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Effect of tillage and irrigation frequency on growth of Indian mustard [*Brassica juncea* (L.) Czernj and Cosson]

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Abstract
A field experiment was conducted during the *rabi* season of 2014-15 at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh (India) to study the effect of tillage and irrigation frequency on growth of Indian mustard [*Brassica juncea* (L.) Czernj and Cosson]. The experiment was laid out in split-plot design with three replications. The main plot treatment consisted three tillage practices *viz.* Zero tillage, Reduced tillage (2 harrowing + 1 planking), and Conventional tillage (1 deep ploughing with disc + 2 harrowing + 1 planking), whereas four levels of irrigations *i.e.*No irrigation, One irrigation (35 DAS), Two irrigations (35 DAS + 60 DAS), Three irrigations (35 DAS + 60 DAS + 90 DAS) were allocated to sub-plots. Plant height, functional leaves plant^{-1}, leaf area index, dry matter accumulation and primary and secondary branches plant^{-1} increased with increasing tillage intensity and irrigation frequency. The value of all these growth parameters improved significantly under conventional tillage. Significantly higher values of growth attributing character were obtained with three irrigations as compared to other irrigation frequency

Keywords: Mustard, conventional tillage, reduced tillage, zero tillage, irrigation frequency

Introduction
Oilseeds play a vital role in Indian economy, accounting for 5% of gross national product and 10% of the value of agricultural product. In India, oilseeds are the second largest agricultural commodity after cereals, which occupy about 13.5% of the gross cropped area in the country. India is the fourth largest oilseed economy in the world after the U.S., China and Brazil, and it is the second largest importer after china. The country accounts for 15 per cent of global oilseeds area, 7 per cent of vegetable oils production and 10 per cent of the total edible oils consumption (Jha *et al.*, 2012). Rapeseed-mustard is the third important oilseed crop in the world after soybean (*Glycine max*) and palm (*Elaeisguineensis* Jacq.). Among the seven edible oilseeds cultivated in India, rapeseed-mustard (*Brassica* spp.) contributes 28.6% to the total production of oilseeds. It ranks second in oilseeds production after groundnut, sharing 27.8% in the India's oilseed economy. Indian mustard accounts for about 75-80% of the 5.8 m ha of rapeseed and mustard with the productivity of 1142 kg ha^{-1} in the country. Mustard seed has 36% protein content with a high nutritive value. The oil content varies from 37 to 42%. It is a winter (*Rabi*) season crop that requires relatively cool temperature, a fair supply of soil moisture during the growing season and a dry harvest period. In the eastern Uttar Pradesh region the crop is primarily grown as a mixed crop mainly with wheat in rice wheat cropping system. As a pure crop it is grown on marginal lands under constraints of delayed sowing, nutrient, irrigation and plant protection. Therefore, to maintain the increasing production trend of Rapeseed and mustard in the country, it becomes imperative to boost the productivity of mustard in this region.

The productivity of Rapeseed-Mustard in Rice-Mustard system is low due to many related problems. The major contributory causes are delayed sowing. Cultivation of mustard after puddled transplanted rice requires relatively more tillage operations to bring the required tilth. Puddled soil generally becomes heavy due to breaking of water stable aggregates, increased bulk density and soil impedance. However, this loss can be minimized through manipulation of tillage operations enabling early sowing of mustard by adopting the concept of reduced tillage system.

Owing to its hardy nature and capacity to thrive well under poor condition of moisture, mustard is raised without adequate irrigation. This practice results in low yields (Rathore *et al.*, 1999) [14]. Water is costly and scarce input. Its judicious use is an important aspect to get maximum efficiency under resource conditions. Irrigation water has to be utilized in a manner that matcher the crops need. Optimum crop yield is not possible without application of timely and right amount of irrigation water. The yield of mustard in India is low as the crop is grown under rainfed condition. The crop is usually grown during November to January. Since rainfall during this period is inadequate and uncertain, mustard requires supplemental irrigation for its proper growth and development, otherwise the crop is likely to suffer from water stress and reduce ultimately the yield. In general, irrigation can be supplied to the crop based on the critical stages which are governed by the irrigation frequency or the number of irrigation given to a crop during its lifecycle. In general it can be stated that out of the four stages *viz.* the mid-season stage is most sensitive to water shortages (Brouwer *et al.* 1989). This is mainly because it is the period of highest crop water need. If water shortages occur during mid-season stages, the negative effect on the yield will be pronounced. The least sensitive to water shortages is the late season; this stage includes ripening and harvest. The growth stages of mustard are: vegetative stage, flowering stage, pod development stage, seed filling and ripening stage. Two irrigations one at pre-flowering and other at pod development stage are necessary for maximum seed yield of mustard (Ali, 1997).

