The Journal of Animal & Plant Sciences, 23(1): 2013, Page: 216-221
ISSN: 1018-7081

DETERMINING CRITICAL WEED COMPETITION PERIODS FOR BLACK SEED

M. A. Nadeem, A. Tanveer, T. Naqqash, *A. J. Jhala and **K. Mubeen

Department of Agronomy, University of Agriculture Faisalabad
*Department of Agronomy and Horticulture, University of Nebraska-Lincoln, USA.
**Department of Agronomy, The University of Poonch Rawalakot (AJ & K, Pakistan)
Corresponding Author Email: drman@uaf.edu.pk

ABSTRACT

Effect of weed competition periods on weeds and yield of black seed was studied through field experiments conducted at Agronomic Research Area, University of Agriculture, Faisalabad during winter 2006-07 and 2007-08. Weeds were allowed to compete with the crop for 40, 50, 60, 70, 80 days after sowing and throughout the growth season along with a weed free treatment. The data on weed density and biomass; yield components and yield of black seed were documented. Weed density and biomass increased with the increase in weed competition periods and the maximum weed density and biomass was recorded in weedy check during both the years of study. Outcome of the differences between the weed free and competition for 40 days after emergence was statistically similar for number of capsules per plant, number of branches and number of seeds per capsule during first year of study, however, all yield components showed a significant decline when weeds were allowed to compete compared with weed free treatments during second year. The maximum seed yield was recorded in weed free treatment and it showed a linear decline as the weed competition period was increased during both the years of study. Weeds must be controlled within 40 days after emergence of black seed to avoid the risk of economic yield loss as it has been found to be the critical period of weed crop competition in black seed.

Key words: Black seed, Weed-crop competition, Weeds, Yield, Pakistan.

INTRODUCTION

There is a period during the life cycle of a crop when it is most sensitive to presence of weeds. This period is known as critical period of competition (Mubeen *et al.,* 2009).There are three relationships which exist in critical period studies: a) the crop must be kept weed-free for the same duration that a weed infestation can be tolerated. In this situation, yield loss will be avoided if weed control is performed at this one critical time; b) when the critical timing of weed removal is longer than the critical weed-free period. In this case, yield loss will not occur if weeds are controlled at any point between these critical stages; c) When the critical weed free period is of no longer duration than the critical timing of weed removal, the crop must be kept weed free between these timings to prevent yield loss.

Black seed (*Nigella sativa* L.) is an annual herbaceous plant belongs to family Ranunculaceae, also known as black cumin. It is widely cultivated throughout South Europe, Syria, Egypt, Saudi Arabia, Iran, Pakistan, India and Turkey (Riaz *et al*., 1996). It is a spicy herb and is a crop of great medicinal importance. The principle active ingredient isolated from the volatile oil of black seed is thymoquinone (Mahfouz and El-Dakhakhany, 1960). In Turkish folk medicine, black seed was used as a natural stimulant of immunity, antidiabetic, digestive disorders, carminative, anthelmintic and appetitive (Baytop, 1984; Hussain and Tobji, 1997).

In spite of its great importance, little attention has been paid to this minor crop in Pakistan. It is grown at a small scale level in Khyber Pakhtunkhwa region with an annual production of about 200-250 tons (Ahmad and Gafoor, 2004). The yield of black seed is lower than its potential. Among different factors responsible for lower yields, weed interference is of supreme importance. Weed interference in black seed can cause 60-85% reduction in crop yield (Ahmad and Gafoor, 2004). The critical weed crop competition period is very important for planning efficient weed control strategy. Critical weed competition period varies with season and nature of crops and weeds. For example in wheat, critical period of weed competition is 30 to 60 days after sowing (DAS) (Ahmad and Sheikh, 2003), chickpea 40 to 45 DAS (Chopra *et al.*, 2003), and in soybean 50 to 60 DAS (Juan and Cendoya, 2002). However, there is no information available about the critical weed competition period in black seed.

To realize the full economical and yield potential of black seed, production practices will have to be optimized by improving weed control efficiency in this crop. Being a low acreage crop, the choice of herbicide in black seed is limited. In order to develop efficient herbicide use and provide a logical basis for the development of an integrated weed management system, information on critical period of weed control is essential. This information may lead to less reliance on the use of residual herbicides and to more reliance on well-timed post-emergence herbicides. Reductions in quantities of

herbicide applied will reduce potential environmental contamination and will reduce selection pressure for herbicide resistant weeds. In addition, timing of cover crop seeding and cultivations could be improved based upon critical period of weed competition in this crop.

