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Management of Weeds by using crop competition in mustard (*Brassica juncea* L.)

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Abstract

Mustard (*Brassica juncea* L.) is the main crop among the oilseed crops of the world. Weeds are the main factors, responsible for the low production. Field research was planned and conducted during the winter season of 2016-17 at the College of Agriculture, the University of Sargodha to evaluate the impact of various row spacing on yield and its components under various weed competition durations. Maximum weed dry weight (79.1g m^{-2}) was found at weedy condition till harvest while lowest (9.1 g m^{-2}) in weed-free conditions till 70 DAS excluding the weed-free conditions. A higher number of branches $plant^{-1}$ (7.8), no. of plants (137), 1000-seed weight (3.3 g), seed yield (1536 kg ha^{-1}) was in narrow 15 cm row spacing over the wider row spacing. About 42.64% yield reduction was recorded in weedy conditions till harvesting over weed-free conditions up to harvesting while 9.34% yield reduction was recorded when row spacing was increased from 15 cm to 20 cm while a 10.27% yield decline observed when row spacing increased from 20 cm to 25 cm. The critical period for weed control is 38DAS. The interaction was also significant. Maximum seed yield (1965.7 $kgha^{-1}$) was found at 15 cm row spacing with weed-free conditions till harvesting followed by (890 kg ha^{-1}) at 25 cm row spacing with weedy conditions till harvesting of the crop. It is concluded that as the row spacing of the crop increases from narrower to wider, the weed dry matter increases and seed yield decreases.

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Introduction

Oilseed crops are very imperative for human food and have attained the third position among the crops among cereals and legumes and are a very important source of vegetable oil which offers 2.5 times extra energy over carbohydrates and protein. It has certain vitamins i.e. E and D as well as essential fatty acids obligatory for the human body (Downey, 1990). The production of oilseed crops has not been increased at the same rate as it has occurred in cereal crops. The foremost constraint to enhance oilseed crop productivity is inappropriate weed control practices. The best way to enhance the production of mustard is to adopt the better management of weeds in crops (Singh and Verma 1993). Mustard faces severe problems and competition by weeds for nutrients and moisture, which consequently loss of about 20-30% and up to 60% of the potential yield under intense competition (Singh, 1992). Among the numerous production components, weed management in mustard needs additional attention. Weeds badly affect the crop growth rate, yield and yield components by competing with crops for the resources necessary for growth and development, for example, water, light and nutrients, etc. Duration and intensity of weed crop competition determine the degree of yield losses in crops (Swanton *et al.*, 2015).

The critical period of weed control (CPWC) is the main component of combined weed management practices. The CPWC is a period of the crop growth cycle during which weeds must be managed properly to avoid losses in yield (Knezevic *et al.*, 2002). Weed interference period is one of the vital factors that determine the magnitude of yield reduction. Interference of weed with crops is not analogous at different growth periods; thus, weed-crop competition ability is varying in the life cycle. Lessening of weed intervention and rise in weed-free intervals results in the proliferation of yield and yield constituents (Singh *et al.*, 1993). Chauhan *et al.* (2005) documented that competition of weeds in mustard is more intense in the early stage of growth because crop growth rate remains slow during the winter season or at the early stages of the life cycle. In mustard, weed damages are maximum after the 20 to 40 days of planting (Bhan and Mishra, 1993) because, in the early stages of growth, the mustard crop has a slow growth rate and the weed thrive and produced the higher dry matter during this time. Proper row spacing of a particular crop is a significant agricultural factor and has a lot of impacts on the yield and its various components (Diepenbrock, 2000). Appropriate crop row spacing shows a substantial managing part in enhancing the crop yield by minimizing the growth of the weeds at the initial stages of crop growth and development. Appropriate plant population achieved by keeping suitable row spacing is the main aspect to achieve maximum production of any crop (Singh *et al.*, 1990; Alam, 2004). Many scientists reported that narrow row spacing resulted in maximum seed yield overboard row spacing. Plants that grow in extensive wider rows may not effectively exploit the natural growth factors like light, water and nutrients, however, planting of crop in too much narrower rows may result in extreme inter and intra-row spacing competition (Ali *et al.*, 1999). Narrower crop row space improves the capability of the crop to contest for limited resources as a result of brisk canopy closure, lessened the seedling growth of weed, and ultimately lessened weed seed bank. With no additional costs, narrow row space of the crop can give a competitive advantage to the crop through rapid canopy closure inhibit the later-emerging weeds, providing less chance for the nourishment of weed (Khaliq *et al.*, 2014). Keeping in mind the above-defined facts, the research was executed with the following objectives i.e. Optimizing the row spacing of the crop; Determine the critical weed-crop competition period; Find out the best suitable combination of row spacing and competition period.

