Int.J.Curr.Microbiol.App.Sci (2017) *6*(7): 2586-2593

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 6 Number 7 (2017) pp. 2586-2593**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2017.607.365

Growth and Yield of Mustard (*Brassica juncea* L.), Dry Weight of Weeds and Weed Control Efficiency Influence by Different Planting Methods and Weed Management

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Keywords

Growth and Yield, Mustard (*Brassica Juncea* L.), Planting and Management.

Article Info

Accepted:
26 June 2017
Available Online:
10 July 2017

A B S T R A C T

A field experiment was conducted during *rabi* season of 2014-15 at College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari with fifteen treatment combinations. Treatments were replicated thrice as per randomized block design with factorial concept. Significantly higher values of plant height (171.63 cm), number of branches plant^{-1} (18.07), dry matter accumulation (80.07 g plant^{-1}), number of siliqua plant^{-1} (204.16), seed yield (1851 kg ha^{-1}) and stover yield (3808 kg ha^{-1}) were recorded with row spacing of 45 cm x 10 cm with normal planting (P_2) followed by 30/60 cm x 10 cm with paired row planting (P_3). Likewise, significantly maximum plant height (184.10 cm), number of branches plant^{-1} (19.36), dry matter accumulation (84.42 g plant^{-1}), number of siliqua plant^{-1} (223.31), seed yield (2085 kg ha^{-1}) and stover yield (4230 kg ha^{-1}) were obtained with W_4 (Pendimethalin @ 1.0 kg ha^{-1} as PE + Quizalofop - P - ethyl @ 0.04 kg ha^{-1} at 20 DAS + HW and IC at 40 DAS). Significantly lowest dry weight (269.59 kg ha^{-1}) of total weeds was noted under treatment P_1 (30 cm x 10 cm with normal planting). In weed management treatments W_4 recorded markedly lower value of dry weight (168.31 kg ha^{-1}) of total weeds. Hence the crop sown with wider row spacing and weed management with integration of all methods showed favourable growth leads to higher yield of mustard.

Introduction

Oilseeds are backbone of agricultural economy of India since long and considered as the second largest agricultural commodity in India after cereals (Yadav, 2011). Oilseeds are rich source of energy and nutrition. At an estimated per capita consumption of 16 kg edible oil/person/year, 21.12 million tonnes of edible oil will be required for an estimated Indian population of about 1.32 billion, by the end of 12th five year plan in 2017. This demand can only be fulfilled by producing about 63.4 million tonnes of total oilseeds, out of which, about 20 per cent (12.7 million tonnes) has to be meet by rapeseed-mustard (Annon, 2011).

India's rank is first in area (20.2%) and second in production (10.7%) after China in rapeseed and mustard growing countries of the world (Annon, 2014). Mustard occupies an area of 6.5 million hectare with the total production of 7.8 million tonnes and productivity of 1208 kg ha^{-1} during 2013 among the different oilseed crops (Annon, 2013).

Mustard (*Brassica juncea* L.) is known by different names in different places e.g., rai, raya, laha and raiya. Its green tender plant is used for preparing vegetable commonly called as "Sarson Ka Sagg". The oil is utilised for human consumption throughout northern India in cooking and frying purposes. The whole seed is used as condiment in the preparation of pickles and for flavouring curries and vegetables. The mustard oil is also used in preparing vegetable ghee, hair oil, medicines, soaps, lubricating oil and in tanning industries. The oil content in mustard seeds varies from 37-49 per cent (Bhowmik *et al.,* 2014). The oil cake is left after extraction is utilized as cattle feed and manure.

Growth, development and final yield are mainly affected by the space available to plants; however, the precise and exact response will be species and cultivar specific. So, it is imperative to adjust plant population through planting method which may help in avoiding excessive crowding. Higher plant population per unit area beyond an optimum limit results in competition among the plants for natural resources, resulting weaker plant and may cause severe lodging (Kumar *et al.,* 2004). Weed competition in Indian mustard is more serious during early stage; because crop growth during winter (*rabi*) season remains slow during the first 4-6 weeks after sowing (Chauhan *et al.,* 2005). Approximately, 20-30 per-cent yield reduction cause by weeds in rape/mustard crop (Singh *et al.,* 2010). If left uncontrolled, the weeds in many fields are capable of reducing yields by more than 80 per cent (Singh *et al.,* 2012).

Materials and Methods

In order to study the "Performance of mustard (*Brassica juncea* L.) to different planting methods and weed management under south Gujarat condition". A field experiment was conducted at College Farm, Navsari Agricultural University, Navsari throughout *rabi* season of 2014-15. Navsari Agricultural University campus is geographically located at 20^0-57' N latitude and 72^0-54' E longitude at an altitude of 10 meters above the mean sea level. According to agro-climatic condition, Navsari is located in south Gujarat heavy rainfall zone-I (Agro-ecological situation-III). The climate of this zone is typically tropical, characterized by humid and warm monsoon with heavy rain, quite cold winter and fairly hot summer. The average annual rainfall of the tract is about 1500 mm.

