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Productivity and profitability of rapeseed (*Brassica rapa* var. *dichotoma*) under system of rapeseed intensification

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Abstract

A field experiment was conducted during *rabi* 2016-2017 and 2017-18 at Assam Agricultural University, Jorhat to find out the optimum irrigation scheduling and to evaluate the suitable planting geometry of rapeseed (*Brassica rapa* var. *dichotoma*) under system of rapeseed intensification with 4 irrigation regimes *viz*. one irrigation at flower initiation stage, two irrigations at flower initiation and 50% flowering stage, three irrigations at flower initiation, 50% flowering and at siliqua development stage and rainfed with four different planting geometry *viz.* 30 cm × 30 cm, 30 cm × 25 cm, 25 cm × 25 cm and 30 cm × 5-7 cm. Three irrigations applied at flower initiation, 50% flowering and at siliqua development stage recorded the highest growth *viz*., plant height, dry matter/m^2, primary branches/plant and crop growth rate and yield attributes *viz*., number of branches/ plant, siliquae/plant and number of seeds/ siliqua. Three irrigations applied at flower initiation, 50% flowering and at siliqua development stage recorded highest seed and stover yield, net return and field water use efficiency. Among the planting geometry, 30 cm × 30 cm recorded the highest plant height, total branches/ plant and siliqua/ plant. However, planting geometry 25 cm × 25 cm recorded the highest seed yield, net return and water use efficiency.

Key words: *Crop growth rate, irrigation, planting geometry, water use efficiency*

Introduction

Oilseed crops play an important role in agriculture economy of India. (*Brassica rapa* var. *dichotoma*) belongs to cruciferae family and received a remarkable attention due to oil production as well as feed for animals and as bio-fuel. India occupies the second position in area after China and third position in production in the world after China and Canada. Among the seven edible oilseed cultivated in India, rapeseed-mustard contributes 28.6 per cent in the total production of oilseeds. In India, it is the second most important edible oilseed after groundnut sharing 27.8 per cent in the India's oilseed economy. The share of oilseeds is 14.1 per cent out of the total cropped area in India; rapeseed-mustard accounts for 3 per cent of it (Anonymous, 2015). Over the last ten years, the oilseeds production in the country has increased to around 34 million tonnes in 2017 from 24 million tonnes in 2007. Considering the importance of oilseeds, and the high level of imports, various oilseeds development schemes have been funded by the government to encourage cultivation of oilseeds. Average yield of various oilseeds crops in India, though improved, is lower than world average and significantly lower than other major oilseeds producing nations. As area under oilseeds has been almost stagnant during the last decade, there is little scope for extension of area given the competing demands. Thus yield rates need to be stepped up significantly in order to increase the production of oilseeds.

An option of suitable crop management practices are important factors for improving crop productivity. Irrigation plays an important role in enhancing crop yield. Planting geometry on the other hand is a non monetary input which affects canopy structure of crops and influences other physiological characteristics such as light interception and radiation use efficiency. A uniform distribution of plants per unit area is a prerequisite for yield stability (Diepenbrock, 2000). At present no recommended packages of practices have been developed for cultivation of rapeseed under system of crop intensification. With this idea in mind, the present investigation was planned to find out the influence of irrigation and planting geometry on growth and yield of rapeseed under system of rapeseed intensification.