Materials and methods

Site and soil

The experiment was executed at the Research site of the Department of Agronomy, College of Agriculture, University of Sargodha, in winter season 2016-17. Sargodha city lies among 31.32°N latitude and 71.18°E longitude. Sargodha is at 190 m altitude since the sea level. The climate of Sargodha is subtropical and semi-arid. The experimental site was loamy in texture having good drainage. The organic matter content of the soil was about 1.1%.

Experimental design and the treatments

Treatments were different transplant spacing as 15 cm × 15 cm, 20 cm × 20 cm and 25cm × 25 cm and competition periods viz., 14,28, 42, 56,70 and till harvest DAS (days after Sowing) weed-free as well as weedy. A weedy check and weed-free for the whole season were kept as controls. The trial was arranged out in Randomize complete block design (RCBD) with a split-plot arrangement. Row spacing's were placed in the subplot while the competition durations were placed in the main plot. Each treatment was repeated three times. The 4 × 2 m was the net plot size.

Crop husbandry

Since mustard is a small-seeded crop, it requires a well prepared, fine and level field with proper moisture for the good germination of seed and establishment of the plant. Heavy irrigation was applied to the field and when it reached the workable condition, the seedbed was prepared by two to three ploughings followed by planking. Mustard was sown on the 7th of November, 2016. Sowing was done by a single row manual drill. A recommended seed rate of 4-5 kg/ha was used. Thinning of the crop was done after 20 days after sowing. Fertilizer nitrogen and phosphorus were applied in 40:40 kg/ha. First irrigation was applied after one month of sowing while subsequent irrigations were applied at 20-30 days interval. Plant protection measured was taken out to keep the crop free from diseases and pests. All the other agronomic practices were kept as per the standard recommendations.

Data collection

Various weed parameters (weed dry weight) and crop parameters (plant height, number of plants per m^{-2}, number of branches per plant, 1000-seed weight, seed yield) were recorded. To record the dry weight of weeds, the above-ground portion of weeds from one square meter was placed in an electric oven at 72 C^{o} for 24 hours. Then their dry weight was taken by the sensitive electronic balance. For recording the plant height, 10 plants at random were picked from every plot and the height of those plants was measured from base to the tip of the plant at physiological maturity using a measuring tape and then the average was calculated. For counting the number of plants, a quadrant of the one-meter square was placed at random in each plot and then counts the total plants which were in the quadrant. For recording the seed yield of mustard of each plot, the above-harvested produce was dried and then threshed by the labor manually and cleaned. The seed obtained was weighed with the balance.

Statistical analysis

The data were analyzed by using Fisher's analysis of variance technique, and the least significant difference (LSD) test at $p \geq 0.05$ was used to evaluate the significant means of the treatments (Steel *et al.*, 1997). The mean comparison of the treatments was done by the least significant difference (LSD) test at 5% probability level.

Results and discussion

Weed dry weight

A significant impact of row spacing, competition periods and their interaction was observed on the dry weight of weeds. As the data in Table 1 indicates that the higher dry weight of weeds (40.62 g m^{-2}) was found in 25 cm row spacing whereas the lowest dry weight (39.07 g m^{-2}) was found in narrow 15 cm row spacing. However, in 20 cm row spacing weed dry weight was (39.68 g m^{-2}). Wider row spacing produces more weed dry weight since extra area inside plants delivered additional space and resources for the weed leads to the higher dry matter gathering.