Therefore, present study was designed to determine the effects of weed competition periods on growth and yield of black seed. The value of critical period studies rests with the eventual uncovering of the physiological bases for crop-weed competition and its eventual use for weed control.

MATERIALS AND METHODS

Effect of weed competition periods on weeds and yield of black seed was studied through field experiments conducted at Agronomic Research Area, University of Agriculture, Faisalabad during winter 2006-07 and 2007-08. The soil was sandy clay loam with 189 ppm phosphorus, 6.3 % total nitrogen and 8.0 pH. The experiment was laid out in randomized complete block design having three replications and a net plot size of 5 m × 1.2 m. Weeds were allowed to compete with crop for 40, 50, 60, 70, 80 days after sowing and throughout the growth season, along with weed free treatment. The data on weed density and biomass; yield components and yield of black seed were recorded. Density and biomass of individual weeds were recorded on per square meter basis when competition period was completed as per treatment and plant population of blackseed was recorded at harvested. Ten plants were selected at maturity randomly from each plot for recording plant height, number of branches per plant, number of capsules per plant and number of seeds per capsule. Three samples of 1000 seeds each were taken from each plot to record 1000-seed weight. Yield was recorded on per plot basis and was converted to kg ha^{-1}. Data collected were analyzed statistically using Fisher's analysis of variance techniques and least significant difference test at 5% probability level was applied to compare the treatment's means (Steel *et al.,* 1997).

RESULTS AND DISCUSSION

WEED DENSITY (m^{-2})

***Phalaris minor*:** Effect of different weed competition periods on density of *P. minor* was significant during both the years (Table 1). The minimum weed density was recorded in weed free treatment. The density of *P. minor* increased significantly with each increase in competition period during 2006-07, while, during 2007-08 the differences between 40 and 50 Days after emergence (DAE) and 50 and 60 DAE were non-significant. The maximum density of *P. minor* of 50.56 and 97.82 m^{-2} was recorded in weedy check where weeds were allowed to grow throughout the growth season during 2006-07 and 2007-08, respectively. Seeds of *P. minor* present in the soil at various depths continued to germinate with the passage of time resulting in greater weed density where weeds were allowed to compete for longer period. The minimum density of weeds in weed free plots has also been reported by Sarandon *et al*. (2002) for linseed crop.

***Chenopodium album*:** The minimum density of *C. album* was recorded in weed free plots where weeds were not allowed to grow. The density of *C. album* showed an increasing trend as the competition periods were increased during both the years (Table 2). The maximum density of *C. album* was recorded in weedy check (24.44 and 19.64) where weeds were allowed to compete throughout the growth period, which, was statistically at par with competition period of 80 DAE during both the years. Increase in the density of *C. album* with increased competition period can be attributed to availability of more time for the germination and growth of weeds. Sarandon *et al*. (2002) had also reported significant differences among weed competition periods for weed density in linseed crop.

***Convolvulus arvensis*:** This weed was found in the experimental area only during 2006-07 and did not appear during second year most probably because of dormant seeds and unfavorable environmental conditions for weed seed germination and/or growth of *C. arvensis*. During 2006-07 the minimum density of *C. arvensis* was recorded in weed free plots where weeds were not allowed to grow. The density of *C. arvensis* increased significantly with each increase in competition period up to 80 DAS. The differences between competition period of 80 DAS and weedy check were non-significant. The maximum density of *C. arvensis* was recoded in weedy check treatment (14.13). The competition period for *C. arvensis* seems to be 70 days after sowing. Ciuberkis *et al.* (2004) also reported that weed density increased with increase in competition period up to 25 days after flowering in potato.

