seed rate of 10 kg/ha (S_3) was found to be 673.33 kg/ha and 695.66 kg/ha in first and second year, respectively which was higher than the seed rate of 6 and 8 kg/ha. Results of this experiment indicated that higher seed rate (10 kg/ha) produced maximum seed yield and this might be attributable to higher plant population, longer siliqua and more number of seeds per siliqua. The lowest yields were obtained at the lowest seed rate (6 kg/ha). Similar result was reported by Shahin and Valiollah (2009). Sharma (2009) also found the seed rate of 10 kg/ha resulted higher seed yield than the seed rate of 15 kg/ha. The stover yield of rapeseed also followed increasing trend for every 2 kg/ha increase in seed rate up to 10 kg/ha. Method of sowing produced significant effect on seed and stover yield. Line sowing produced significantly higher seed and stover yield than that of broadcasting. Seed yield reduced by 10.86% and 10.29%, and stover yield reduced by 9.62% and 8.51% in broadcasting method than that of line sowing in first and second year, respectively. The pooled mean of two years in respect of seed and stover yield were also found to be higher in line sowing. These results corroborate with the findings obtained by Singh *et al*. (2001).

Economics

The highest gross return, net return and benefit-cost ratio were recorded under 1st December sown crop than those of the dates. This corroborates the finding of Dinda *et al*. (2015). The highest gross return (50223.35) and net return (33013.35) were recorded

by D_1 under S_3 (10 kg seeds/ha) and M_1(line sowing). Considering the B:C ratio obtained and the average productivity of the state it could be concluded from this experiment that sowing of the recently developed late sown toria variety JT-90-1 (*Jeuti*) could be delayed upto 15th of December under medium land rice-fallow situation seed rate of 10 kg/ha in lines made at 25 cm apart.

From this field investigation it could be concluded that there was significant reduction in seed and stover yield and oil content of late sown *toria* due to delay in sowing from 1st December to 22nd December. Higher seed rate (10 kg/ha) and line sowing produced significantly higher seed, stover and oil yields of *toria* under late sown rice –fallow condition of Assam.

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