The soil of the experimental field was clayey in texture and showed low, medium and high rating for available nitrogen (197.26 kg ha^{-1}), phosphorus (30.93 kg ha^{-1}) and potassium (369.80 kg ha^{-1}), respectively. The soil was found slightly alkaline (pH 7.8) with normal electrical conductivity (0.36 dsm^{-1}).

The experiment was conducted with total fifteen treatment combinations consisting of three levels of planting methods *viz*., P_1: 30 cm x 10 cm with normal planting, P_2: 45 cm x 10 cm with normal planting and P_3: 30/60 cm x 10 cm with paired row planting and five levels of weed management practices *viz*., W_0: Weedy check, W_1: HW and IC at 20 and 40 DAS, W_2: Pendimethalin @ 1.0 kg ha^{-1} as PE + Quizalofop - P - ethyl @ 0.04 kg ha^{-1} at 20 DAS, W_3: Pendimethalin @ 1.0 kg ha^{-1} as PE + HW and IC at 40 DAS and W_4: Pendimethalin @ 1.0 kg ha^{-1} as PE + Quizalofop - P - ethyl @ 0.04 kg ha^{-1} at 20 DAS + HW and IC at 40 DAS, were evaluated with randomized block design with factorial concept and replicated thrice. The investigation was carried out with "GDM-4" variety of mustard and seeds were treated with Dithane M-45 fungicide @ 3 g kg^{-1}. Spraying of herbicide pre-emergence Pendimethalin and post emergence Quizalofop-P-ethyl was done at 2 DAS and 20 DAS respectively as per treatment. The

observations for different characters were recorded at different periodical intervals. The statistical analysis of data was carried out through the procedure appropriate to the randomized block design with factorial concept of the experiment as described by Panse and Sukhatme (1967).

The observations for different characters were recorded at different periodical intervals. For biometric observation five plants were selected at random from each net plot and tagged for recording periodical growth and yield attributing parameters.

The numbers of days required from the date of sowing to date at which 50 per cent plants have come to flowering were recorded as days to 50 per cent flowering for each treatment. For recording dry matter accumulation by plant randomly five plants were dug out from the border area and expressed as g plant^{-1}.

In case of weed dry matter accumulation the weed samples were collected from 1.0 m2 area and expressed as g m^{-2} and finally at the time of harvest from entire net plot area of each plot and expressed as kg ha^{-1}. After removing the roots, the above ground plant parts and whole weed samples were first sun dried and finally oven dried at 65 ^{0}C for 72 hours up to constant dry weight.

Leaf area meter (Model L1-COR 3100) was used for recording the area of leaves. The following formula was used to get leaf area index.

$$LAI = \frac{\text{Leaf area (cm}^2\text{)}}{\text{Land area (cm}^2\text{)}}$$

The harvest index (%) was computed by using the formula suggested by Donald (1963) and recorded separately for each treatment.

$$HI\ (\%) = \frac{\text{Economical yield (kg ha}^{-1}\text{)}}{\text{Biological yield (kg ha}^{-1}\text{)}} \times 100$$

The weed control efficiency was calculated by using the following formula (Kondap and Upadhyay, 1985).

$$WCE\ (\%) = \frac{DWC - DWT}{DWC} \times 100$$

Where, DWC and DWT were the weed dry weight in control and treated plots, respectively.

Results and Discussion

Effect of planting methods

Different planting methods exert significant impact on crop growth (Table 1). The treatment P_2 registered significantly higher plant height (171.63 cm), maximum no. of branches plant^{-1} (18.07) and dry matter accumulation of plant (80.08 g m^{-2}) but it was at par with treatment P_3 only in case of plant height and number of branches. The probable reasons for better growth might be due to relatively competition free environments prevail, hence more availability of nutrients, greater light interception, efficient utilization of soil moisture and space under lower degree of inter-plant competition ultimately leads to increased synthesis of carbohydrate and production of more dry matter plant^{-1}. The present result is close conformation with Singh *et al.,* (2006) at Ludhiana; Pyare *et al.,* (2008) at Kanpur; Kumari *et al.,* (2011) at Pantnagar; and Rajput (2012) at Firozabad (UP). Significantly higher leaf area index (0.82) was recorded with the treatment P_1 but it was at par with treatment of P_2 (0.79) (Table 1). This may be due to more number of