Competition throughout the season shows the maximum dry weight (79.18 g m^{-2}) followed by (74.64 g m^{-2}) in weed-free situations of 14 DAS (days after sowing) conditions though the least dry weight (6.47 g m^{-2}) noted in weedy conditions of 14 DAS and at par (9.2 g m^{-2}) in weed-free conditions of 70 DAS excluding the weed-free conditions. Data of interaction showed that higher dry weight of weeds (80.16 g m^{-2}) was recorded in 25 cm row spacing and weedy conditions throughout the growing season followed by (79.067 g m^{-2}) in 20 cm row spacing and weedy conditions in the whole growing season. However, the minimum dry weight (5.9167 g m^{-2}) was noted in 15 cm row spacing and 14 days weedy conditions after sowing being at par (6.2167 g m^{-2}) observed in the case of 20 cm row spacing and 14 DAS. Weed-free throughout the growing season in arrangement with each of the row spacing did found zero dry weight of the weed.

Table 1. Effect of different weed control treatments on the weed dry weight (g m^{-2}), Plant height (cm), no. of plants (m^{-2}), no. of branches per plant, 1000-seed weight (g), seed yield (Kg ha^{-1}).

Parameters	Weed dry weight(g m^{-2})	Plant Height(cm)	No. of plants(m^{-2})	No. of branches per plant	1000-seed weight(g)	Seed yield(Kg ha^{-1})
			Plant spacing (cm)			
S_1 = 15 × 15	39.07 b	132.42 c	137.42 a	7.88 a	3.39 a	1536.3 a
S_2 = 20 × 20	39.68 b	134.75 b	125.08 b	6.77 b	3.38 a	1392.7 b
S3 = 25 × 25	40.62 a	136.64 a	121.42 c	5.66 c	3.30 b	1249.7 c
LSD P≤5%	0.0000	0.0000	0.0000	0.0234	0.0000	0.0000
			Weed crop competition Duration (Days after sowing)			
C_1 = 14 weedy	6.47 k	140.00 d	135.44 c	6.55 bd	3.45 a	1673.7 b
C_2 = 28 weedy	15.07 i	142.00 c	120.44 g	7.11 ac	3.38 ab	1614.1 c
C_3 = 42 weedy	34.45 g	134.00 g	114.78 h	6.66 ad	3.42 a	1307.9 e
C_4 = 56 weedy	53.80 e	132.00 h	128.44 de	6.33 cd	3.35 bc	1161.4 g
C_5 = 70 weedy	1673.7 b	128.89 j	130.11 de	6.44 cd	3.44 a	1082.1 h
C_6 = Weedy till Harvest	79.189 a	120.33 l	127.78 ef	6.33 cd	3.40 ab	1015.0 i
C_7 = 14 Weed Free	74.640 b	124.00 k	127.67 ef	7.44 a	3.30 cd	1126.2 gh
C_8 = 28 Weed Free	63.27 d	130.00 i	125.22 f	7.33 ab	3.27 de	1220.2 f
C_9 = 42 Weed Free	45.33 f	136.00 f	130.44 d	6.00 d	3.23 e	1463.7 d
C_{10} = 56 Weed Free	27.08 h	138.00 e	110.00 i	6.66 ad	3.35 bc	1596.9 c
C_{11} = 70 Weed Free	9.23 j	144.00 b	139.78 b	7.11 ac	3.28 ce	1684.2 b
C_{12} = Weed free till Harvest	0.00 l	146.00 a	145.56 a	7.44 a	3.43 a	1769.3 a
LSD P≤5%	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
			Interaction			
$S_1 \times C_1$	5.91 uv	138.00 f	148.00 b	7.66 bc	3.53 ab	1798.7 c
$S_1 \times C_2$	14.50 rs	140.00 e	131.33 fg	8.66 a	3.43bg	1768 c
$S_1 \times C_3$	33.48 o	132.00 i	123.6 jm	7.66 bc	3.35 fj	1401.3 jk
$S_1 \times C_4$	53.10 lm	130.00 j	138.33 ce	8.33 ab	3.43 bg	1277.7 mn
$S_1 \times C_5$	68.06 gh	126.00 l	140.00 cd	7.66 bc	3.50 ac	1186.7 op