Materials and Methods

A field experiment was conducted for two years (2016–2017 to 2017–2018) with rapeseed at Instructional Cum Research Farm of Assam Agricultural University, Jorhat, India. The climate of the area is sub-tropical, with an average annual rainfall of 1864.8 mm. Out of this, 1194.8 mm, 467.1 mm, 151.4 mm and 51.5 mm are received during monsoon, pre-monsoon, post monsoon and winter, respectively. Minimum monthly temperature of 9.7 p C and maximum monthly temperature of 32.4 p C are observed in January and August, respectively. During January and March, maximum (morning) and minimum (evening) monthly relative humidity of 94.8% and 61.1%, respectively are observed. The soil of the experimental plots were sandy loam in texture, acidic in reaction (pH 5.2), medium in organic carbon (7.2 g/kg), low in alkaline KMnO4 extractable N (181.0 kg/ha), medium in Brays I P (10.7 kg/ha) and low in 1 N ammonium acetate extractable K (100.4 kg/ha). It contained soil moisture 21.5 percent at 0.03 MPa and 7.3 per cent at 1.5 MPa with bulk density of 1.40 g/cc. Experimental plots, 12 m^2 (4 m × 3 m) in size, were arranged in a split plot design and each treatment was carried out in triplicate. The main plot treatment included I_1 : Irrigation at flower initiation stage, I_2 : Irrigation at flower initiation and 50% flowering stage, I_3 : Irrigation at flower initiation, 50% flowering and siliqua development stage I_4 : rainfed. The subplot treatment included different levels of planting geometry *viz*. S_1 : 30 cm × 30 cm, S_2 : 30 cm × 25 cm and S_3 : 25 cm × 25 cm and S_4 : 30 cm × 5-7 cm. The nutrients N, P and K @ 27.6-6.4-24 kg/ha were applied in the form of urea, single super phosphate and muriate of potash, respectively. Half of the N and full dose of P and K were applied as basal. Remaining N was applied at 20 days after sowing. Borax @ 10 kg/ha was applied to all the treatments at the time of sowing. The crop (var. TS-38) was sown on 23 October and 10 November and harvested on 25 January and 12 February during 2016-17 and 2017-18, respectively. One weeding was done at 15 days after sowing with light hoeing. In S_1, S_2 and S_3 plots, 5-6 seeds were sown as per spacing and thinned out to two after emergence. Finally, plants were thinned out to one at 15 days after sowing. In S_4 plots, thinning was done maintaining a plant to plant spacing of 5-7 cm at 15 days after sowing. Plant protection measures were taken as and when necessary. The crop was irrigated as per treatment. Yields were recorded on a whole-plot basis after discarding border plants.

The data were analyzed statistically and the mean differences among the treatment means were evaluated by the least significance difference (LSD) at 5% level of probability (Sarma, 2016). For economic analysis, all input costs including the cost for lease of land and interest on running capital were considered for computing the cost of production.

Results and Discussion

Growth characters

Data pertaining to growth characters *viz.* plant height, dry matter/m^2 and primary branches/ plant of rapeseed recorded at various growth stages as affected by irrigation scheduling and planting geometry have been presented in Table 1. Plant height increased successively with age of crop. In both the years, three irrigations at flower initiation, 50% flowering and siliqua development stage (I_3) being at par with two irrigations at flower initiation and 50% flowering (I_2) and one irrigation at flower initiation (I_1) recorded the tallest plant. This corroborates the findings of Belal (2013). The treatment I_3 also recorded the highest crop growth rate (Fig 1). This might be due to the adequate availability of moisture during growing period which increased the availability of nutrients and led to better vegetative growth (Jat, 2018). Three irrigations applied at flower initiation, 50% flowering and at siliqua development stage (I_3) increased the biomass production due to increased plant height and number of branches/ plant as compared with less moisture availability to plants under one irrigation (I_1), two irrigation (I_2) and without irrigation *i.e*. rainfed (I_4). Moaveni *et al*. (2010) also observed similar results. It is possible that with higher irrigation frequency the plant water status improved leading to better growth and enhanced tissue differentiation, expansion and growth that resulted in taller plants, production of higher number of leaves and branches in turn increasing the dry matter accumulation of the plants (Lal *et al.*, 2013; Singh and Singh, 2014). Under rainfed condition, water stress reduced growth characters, which may be due to reduction in photosynthesis and plant biomass. Under increasing water stress levels, photosynthesis was limited by low CO_2 availability due to reduced stomatal and mesophyll conductance. This reduction in the plant height due to water deficit stress is probably related to decline in photosynthetic products as a result of soil moisture decrease, which eventually causes the plant not to reach its genetic potential (Said-Al Ahl *et al*., 2016).

Among the Planting geometry, taller plants were obtained at planting geometry of 30 cm × 30 cm (S_1) which was at par with 30 cm × 25 cm (S_2) and 25 cm × 25 cm (S_3). Shorter plants were recorded under normal line sowing *i.e* planting geometry 30 cm × 5-7 cm (S_4). The crops under system of rapeseed intensification (S_1, S_2 and S_3) recorded higher dry matter/m^2 as compared to normal sowing method (S_4) due to better canopy development and plant height under wider spacing. The highest dry matter at harvest and crop growth rate was recorded under crop geometry 25 cm × 25 cm (S_3). This might be due to optimum plant

Table 1: Effect of irrigation regimes and planting geometry on plant height, dry matter and number of branches/plant of rapeseed at harvest