Materials and Methods

The field experiment was conducted during the *rabi* season of 2014-15 at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh (India).The soil of experimental site was Gangetic alluvial having sandy clay loam texture with *p*H 7.4. Experimental soil was moderate in fertility with organic carbon of 0.35 per cent and available nitrogen content being 212.4 kg ha^{-1}, available phosphorus (25.7 kg ha^{-1}) and available potassium (187 kg ha^{-1}) in soil. “Ashirwad” variety of mustard was used for the experiment. The experiment was laid out in split-plot design with three replications. The main plot treatment consisted three tillage practices *viz.* Zero tillage, Reduced tillage (2 harrowing + 1 planking), and Conventional tillage (1 deep ploughing with disc + 2 harrowing + 1 planking), whereas four levels of irrigations *i.e.* No irrigation, One irrigation (35 DAS), Two irrigations (35 DAS + 60 DAS), Three irrigations (35 DAS + 60 DAS + 90 DAS) were allocated to sub-plots. So the total numbers of treatment combinations were twelve. The treatments were replicated thrice to avoid any effect of heterogeneity.

Result and Discussion

Growth of plant can be measured vertically in terms of plant height and horizontally in terms of number of leaves, leaf area index, number of branches, dry matter accumulation etc. Dry matter accumulation is more important because all other vegetative characters are contained in it. Further, the growth characters *viz.*, plant height, number of green leaves, leaf area index, dry matter accumulation, and number of primary and secondary branches $plant^{-1}$ increased with the advancement in the age of mustard crop irrespective of treatments. The increasing the intensity of tillage operations markedly influenced the growth parameters *viz.* plant height, no of green leaf, leaf area index, dry matter production as well as phonological events. All the growth attributes improved with conventional tillage at most of the growth stages during the experimentation. This supports the well-established fact that a fine seed bed is very much essential for good germination, growth and development and getting better yield.

Conventional tillage produced tallest plant height at all the growth stages *viz.* 30, 60, 90 DAS and at harvest over other methods of crop establishment. The plant height increased significantly with reduced tillage over zero tillage whereas the conventional tillage recorded significantly highest plant height as compared to zero tillage and reduced tillage practices (Table 1).These results are in conformity with the findings of Ghosh *et al.* (2014).

Three irrigations produced tallest plant height at all the growth stages *viz.* 30, 60, 90 DAS and at harvest over other methods of crop establishment. Lucid improvement in plant height was noticed with increasing the frequency of irrigation *i.e.* one irrigation to two and three irrigation treatments (Table 1).

This may be due to the reason that water is the chief metabolic constituent of plant body and water stress at any stage of the crop can reduce the plant metabolic activity affecting the plant height. These results are in conformity with the findings of Saud and Singh (2004) and Piri *et al.* (2007).The number of green leaves per plant was also found to be significantly higher in case of conventional tillage over reduced tillage and zero tillage. Under conventional tillage number of green leaves $plant^{-1}$ which was significantly higher than zero tillage at all stages of observation (Table 2). This may be due to good growth conditions favoured by better root growth enhancing nutrient uptake from soil and better utilization to produce higher number of leaves. This is in confirmation with the finding of Teng *et al.* (1997) [19] and Mondal *et al*. (2008). Highest number of green leaves $plant^{-1}$ was observed with three irrigations followed by two irrigations.