$S_1 \times C_6$	78.33 c	117.00 p	137.33 de	7.33 cd	3.46 ae	1140.0 pr
$S_1 \times C_7$	38.01 ce	122.00 no	136.33 e	8.66 a	3.25 jn	1258.0 n
$S_1 \times C_8$	37.83 ce	128.00 k	133.00 f	7.33 cd	3.38 di	1355.0 kl
$S_1 \times C_9$	32.42 km	134.00 h	137.00 de	6.33 ef	3.18 mn	1631.3 f
$S_1 \times C_{10}$	31.01 mn	136.00 g	119.67 n	8.33 ab	3.38 di	1787.7 c
$S_1 \times C_{11}$	29.53 no	142.00 d	147.33 b	8.66 a	3.31 hl	1865.3 b
$S_1 \times C_{12}$	27.12 p	144.00 c	157.00 a	8.00 ac	3.48 ad	1965.7 a
$S_2 \times C_1$	6.216 uv	140.00 e	132.00 f	6.66 de	3.53 ab	1695.7 de
$S_2 \times C_2$	14.88 rs	142.00 d	116.00 o	7.33 cd	3.56 a	1627.0 f
$S_2 \times C_3$	34.50 no	134.00 h	112.33 p	6.66 de	3.48 ad	1330.0 lm
$S_2 \times C_4$	53.61 kl	132.00 i	122.33 ln	6.33 ef	3.38 di	1156.7 pq
$S_2 \times C_5$	68.95 gh	128.00 k	127.67 ih	6.33 ef	3.33 gk	1105.0 qs
$S_2 \times C_6$	79.06 b	123.00 mn	126.33 hj	6.33 ef	3.38 di	1015.0 tu
$S_2 \times C_7$	74.67 e	124.00 m	125.33 il	7.33 cd	3.41 ch	1135.7 pr
$S_2 \times C_8$	63.21 ij	130.00 j	123.00 km	8.33 ab	3.30 il	1225.0 no
$S_2 \times C_9$	45.20 mn	136.00 g	128.67 gh	5.33 g	3.21 ln	1486.3 hi
$S_2 \times C_{10}$	26.86 p	138.00 f	107.00 q	6.33 ef	3.35 fj	1540.7 gh
$S_2 \times C_{11}$	8.966 tu	144.00 c	140.67 c	6.66 de	3.28 im	1645.0 ef
$S_2 \times C_{12}$	0.00 w	146.00 b	139.67 cd	7.66 bc	3.36 ei	1750.7 cd
$S_3 \times C_1$	7.28 tu	142.00 d	126.33 hj	5.33 g	3.30 il	1526.7 h
$S_3 \times C_2$	15.83 r	144.00 c	114.00 op	5.33 g	3.16 n	1447.3 ij
$S_3 \times C_3$	35.37 no	136.00 g	108.33 q	5.66 fg	3.43 bg	1192.3 op
$S_3 \times C_4$	54.70 kl	134.00 h	124.67 il	4.33 h	3.23 kn	1050.0 st
$S_3 \times C_5$	69.82 gh	132.67 i	122.67 kn	5.33 g	3.50 ac	954.7 u
$S_3 \times C_6$	80.16 a	121.00 o	119.67 n	5.33 g	3.35 fj	890.0 v
$S_3 \times C_7$	75.75 d	126.00 l	121.33 mn	6.33 ef	3.25 jn	985.0 u
$S_3 \times C_8$	64.33 ij	132.00 i	119.67 n	6.33 ef	3.15 n	1080.7 rs
$S_3 \times C_9$	46.31 lm	138.00 f	125.67 ik	6.33 ef	3.30 il	1273.3 mn
$S_3 \times C_{10}$	28.16 op	140.00 e	103.33 r	5.33 g	3.31 hl	1462.3 i
$S_3 \times C_{11}$	9.750 t	146.00 b	131.33 fg	5.66 fg	3.25 jn	1542.3 gh
$S_3 \times C_{12}$	0.00 w	148.00 a	140.00 cd	6.66 de	3.45 bf	1591.7 fg
LSD P≤5%	0.0002	0.0002	0.0000	0.0000	0.0000	0.0000

As the wider row spacing and competition duration increase, the dry weight of weeds also increases and vice versa. To achieve effective and proper control of weeds, it is very necessary to keep the narrow 15 row spacing of the crop and control the weed before the 42 DAS for the economical production of mustard. Fig. 1 shows the relationship between weed dry weight and competition durations (weedy and weed-free). Mekki *et al.* (2010) found the highest weed dry weight (64.60 g m^{-2}) in the weedy circumstances of the complete growing season of the crop. An increase in row spacing and competition period provides more area to utilize the natural resources and time to flourish and accumulate the maximum dry weight.