Treatments	Plant height at harvest(cm)		Dry matter (g)/m^2		Primary branches/plant	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Irrigation Schedule (I)						
I_1	122.7	109.1	501.5	437.9	6.4	6.2
I_2	130.3	115.2	563.2	514.3	6.8	6.5
I_3	132.5	116.1	597.5	533.7	7.0	6.6
I_4	112.7	100.2	445.2	361.1	5.4	5.3
SEm$\pm$	3.9	3.53	18.6	12.2	0.3	0.2
$CD_{0.05}$	13.5	12.2	64.2	42.2	0.9	0.6
Planting geometry (S)						
S_1	131.6	115.1	522.3	446.7	7.9	7.7
S_2	127.7	112.5	542.6	466.7	7.1	6.8
S_3	124.1	110.3	570.2	483.7	6.7	6.6
S_4	114.8	103.0	472.3	450.0	3.9	3.8
SEm$\pm$	4.6	3.6	13.9	10.3	0.2	0.2
$CD_{0.05}$	13.4	10.5	40.5	30.0	0.6	0.6
Interaction	NS	NS	NS	NS	NS	NS

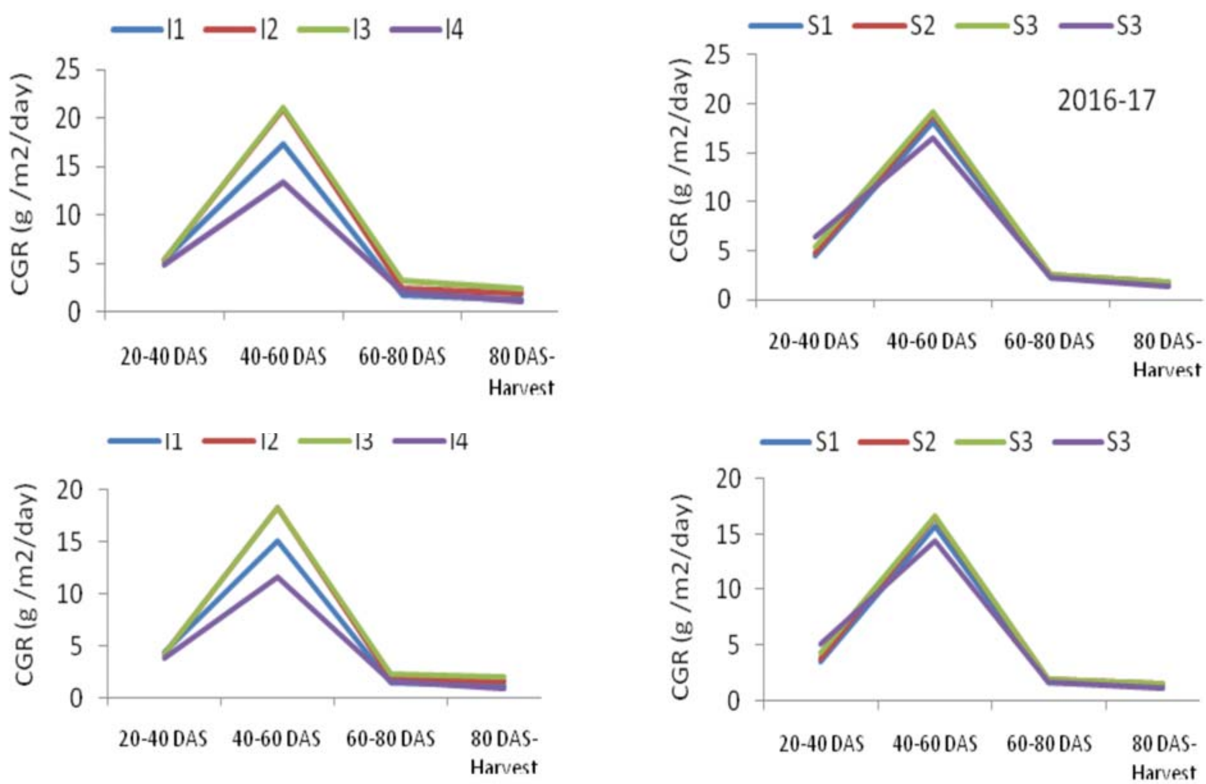

Fig 1: Effect of irrigation regimes and planting geometry on crop growth rate of rapeseed

population and comparatively better growth of plants under this treatment. Singh *et al*. (2016) also reported better canopy development and better interception of sunlight due to wider planting geometry.