Total weed density (m^{-2}): Total weed density was also affected significantly by weed competition periods during both the years of study (Fig-1). The maximum weed density (102.50 and 120.71) was recorded in weedy check during 2006-07 and 2007-08, respectively. The weed density decreased significantly with each decreased competition period and minimum density was recoded in weed free plots where weeds were not allowed to compete with the crop (Table 1). The complete control in weed free was due to the fact that weeds were eradicated from the weed free plots repeatedly and no weed was allowed to grow there. The increase in weed density with increased competition period might be due to germination of weed seeds at lateral stages. The maximum weeds in weedy check and minimum in weed free plots has also

been reported by Sarandon *et al*. (2002) for linseed crop and Hussain *et al*. (2009) for and black seed.

Total weed dry weight (g m^{-2}): Dry weight of all the weeds was affected significantly by weed crop competition periods (Table 2). The minimum weed density (00.00) was recorded in weed free plots in all the weeds during both the years. The dry weight of the entire weeds increased significantly with each increased competition period during both the years. However, the differences for dry weight of *C. album* between 40 and 50 DAS were statistically similar during 2007-08. The total dry weight of weeds showed similar trend during 2007-08 however, during 2006-07 the differences between 40 and 50 DAS, 50 and 60 DAS and among 60, 70 and 80 DAS were statistically non-significant. No dry weight of *C. arvensis* was recorded during second year because this weed appeared only during first year in the experimental area because of weed seeds dormancy. As the weeds were allowed to grow for longer period, they produced greater biomass resulting in the greater dry weight. The differences in the dry weight of weeds can be attributed to the differences in the density of weeds (Table-1) and fresh weight of the weeds (data not given) depending upon the duration of competition period. The results are in accordance with those of Hussain *et al*. (2009) and Mubeen *et al*. (2009) who reported increase in weed dry weight with increased competition periods in blackseed and fennel crops respectively.

Plant population (m^{-2}): Effect of weed competition periods on plant population of black seed was significant. During 2006-07 the maximum plant population (32.00) was recorded in weed free treatment which was statistically at par with competition periods of 40, 50 and 60 DAE. The minimum plant population (28.00) was recorded in weedy check which however was statistically similar to competition periods of 60, 70 and 80 DAE. During second year, the outcome of weed free treatment resulted in maximum plant population (41.32). The plant population decreased significantly with each increased competition period, however, the difference between 50 and 60 DAE was non significant. The minimum plant population (24.67) in 2007-08 was recorded in weedy check. Reduced plant population with higher competition period might have been due to greater struggle for resources. Furthermore, weeds like *P. minor* attained greater height (Table-3) and over shaded the crop plant resulting in their mortality. The significant differences in population of crop plants due to competition periods have also been reported by Hussain (2007). The results are however, in denial with those of Das and Yaduraju (1999) who stated non-significant effect of weed competition periods on the plant population of wheat crop. The differences in results might have been due to the difference in the crop growth habit and type of weeds present in the experimental area.

Plant height of crop (cm): Plant height of black seed was also significantly affected by weed competition periods. During 2006-07, the maximum plant height (80.75 cm) was documented in weed free treatment which was statistically at par with competition periods of 40, 50 and 60 DAE. The minimum plant height (62.00 cm) was recorded in weedy check, which however, was statistically similar to competition periods of 70 and 80 DAE. During second year, weed free treatment resulted in maximum plant height (99.05 cm) which was statistically at par with competition period of 40 DAE. The plant height decreased significantly with each increased competition period, however, the difference between 50 and 60 DAE was non significant. The significantly minimum plant height was recorded in weedy check. Greater plant height of black seed in weed free treatment might have been due to more availability of resources in the absence of weeds. The minimum plant height (76.15 cm) in weedy check can be attributed to greater competition and suppressive effect of weeds. Further, some weeds like *P. minor* attained greater height than crop plants and resulted in their suppressive growth. The results are similar with those of Hussain *et al*. (2009) who reported lower plant height in black seed with increased competition periods. The results are however, in contrast with those of Mubeen *et al*. (2009) who reported an increase in plant height of fennel (*Foeniculum vulgare* Mill.) with increase in competition period from 50 to 80 days after sowing. These differences in the results can be attributed to the differences in the genetic makeup of crop plants and density and type of weed flora.