plants per unit area under treatment P_1. Singh *et al.,* (2006) also reported similar results in African mustard at Ludhiana. Days to 50 per cent flowering did not differ significantly due to various treatment of planting methods (Table 1). Shivani and Kumar (2002) reported contradictory results in this regard. The treatment P_2 recorded significantly higher number of siliqua plant^{-1} (204.16), maximum seed yield (1851 kg ha^{-1}) and stover yield (3808 kg ha^{-1}) and remained statistically at par with treatment P_3. The magnitude of increase in seed yield kg ha^{-1} under P_2 and P_3 were 15.2 and 10.3% respectively over treatment P_1. It was probably due to better development of various growth parameters such as plant height, number of branches plant^{-1} and dry matter accumulation under optimum plant population per unit area which gave optimum yield per plant and lower plant competition. The wider row spacing improved individual plant yield and yield per unit area is the resultant of cumulative yield from individual plants per unit area. These results are in agreement with those of Pyare *et al.,* (2008) at Kanpur; and Muhammad *et al.,* (2012). This result was also supported by Rajput (2012) and recorded higher seed and stover yield under 30/60 cm x 10 cm with paired row planting which was at par to 45 cm x 10 cm row spacing at Firozabad (UP). Differences in various treatment of planting methods was did not show any significant effect with respect to harvest index (Table 2).

Effect of weed management

The variable performance of mustard was recorded due different weed management practices. Significantly higher value of plant height (184.10 cm), number of branches (19.36), dry matter accumulation of plant (84.42 g m^{-2}), leaf area index (0.94) and number of siliqua plant^{-1} (223.31) were noted under treatment W_4 and remaining at par with treatment W_3. While in case of dry matter accumulation of plant it remained at par with treatments W_3 and W_2. Various weed management treatments did not significantly influence days to 50 per cent flowering (Table 1). It might be due to the fact that both these herbicides when applied as pre-emergence and post-emergence suppresses the weed growth efficiently which is supplemented by hand weeding and interculturing at the crucial stage of crop growth which checks the weed growth and resulted in better plant growth. The results are in agreement with those reported by Chauhan *et al.,* (2005) at Gwalior (UP); Singh (2006) at Jodhpur (Rajasthan) and Kumar *et al.,* (2012) at palampur (HP) in mustard crop.

Treatment W_4 recorded significantly higher seed yield (2085 kg ha^{-1}) and stover yield (4230 kg ha^{-1}) but it was at par with W_3 and W_2. The magnitude of increase in seed yield kg ha^{-1} under treatments W_4, W_3 and W_2 were 109.3, 103.5 and 92.1 per cent, respectively over weedy check treatment (W_0). The remarkable increase in seed and stover yield might be due to effective control of weeds, lower dry weight of weeds and higher weed control efficiency as well as lower weed index which cumulatively facilitated the crop to utilize more nutrients and water for better growth and development in terms of various growth attributing characters and yield attributing characters. These findings are in close agreement with those reported by Sarkar *et al.,* (2005); Rathi *et al.,* (2007); Kumar *et al.,* (2012) as well as Adhikary and Ghosh (2014). There was no significant effect of weed management treatments with respect to harvest index (Table 2). Almost similar result was also reported by Mishra and Kurchania (2001) at Jabalpur (MP). While, contradictory result was recorded in this regard by Arya (2004) at Kanpur (UP).

Table.1 Effect of different planting methods and weed management treatments on growth and Growth attributes of mustard

Treatments	Plant height (cm)		Number of branches plant^{-1}		Leaf Area Index		DMA (g plant^{-1})		Days to 50% flowering
	90 DAS	At harvest	90 DAS	At harvest	90 DAS	At harvest	90 DAS	At harvest	
Planting methods (P)									
P_1	148.37	159.99	15.01	16.01	0.87	0.82	65.76	72.86	58.77
P_2	161.44	171.63	16.81	18.07	0.83	0.79	72.82	80.08	61.99
P_3	157.23	168.99	16.28	17.40	0.77	0.76	68.77	76.58	58.85
S.Em. ±	2.85	3.03	0.40	0.35	0.02	0.02	1.34	1.20	1.06
C.D. at 5%	8.24	8.78	1.15	1.00	0.06	0.05	3.88	3.49	NS
Weed management practices (W)									
W_0	129.99	138.17	12.60	13.42	0.61	0.58	57.43	65.99	56.97
W_1	152.20	165.48	15.49	16.89	0.75	0.73	66.64	71.35	58.93
W_2	159.40	171.67	16.69	17.71	0.83	0.81	72.18	78.95	59.60
W_3	162.54	174.96	17.36	18.42	0.93	0.89	73.49	81.84	60.89
W_4	174.26	184.10	18.04	19.36	1.01	0.94	75.85	84.42	62.96
S.Em. ±	3.67	3.91	0.51	0.45	0.03	0.02	1.73	1.55	1.37
C.D. at 5%	10.64	11.34	1.49	1.29	0.08	0.06	5.02	4.50	NS
C.V. %	7.08	7.04	9.61	7.81	9.96	8.21	7.52	6.09	6.87
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table.2 Effect of different planting methods and weed management treatments on yield and Yield attributes of mustard