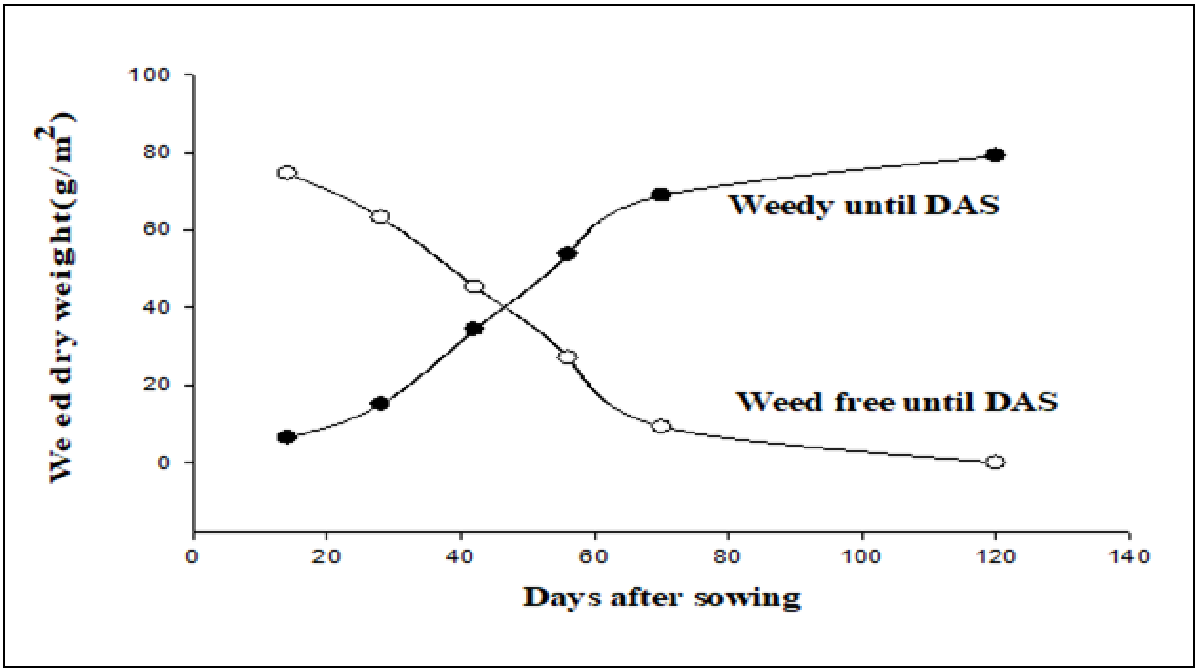

Fig. 1. Relationship between competition duration (weedy and weedy free) and weed dry weight.

Plant height

A significant influence of row spacing, competition days and their interaction was detected on the plant height. Data present in Table 1 shows that maximum plant height (136.64 cm) was recorded at wider 25 cm row spacing then (134.75 cm) in 20 cm spacing, however, the minimum plant height (132.42 cm) was noted in 15 cm row spacing. Morrison *et al.* (1990a) noted that with an increase in row spacing the plant height also increases. The lowest plant height (120.33 cm) was recorded in weedy conditions throughout the growing season and at par (124.00 cm) in weed-free circumstances up to 14 DAS. The higher plant height (146.00 cm) was found in weed-free conditions in the whole growing season followed by (144.0 cm) in weed-free situations up to 70 DAS. In another study, Shaheenuzzamn *et al.* (2010) recorded the plant height (110 cm) in weedy conditions throughout the growing season of the crop while (124.7 cm) in weed-free conditions throughout the growing season. Data of interaction demonstrated that higher plant height (148.0 cm) found in 25 cm row spacing with weed-free conditions till harvesting of the crop while the lowest plant height (117.0 cm) noted in 15 cm row spacing and weedy conditions up to harvesting of the crop and being at par (121.0 cm) in 25 cm row spacing and weedy circumstances in the whole growing season of the crop.