Yield attributes and yield

The results revealed that all the yield attributing characters of rapeseed *viz*. number of primary branches/ plant, number of siliquae/ plant and number of seeds/

siliqua were influenced due to irrigation regimes and planting geometry (Table 2). All the yield attributing characters were positively influenced by increasing frequency of irrigation. Solanki and Mundra (2015) also reported positive effect of irrigation on yield attributes. As irrigation increases the plant water status is improved. Thus, boosting metabolism and the availability of different nutrients in the soil, its application has been found to enhance the process of tissue differentiation, cell multiplication, cell enlargement *i.e.* from somatic to reproductive phase, meristematic activity and development of floral primordia, thereby, leading to increased flowering and ultimately the fruit setting. As a result of this, higher siliqua/ plant were obtained with increasing frequency of irrigation application up to highest level (3 irrigations). Moreover, the taller shoot produced under the influence of increasing frequency of irrigation, enabled the plants to bear higher number of siliqua on main shoot which is considered to be the major determinate of mustard seed yield. Mishra (2016) also reported similar results. The treatment three irrigations at flower initiation, 50% flowering and siliqua development stage (I_3) recorded the highest number of primary branches, number of siliquae/plant and number of seeds/ siliqua followed by two irrigations at flower initiation and 50% flowering (I_2) , one irrigation at flower initiation (I_1) and rainfed (I_4). This might be due to higher photosynthesis and translocation of assimilates toward reproductive structure owing to sufficient soil moisture (Shivran, 2018). The increase in number of branches/ plant was also reported by Lakra *et al*. (2018).

Seed yield and stover yield were highest in I_3 which were at par with I_2 treatment. Rainfed crop recorded the lowest seed and stover yield. Decreasing irrigation water decreased plant height, number of branches and number of pods per plant as well as seed yield. The positive effect of irrigation on yield attributing characters improved the yield of irrigated treatments. These findings are in agreement with the results of Sarma and Das (2017) and Deka *et al.* (2018).

Planting geometry of 30 cm × 30 cm (S_1) recorded highest yield attributing parameters than 30 cm × 25 cm (S_2) and 25 cm × 25 cm (S_3) and 30 cm × 5-7 cm (S_4). This is due to the greater area per plant for which individual plant growth is more. However, due to relatively higher plant population per unit area, 25 cm × 25 cm (S_3), produced higher seed and stover yield than 30 cm × 30 cm (S_1) and 30 cm × 25 cm (S_2). At normal line sowing (S_4), the shortage of space and higher competition for space, nutrient and moisture, the number and dry matter accumulation in siliquae were reduced. Similarly, closer planting geometry increased the population density which decreased the number of seeds/ siliqua due to the competition between plants that had a detrimental effect on siliqua formation in rapeseed and finally the seed yield decreased. These findings were similar with the results of Yadav *et al.* (2018).

Water use efficiency (WUE)

Total use of water increased with increasing number of irrigation up to three (Table 4). The crop water use efficiency (crop WUE) increased with the application of number of irrigations over rainfed crop. The highest crop

Table 2: Effect of irrigation regimes and planting geometry on yield attributes of rapeseed.

Treatments	No. of siliqua/ plant		No. of seeds/ siliqua		Test weight (g)	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Irrigation Schedule (I)						
I_1	283.1	251.8	10.8	11.9	3.24	3.19
I_2	292.2	279.1	11.1	12.1	3.30	3.28
I_3	300.1	280.4	11.3	12.2	3.34	3.33
I_4	246.3	193.4	10.3	10.5	3.12	3.10
SEm$\pm$	12.3	10.1	0.3	0.3	0.12	0.09
$CD_{0.05}$	42.4	34.9	NS	1.1	NS	NS
Planting geometry (S)						
S_1	403.2	333.4	11.1	12.0	3.29	3.26
S_2	348.1	317.9	11.0	11.8	3.26	3.22
S_3	296.2	281.6	10.9	11.7	3.25	3.24
S_4	74.1	71.6	10.5	11.4	3.20	3.18
SEm$\pm$	10.6	11.4	0.3	0.3	0.11	0.07
$CD_{0.05}$	30.8	33.2	NS	NS	NS	NS
Interaction		NS		NS	NS	NS

Table 3: Effect of different treatments on seed and stover yield, harvest index and economics of rapeseed