Height of *P. minor* (cm): As *P. minor* has more inherent plant height and due to intra specific competition the height of this weed increased further which could have a serious impact on growth and development of black seed crop. Furthermore the other dominant weeds though competed with crop for growth resources but could not produce a serious impact on crop as far as the height of these weeds is concerned. Therefore the height of the weeds other than *P. minor* is not given here. Significantly minimum height of *P. minor* (70.00 cm and 55.52 cm) was recorded in competition periods of 40 DAE. The height of *P. minor* increased significantly with each increased competition period and significantly maximum height of *P. minor* (101.30 and 101.60) was recorded in weedy check during both the years. As the height of *P. minor* was increased, the height of black seed was also decreased and vice versa. Increase in height of *P. minor* with increase in weed competition period might be due to the availability of more time and resources for growth of this weed. Increase in height of *P. minor* plants with longer competition period can be attributed to higher density of *P. minor* resulting in greater intra-specific competition among *P. minor* plants. Availability of

greater time for utilization of more resources with prolonged competition period can also be the reason for greater height of *P. minor* plants. The results are in agreement with those of Hussain *et al*. (2009) who also reported a significant increase in height of *P. minor* with increase in competition period in black seed crop.

Number of branches: The number of branches per plant of black seed was affected significantly during both the years (Table 3). During 2006-07, the maximum number of branches of black seed (8.00) was recorded in weed free treatments where weeds were not allowed to grow and was statistically at par with competition periods up to 60 days after emergence. The minimum number of branches per plant (4.75) was observed in weedy check where weeds were not controlled throughout the growing season, which, however was statistically at par with competition period of 80 days after emergence. During second year, the significantly maximum number of branches (15.60) was recorded in weed free treatment. The number of branches decreased with each increase in competition period, however, the differences between 50 and 60 days after emergence and 70 and 80 days after emergence could not reach to the level of significance. The significantly minimum number of branches (6.85) was recorded in weedy check. The decrease in number of branches with increased competition period can be attributed to the greater weed density and biomass at increased competition periods which deprive the crop plants from essential inputs like nutrients and moisture.

Number of capsules per plant: Number of capsule per plant of black seed was affected significantly by weed crop competition periods during both the years (Table 4). The maximum number of capsules was recorded in weed free treatment during both the years; however, during 2006-07 it was statistically at par with competition period of 40 days after emergence. The minimum number of capsules was recorded in weedy check which was statistically similar to competition period of 80 days after emergence in both the years. The differences among competition periods of 40, 50 and 60 days after emergence were statistically similar. The minimum number of seeds per plant was due to augmented competition between weeds and crop plants through out the life span. The depletion of resources by weeds resulted in scarcity of resources and ultimately crop plants had less number of branches and capsules with short stature. A decrease in fruit bearing ability of fennel plants with intensification in competition period has also been discovered by Mubeen *et al*. (2009).

1000-seed weight (g): The variation among weed crop competition period was significant for 1000-seed weight during both the years (Table 4). The significantly maximum seed weight (2.30 and 3.45 g) was recorded in weed free treatment in both the years, respectively. During 2007-08, each increase in competition period significantly decreased the seed weight except between 60 and 70 days after emergence where, the decrease could not reach the level of significance. However, during 2006-07 the trend showed a decrease in seed weight with increase in competition period but the differences could not reach to the level of significance with each hoist in competition period. The significantly minimum seed weight (1.80 and 2.25 g) was recorded in weedy check during both the years of study, respectively. Although, the weed free treatment resulted in maximum number of capsules and seeds per capsule, yet the seed weight was the maximum in this treatment. This might be due to healthier crop plants, in the absence of weeds, which have more plant height and greater number of branches that resulted in more nutrient availability and higher rate of photosynthesis and ultimately greater seed weight due to more storage in sink. The significant differences in seed weight of black seed due to weed competition has also been reported by Hussain *et al*. (2009)

Seed yield (kg ha^{-1}): The seed yield of black seed was affected significantly by weed competition periods. During both the years the maximum seed yield (1720.00 and 1558.15 kg ha^{-1}) was recorded in weed free periods. With each increase in competition period the seed yield increased significantly in 2006-07, however, in 2007-08 the seed yield decreased with increase in competition periods but the difference between 50 and 60 days after emergence and 70 and 80 days after emergence were statistically similar. The minimum seed weight was recorded in weedy check (526.20 and 266.89 kg ha^{-1}). The minimum seed weight in weedy check can be attributed to maximum weed density and minimum number of crop plants, number of capsules per plant, number of seeds per capsule and 1000-seed weight. The higher seed yield in weed free plots has also been reported by Sarandon *et al*. (2002), Ciuberkis *et al.* (2004) and Mubeen *et al*. (2009).