Application of two and three irrigations though remained comparable produced significantly higher number of functional leaves $plant^{-1}$ than control at the stages of observation. It is possible that the number of green leaves $plant^{-1}$ were increased because of better metabolism in the plant to produce higher plant biomass and leaves for efficient photosynthesis. These findings are in agreement with that of Singh and Singh (2014) [17]. Increasing intensity of tillage operations favourably influenced the leaf area index (LAI). Higher leaf area index was obtained under conventional tillage (Table 3). At al the stages of growth the LAI was significantly higher in conventional tillage as compared to reduced tillage and zero tillage which were both significant in their leaf area index. It is possible that conventional tillage though creating better growth conditions might have enhanced tissue differentiation and expansion that resulted in taller plants and production of higher number of leaf $plant^{-1}$ with expanded leaves. These results are in conformity with the findings of Saha *et al.* (2010). Three irrigations produced highest leaf area index at all the growth stages *viz.* 30, 60, 90 DAS and at harvest over other methods of crop establishment. Irrigation frequency also showed lucid effect on LAI of mustard. Increasing levels of irrigation from 0 to 3 irrigations correspondingly and significantly increased the LAI at 60 DAS. The increase in leaf area index may be due to high water potential of the leaf leading to full growth and expansion of the leaf area. The findings of present investigation are in conformity with the findings of Piri and Sharma (2006).

Conventional tillage produced highest number of branches both primary branches and secondary branches as compared to reduced tillage and zero tillage. The number of branches plant^{-1} declined significantly with decreasing the intensity of tillage from conventional tillage to zero tillage (Table 4 and 5).

This may be because of the reason that better soil characteristics promoting better root growth in turn better shoot growth and higher number of branches. This is in confirmation with the finding of Belal *et al.* (2013) and Mondal *et al*. (2008).

Three irrigations produced highest number of branches both primary branches and secondary branches as compared to other irrigation frequencies Increasing frequency of irrigation from no irrigation to three irrigations showed increasing trend, in terms of number of branches plant^{-1} at all the stages of observation. This might be due to the reason that high water potential in plants enhances growth and better growth produces higher number of branches. These results are in conformity with the findings of Piri and Sharma (2006) and Piri *et.al.* (2012).Shoot dry weight plant^{-1} increased markedly with increasing intensity of tillage operations upto the highest level (Table 4.6).With increase in intensity of tillage upto conventional tillage, there was a sharp and significant increase in dry matter accumulation at all the stages. It is possible that conventional tillage though creating better growth conditions might have 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.

These results are in conformity with the findings of Ghosh *et al.* (2010) and Arora *et al.* (1993) [1]. Highest plant dry matter accumulation was observed with three irrigations over other irrigation frequencies. Dry matter accumulationplant^{-1} was found to improve with increasing irrigation frequency. Increasing frequency of irrigation application from no irrigation to three irrigations enhanced dry matter accumulation at all the stages.

It is possible that with higher irrigation frequency the plant water status improved leading to better growth might have 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. The findings of present investigation are in conformity with the findings of Panda *et al.* (2004) [8] and Singh and Singh (2014) [17].

All the growth attributing character of mustard *viz.* plant height, no. of green leaves plant^{-1}, primary and secondary branches plant^{-1}, LAI, dry weight of shoot plant^{-1} were found to improve under three irrigations but remained comparable with two irrigations at all stages of crop growth during the experimentation.

Conclusion

The increasing the intensity of tillage operations markedly influenced the growth parameters *viz.* plant height, no of green leaf, leaf area index, dry matter production as well as phonological events. All the growth attributes improved with conventional tillage at most of the growth stages during the experimentation. All the growth attributing character of mustard *viz.* plant height, no. of green leaves plant^{-1}, primary and secondary branches plant^{-1}, LAI, dry weight of shoot plant^{-1} were found to improve under three irrigations but remained comparable with two irrigations at all stages of crop growth during the experimentation.