Number of plants (m^{-2})

As the data in table 1 depicts that the maximum number of plants (137.42) was noted in narrow 15 cm row spacing followed by (125.08) in 20 cm row spacing, however, the minimum number of plants (121.42) were recorded at wider 25 cm row spacing. A higher number of plants (145.56) were found in weed-free conditions in the whole growing season of the crop followed by (139.78) in weed-free circumstances up to 70 DAS however, the lowest number of plants (110.00) were recorded in weed-free conditions till 56 DAS and at par (114.78) found at weedy conditions till 42 DAS. Data on the interaction of plant spacing and competition duration revealed that a higher number of the plants (157.0) recorded at 15 cm row spacing with weed-free situations till harvesting of the crop followed by (148.0) in 15 cm row spacing with weedy conditions up to 14 DAS. However, the lowest number of the plant (103.33) was found in 25 cm row spacing and weed-free conditions up to 56 DAS and being at pat (107.0) in 20 cm row spacing with weed-free situations till 56 DAS. Our results are similar to the findings of Rahman *et al.* (2010) observed 133 number of plants m^{-2} in 15 cm rows spacing of the crop.

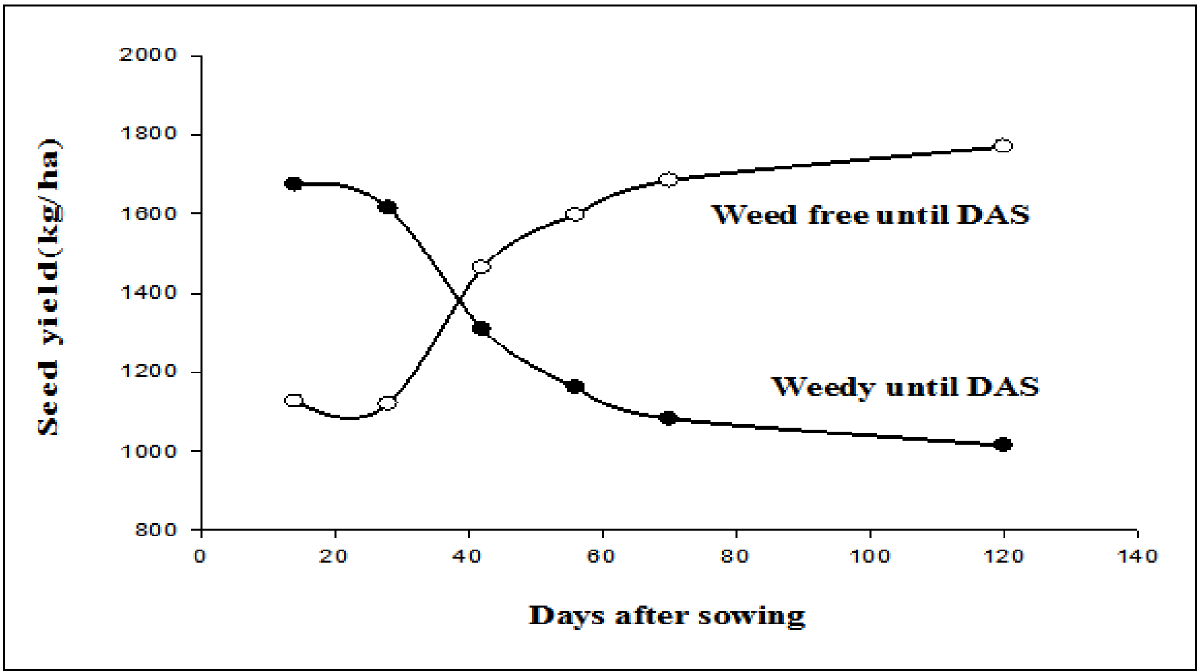

Fig. 2. Relationship between competition duration (weedy and weedy free) and Seed Yield (Kg/ha).