Treatments	No. of siliqua plant^{-1}	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)
Planting methods (P)				
P_1	171.67	1607	3191	33.24
P_2	204.16	1851	3808	32.60
P_3	193.64	1772	3608	33.09
S.Em. ±	4.53	52.05	113.23	0.98
C.D. at 5%	13.13	150.76	327.96	NS
Weed management practices (W)				
W_0	132.80	996	2181	31.46
W_1	184.36	1697	3366	33.46
W_2	197.47	1913	3838	33.31
W_3	211.18	2027	4063	33.28
W_4	223.31	2085	4230	33.37
S.Em. ±	5.85	67.20	146.18	1.26
C.D. at 5%	16.95	194.63	423.39	NS
C.V. %	9.25	11.56	12.40	11.49
Interaction	NS	NS	NS	NS

Table.3 Dry weight of weeds and WCE% as influenced by different planting methods and Weed management treatments in mustard

Treatments	Weed dry weight		Weed control efficiency (%)	
	At 40 DAS (g m^{-2})	At harvest (kg ha^{-1})	At 40 DAS	At harvest
P_1	20.99	269.59	-	-
P_2	26.05	314.26	-	-
P_3	28.41	352.17	-	-
S.Em. ±	0.81	10.77	-	-
C.D. at 5%	2.35	31.21	-	-
W_0	49.93	682.26	0.00	0.00
W_1	24.64	290.89	50.66	57.36
W_2	17.03	198.76	65.89	70.87
W_3	19.61	219.81	60.74	67.78
W_4	14.54	168.31	70.87	75.33
S.Em. ±	1.05	13.91	-	-
C.D. at 5%	3.03	40.29	-	-
C.V. %	12.49	13.37	-	-
Interaction	NS	NS	-	-

Study on weeds

Effect of planting methods

Mustard sown with narrow row spacing (P_1) gave significantly lower dry weight of weeds (269.59 kg ha^{-1}) over other treatments (Table 3). Weed biomass reduction can be explained by more number of plants per unit area in narrow row spacing lead to shading effect resulting from the crop canopy, limits the availability of resources required for weed germination, emergence growth and reduction in total incoming photosynthetic active radiation (PAR) reaching the ground and indicates that narrow inter-row spacing increased the competitiveness of the mustard with weeds. These results are in line with those reported by Takim and Adereti (2012) in soybean; Bakhat and Khan (2014) in tomato.

Effect of weed management

Significantly lower dry weight of weeds (168.31 kg ha^{-1}) was found under treatment W_4 which was at par with treatment W_2. Treatment W_4 recorded maximum weed control efficiency (75.33%) and found most effective in controlling the weeds and followed by W_3 and W_2. This might be due to effective weed control achieved under efficient method of weed management in terms of lower weed population per unit area and less availability of underground (nutrient and moisture) and above ground resources (light) to weeds due to more competitive and smothering effect of crop, resulting lower biomass of weeds and higher weed control efficiency. Almost similar results were also reported by Banga *et al.,* (2004) at Hisar (Haryana); Sarkar *et al.,* (2005) at West Bangal; Adhikari and Ghosh (2014) at West Bangal and Kour *et al.,* (2014) at Jammu (J & K).

P_1: 30 cm x 10 cm with normal planting; P_2: 45 cm x 10 cm with normal planting; P_3: 30/60 cm x 10 cm with paired row planting; W_0: Weedy check; W_1: HW and IC at 20 and 40 DAS; W_2: Pendimethalin @ 1.0 kg ha^{-1} as PE + Quizalofop - P - ethyl @ 0.04 kg ha^{-1} at

20 DAS; W_3: Pendimethalin @ 1.0 kg ha^{-1} as PE + HW and IC at 40 DAS and W_4: Pendimethalin @ 1.0 kg ha^{-1} as PE + Quizalofop - P - ethyl @ 0.04 kg ha^{-1} at 20 DAS + HW and IC at 40 DAS.

Acknowledgement

The authors are grateful to the Department of Agronomy, Navsari Agricultural University for granted approval to conduct this research trail with Institute facilities. The Head of Farm Departments are appreciated for logistic support especially with respect to fertilizers, weedicides and reliable technical support.

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How to cite this article:

Rameti Jangir, L.K. Arvadia and Sunil Kumar. 2017. Growth and Yield of Mustard (*Brassica Juncea* L.), Dry Weight of Weeds and Weed Control Efficiency Influence by Different Planting Methods and Weed Management. *Int.J.Curr.Microbiol.App.Sci.* 6(7): 2586-2593.
doi: https://doi.org/10.20546/ijcmas.2017.607.365