The results of this two year study lead to the conclusion that the maximum seed yield in black seed could be obtained by keeping the plots weed free during initial growth phase of the crop. Therefore, weeds must be controlled within 40 days after emergence of black seed to avoid the risk of economic yield loss as it has been found to be the critical period of weed crop competition in black seed.

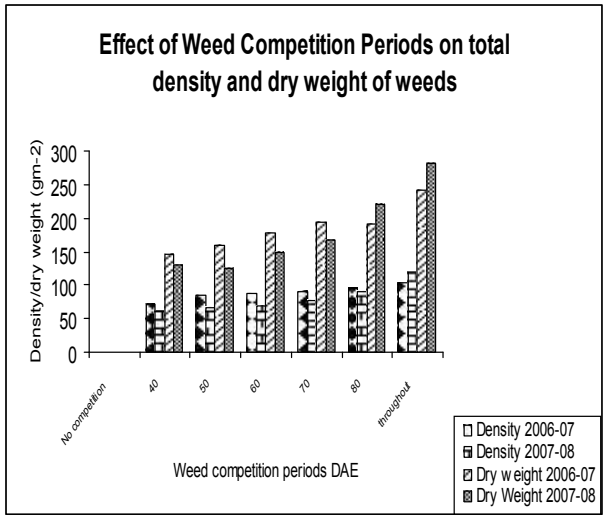

Table 1: Effect of different weed competition periods on the density of weeds in black seed

	P. minor		*C. album*		*C. arvensis*		Total	
	2006-07	**2007-08**	**2006-07**	**2007-08**	**2006-07**	**2007-08**	2006-07	2007-08
Weedy check	50.56 [a]	97.82 [a]	24.44 [a]	19.64 [a]	14.13 [a]	-	102.5 [a]	120.71 [a]
Weed free	0.00 [f]	0.00 [f]	0.00 [e]	0.00 [d]	0.00 [f]	-	0.00 [g]	0.00 [g]
Competition for 40 DAE*	39.25 [e]	48.41 [e]	18.88 [d]	10.5[9]c	5.87 [e]	-	70.94 [f]	62.14 [f]
Competition for 50 DAE	42.63 [d]	50.97 [de]	19.88 [cd]	11.7 [c]	7.10 [d]	-	86.00 [e]	66.37 [e]
Competition for 60 DAE	46.00 [c]	52.18 [d]	21.00 [bc]	13.98 [b]	9.00 [c]	-	88.81 [d]	69.94 [d]
Competition for 70 DAE	45.75 [c]	57.59 [c]	22.00 [b]	15.11 [b]	10.13 [b]	-	91.38 [c]	76.35 [c]
Competition for 80 DAE	48.75 [b]	68.83 [b]	23.50 [a]	18.09 [a]	14.00 [a]	-	95.94 [b]	90.50 [b]
LSD	2.436	3.59	1.146	2.351	0.636	-	1.1891	2.0798

Any two means not sharing a letter in common differ statistically at 5% probability level. * DAE=days after emergence

Table 2: Effect of different weed competition periods on the dry weight of weeds

	P. minor		*C. album*		*C. arvensis*		Total	
	2006-07	**2007-08**	**2006-07**	**2007-08**	**2006-07**	**2007-08**	**2006-07**	**2007-08**
Weedy check	108.2 [a]	204.59 [a]	68.25 [a]	54.19 [a]	27.30 [a]	-	240.35 [a]	282.35 [a]
Weed free	0.00 [g]	0.00 [g]	0.00 g	0.00 [f]	0.00 [g]	-	0.00 [e]	0.00 [g]
Competition for 40 DAE*	68.88 [f]	84.98 [f]	39.50 f	28.16 [e]	11.00 [f]	-	146.8 [d]	130.59 [f]
Competition for 50 DAE	76.13 [e]	91.18 [e]	43.81 e	30.73 [e]	15.70 [e]	-	160.30[cd]	124.71 [e]
Competition for 60 DAE	83.00 [d]	107.51 [d]	49.38 d	36.87 [d]	10.26 [d]	-	178.80 [bc]	149.81 [d]
Competition for 70 DAE	86.13 [c]	121.8 [c]	55.54 c	40.15 [c]	23.08 [c]	-	193.80 [b]	168.24 [c]
Competition for 80 DAE	89.69 [b]	159.31 [b]	60.79 b	49.51 [b]	5.00 [b]	-	190.50 [b]	219.72 [b]
LSD	3.346	4.018	3.227	2.187	1.876	-	9.500	4.485