Number of branches per plant

Table 1 shows that the maximum number of branches per plant (7.88) was recorded at narrower 15 cm row spacing followed by (6.77) in 20 cm row spacing, however, a minimum number of branches per plant (5.66) was noted in narrow 15 cm row spacing. Hasanuzzaman and Karim (2007) noted that the (6.38) number of effective branches per plant in 20 cm rows spacing. A higher number of branches (7.44) were found in weed-free conditions till the complete growing season of the crop while the lowest number of branches per plant was noted (6.0) at weed-free conditions up to 42 DAS. Mankar (2016) also reported that with an increase in weed-free duration and the number of branches per plant also increases. Interaction of plant spacing and competition duration showed that higher number branches (8.66) per plant were recorded at narrower 15 cm row spacing with weed-free situations up to 28 DAS and weedy till 28 DAS however, the lowest number of branches per plant (4.33) were observed at broader 25 cm row spacing with weedy conditions up to 56 DAS.

1000-seed weight (g)

Data in Table 1 shows that the higher 1000-seed weight (3.39 g) was found at a narrower 15-row spacing which was statistically similar (3.38 g) with 20 cm row spacing while the minimum 1000-seed weight recorded at wider 25 cm row spacing. Higher 1000-seed weight (3.45g) was noted in weedy conditions till 14 DAS, however, the lowest 1000-seed weight (3.23 g) was recorded in weed-free circumstances till 42 DAS and being at par (3.27 g) with weed-free situations up to 28 DAS. Singh (1992) found an increase in 1000-seed weight after one hand weeding at 25 DAS. Interaction of plant spacing and competition periods showed that maximum 1000-seed weight (3.56 g) was found at 20 cm row spacing with weedy conditions till 28 DAS while minimum 1000-seed weight (3.15g) recorded at 25 cm row spacing with weed-free situations up to 28 DAS.

Seed Yield (Kg ha^{-1})

The substantial influence of row spacing, competition phases and their interaction was noted on the seed yield of the mustard. Data of Table 1 illustrates that in narrower 15 cm row spacing of the crop higher seed yield (1536.3 kg ha^{-1}) was recorded followed by (1392.7 kg ha^{-1}) seed yield of the crop in 20 cm row spacing while the minimum seed yield (1249.7 kg ha^{-1}) of the crop was found in wider 25 cm row spacing. Christensen and Drabble (1984) stated that with the intensification in row spacing the seed yield is decreased. Maximum seed yield (1769.3 kg ha^{-1}) was noted in weed-free conditions in the whole growing season of the crop followed by (1684.2 kg ha^{-1}) in weed-free circumstances till 70 DAS. However, the lowest seed yield (1015.0 kg ha^{-1}) was noted in weedy conditions until harvesting of the crop and being at par (1082.1 kg ha^{-1}) in weedy conditions up to 70 DAS. Shaheenuzzamn *et al.* (2010) found the seed yield of (1009 kg ha^{-1}) in weedy conditions throughout the growing season of mustard. Interaction of plant spacing and competition period showed that higher seed yield (1965.7 kg ha^{-1}) was recorded in narrower 15 row spacing with weed-free conditions up to the harvesting of the crop followed by (1865.3 kg ha^{-1}) in narrower 15 cm row spacing and weed-free situations up to 70 DAS. However, the lowest seed yield (890.0 kg ha^{-1}) was recorded in wider 25 cm row spacing with weedy conditions till the complete growing season of the crop and was being at par (954.7 kg ha^{-1}) with wider 25 cm row spacing with weedy conditions till 70 DAS. Fig. 2. Shows the relationship between seed yield and competition durations (weedy and weed-free).

Conclusion

A 42.64% yield reduction was recorded in weedy conditions till harvesting over weed-free conditions up to harvesting of the crop while a 9.34% yield decline was found when row spacing was augmented by 15 cm to 20 cm while a 10.27% yield decrease observed when row spacing rises from 20 cm to 25 cm. The critical days for weed management are 38 days after sowing. It is concluded that as the row spacing surges from narrower to wider, the weed dry matter increases and seed yield decreases. It would be worthy to explore whether the combination of different crop varieties and proper seed rates are helpful to suppress the rapid growth of the weeds and can be incorporated in integrated weed management.

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