Table 1: Effect of tillage practice and irrigation frequency on plant height

Treatment	Plant height (cm)			
	30 DAS	**60 DAS**	**90 DAS**	**At harvest**
Tillage practice				
Zero tillage	10.08	90.00	172.38	175.33
Reduced tillage	10.44	98.90	185.43	189.03
Conventional tillage	11.66	118.14	200.01	205.10
SEm±	0.08	0.33	0.62	0.67
CD (P=0.05)	0.33	1.08	1.87	1.84
Irrigation frequency				
No irrigation	10.50	96.80	179.32	182.86
One irrigation	10.67	100.29	183.46	186.39
Two irrigations	10.82	104.12	188.64	193.16
SEm±	0.15	0.18	0.51	0.52
CD (P=0.05)	NS	0.55	1.52	1.55

Table 2: Effect of tillage practice and irrigation frequency on number of Green leaves

Treatment	Green leaves (number plant^{-1})		
	30 DAS	**60 DAS**	**90 DAS**
Tillage practice			
Zero tillage	3.42	28.92	44.83
Reduced tillage	4.67	32.92	46.25
Conventional tillage	5.67	38.25	56.83
SEm±	0.30	1.56	3.08
C.D. (P=0.05)	0.80	4.16	8.15
Irrigation frequency			
No irrigation	4.11	31.78	45.00
One irrigation	4.33	32.33	47.00
Two irrigations	4.44	33.00	50.00
Three irrigations	4.54	36.33	53.22
SEm±	0.36	1.04	1.09
C.D. (P=0.05)	NS	3.09	3.24

Table 3: Effect of tillage practice and irrigation frequency on Leaf area index (LAI)

Treatment	Leaf area index (LAI)		
	30 DAS	**60DAS**	**90DAS**
Tillage practice			
Zero tillage	0.11	1.45	0.73
Reduced tillage	0.12	1.58	0.78
Conventional tillage	0.13	1.77	0.88
SEm±	0.003	0.05	0.02
CD (P=0.05)	0.005	0.12	0.06
Irrigation frequency			
No irrigation	0.12	1.52	0.77
One irrigation	0.12	1.56	0.79
Two irrigations	0.12	1.63	0.81
Three irrigations	0.12	1.70	0.82
SEm±	0.002	0.02	0.02
CD (P=0.05)	NS	0.06	NS

Table 4: Effect of tillage practice and irrigation frequency on Primary branches (number plant^{-1})

Treatment			
	60 DAS	**90 DAS**	**At harvest**
Tillage practice			
Zero tillage	2.83	4.58	4.62
Reduced tillage	3.50	6.17	6.17
Conventional tillage	4.33	7.58	7.58
SEm±	0.25	0.28	0.35
CD (P=0.05)	0.60	0.75	0.90
Irrigation frequency			
No irrigation	3.22	5.33	5.67
One irrigation	3.22	6.09	6.11
Two irrigations	3.89	6.33	6.33
Three irrigations	3.89	6.78	6.78
SEm±	0.20	0.21	0.25
CD (P=0.05)	0.58	0.62	0.73

Table 5: Effect of tillage practice and irrigation frequency on Secondary branches (number $plant^{-1}$)

Treatment	Secondary branches (number $plant^{-1}$)		
	60 DAS	90 DAS	At harvest
Tillage practice			
Zero tillage	2.42	6.20	6.42
Reduced tillage	3.42	7.38	7.59
Conventional tillage	4.67	9.37	9.58
SEm±	0.24	0.34	0.39
CD (P=0.05)	0.70	1.15	1.20
Irrigation frequency			
No irrigation	3.11	6.78	6.98
One irrigation	3.33	7.34	7.40
Two irrigations	3.83	7.54	7.78
Three irrigations	4.82	8.80	8.89
SEm±	0.23	0.30	0.31
CD (P=0.05)	0.67	0.90	0.93

Table 6: Effect of tillage practice and irrigation frequency on Dry matter accumulation by crop (g $plant^{-1}$)

Treatment	Dry matter accumulation by crop (g $plant^{-1}$)			
	30 DAS	60 DAS	90 DAS	At harvest
Tillage practice				
Zero tillage	0.33	9.75	21.90	32.36
Reduced tillage	0.36	10.77	23.49	36.54
Conventional tillage	0.47	11.95	25.64	40.68
SEm±	0.01	0.04	0.16	0.23
CD (P=0.05)	0.03	0.15	0.47	0.59
Irrigation frequency				
No irrigation	0.38	10.46	23.06	34.67
One irrigation	0.37	10.69	23.50	35.81
Two irrigations	0.41	10.88	23.85	36.88
Three irrigations	0.39	11.25	24.30	38.74
SEm±	0.01	0.04	0.12	0.16
CD (P=0.05)	NS	0.13	0.37	0.46

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