Any two means not sharing a letter in common differ statistically at 5% probability level. * DAE=days after emergence

Table 3: Effect of different weed competition periods on plant population, height and branches

	Plant population (m^{-2})		Plant height (cm)		Height of *P. minor* (cm)		Number of branches	
	2006-07	**2007-08**	**2006-07**	**2007-08**	**2006-07**	**2007-08**	**2006-07**	**2007-08**
Weedy check	28.00 [c]	24.67 [f]	62.00 [d]	76.15 [e]	101.30 [a]	101.6 [a]	4.75 [d]	6.85 [e]
Weed free	32.00 [a]	41.32 [a]	80.75 [a]	99.05 [a]	-	-	8.00 [a]	15.6 [a]
Competition for 40 DAE*	30.75 [ab]	38.10 [b]	79.5 [ab]	97.01 [a]	70.00 [f]	55.52 [f]	7.50 [a]	14.25 [b]
Competition for 50 DAE	30.50 [ab]	35.67 [c]	77.50 [ab]	92.28 [b]	74.88 [e]	59.12 [e]	7.5 [ab]	13.23 [c]
Competition for 60 DAE	30.00[abc]	35.57 [c]	73.75 [abc]	93.59 [b]	79.50 [d]	70.25 [d]	7.00 [ab]	13.22 [c]
Competition for 70 DAE	29.75 [bc]	29.69 [d]	70.25 [bcd]	85.75 [c]	88.00 [c]	80.08 [c]	6.50 [bc]	10.63 [d]
Competition for 80 DAE	29.50 [bc]	28.57 [e]	65.30 [cd]	70.21 [d]	98.13 [b]	90.5 [b]	5.75 [cd]	10.56 [d]
LSD	2.140	0.681	9.834	2.481	1.923	3.812	1.084	0.951

Any two means not sharing a letter in common differ statistically at 5% probability level. *DAE=days after emergence

Table 4: Effect of different weed competition periods on yield and yield components of black seed

	Capsules per plant		Seeds per capsule		1000-seed weight (g)		Seed yield (kg ha^{-1})	
	2006-07	**2007-08**	**2006-07**	**2007-08**	**2006-07**	**2007-08**	**2006-07**	**2007-08**
Weedy check	20.00 [e]	17.15 [d]	60.50 [d]	70.48 [e]	1.80 [e]	2.25 [f]	526.2 [g]	266.89 [e]
Weed free	35.75 [a]	26.13 [a]	94.75 [a]	90.15 [a]	2.30 [a]	3.45 [a]	1720.0 [a]	1558.15 [a]
Competition for 40 DAE*	32.00 [ab]	24.71 [b]	90.00 [ab]	85.40 [b]	2.15 [b]	3.09 [b]	1607.0 [b]	1119.15 [b]
Competition for 50 DAE	30.00 [bc]	23.88 [b]	55.75 [b]	83.85 [b]	2.10 [b]	2.93 [c]	1490.0 [c]	907.48 [c]
Competition for 60 DAE	27.25 [cd]	23.24 [b]	82.75 [b]	83.98 [b]	2.07 [bc]	2.79 [d]	1283.0 [d]	809.44 [c]
Competition for 70 DAE	25.00 [d]	19.48 [c]	71.5 [c]	75.41 [c]	1.99 [cd]	2.72 [d]	955.0 [e]	433.11 [d]
Competition for 80 DAE	23.50 [de]	18.58 [cd]	65.25 [cd]	78.45 [d]	1.90 [d]	2.49 [e]	745.0 [f]	409.85 [d]
LSD	3.864	1.481	7.851	2.984	0.094	0.081	3.58	42.485

Any two means not sharing a letter in common differ statistically at 5% probability level. * DAE=days after emergence

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