Treatments	Seed Yield (kg)		Stover yield (kg)		Harvest Index		Net Return (Rs)		B : C ratio	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Irrigation Schedule (I)										
I_1	1717	1421	3041	2644	36.1	35.0	26851.80	23167.40	2.25	1.86
I_2	1928	1612	3381	2966	36.3	35.2	27451.80	29290.60	2.47	2.07
I_3	2043	1703	3498	3067	36.9	35.7	27864.30	32081.30	2.58	2.15
I_4	1482	1104	2736	2098	35.1	34.5	26251.80	12609.00	1.99	1.48
SEm $\pm$	55	44	88	81	1.6	1.1	-	-	-	-
$CD_{0.05}$	192	152	308	279	NS	NS	-	-	-	-
Planting geometry (S)										
S_1	1751	1413	3185	2675	35.4	34.6	25568.00	24169.60	2.41	1.95
S_2	1811	1475	3304	2801	35.3	34.5	27354.00	24566.00	2.33	1.90
S_3	1967	1598	3327	2844	37.2	36.0	29209.70	27039.90	2.37	1.93
S_4	1641	1355	2839	2435	36.5	35.6	26288.00	21408.00	2.20	1.81
SEm $\pm$	65	40	75	55	1.2	0.9	-	-	-	-
$CD_{0.05}$	189	116	218	160	NS	NS	-	-	-	-
Interaction	NS	NS	NS	NS	NS	NS	-	-	-	-

Table 4: Total water used and WUE (kg/ha-cm) of rapeseed

Treatments	Total waterused (cm)		Crop WUE(kg/ha-cm)		Field WUE(kg/ha-cm)	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Irrigation Schedule (I)						
I_1	165.7	139.4	140.9	117.9	103.6	102.0
I_2	219.3	200.3	142.4	121.4	87.9	80.5
I_3	245.4	241.7	145.7	123.5	83.3	70.5
I_4	110.9	95.0	137.3	116.2	133.6	116.2
Planting geometry (S)						
S_1	187.9	170.1	139.4	116.3	93.2	83.1
S_2	189.3	172.6	142.7	121.4	95.7	85.5
S_3	190.5	173.6	151.8	128.4	103.3	92.1
S_4	173.6	160.1	133.1	114.1	94.5	84.7

water use efficiency was found in case of three irrigations applied at flower initiation, 50% flowering and siliqua development stage (I_3). This might be because of proportionately more increase in yield with increase in evapo-transpiration. The lower crop water use efficiency with rainfed treatment (I_4) was due to more water loss in evapo-transpiration by plants without increase in seed yield. The field water use efficiency (Field WUE) was higher under rainfed condition and decreased with increase in irrigation levels. Under rainfed condition, soil moisture was depleted gradually with advancement of crop age and it was held with progressively greater tension. On the other hand, under three irrigations at flower initiation, 50% flowering and siliqua development (I_3), water requirement was the highest. Thus under I_3, water use efficiency was less as compared to rainfed crop due to proportionately greater increase in water use than the increase in seed yield of rapeseed. The results of present investigation are in close conformity with those of Sarma *et al.* (2007), Sarma *et al*. (2013), Trivedi *et al.* (2014) and Tyagi and Upadhyay (2017).

Planting geometry 25 cm × 25 cm (S_3) recorded higher crop WUE and field WUE over 30 cm × 30 cm (S_1), 30 cm × 25 cm (S_2) and 30 cm × 5-7 cm (S_4) . This might be due to proportionately greater increase in yield as compared to consumptive use and total water use. Higher seed yield resulting from planting geometry 25 cm × 25 cm (S_3) caused increase in yield, thus positive impact on WUE. Similar result was also reported by Thakur (2013).

Economics

Net return and benefit: cost ratio realized from I_3 were higher than I_1 , I_2 and I_4 (Table 3). Net return was also increased with increasing frequency of irrigation application from no irrigation to three irrigations. Almost similar results were also reported earlier (Parmar *et al*., 2016 and Jati *et al*., 2018). Among the different planting geometry, S_3 recorded the highest net return and benefit: cost ratio than the other treatments under planting geometry.

Thus, it can be concluded that by adopting system of rapeseed intensification, productivity and monetary return of rapeseed can be increased. Under this system, the crop should be irrigated at flower initiation, 50% flowering and siliqua development stage with 25 cm × 25 cm planting geometry.

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