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ASSESSING THE COMPETITIVE ABILITY OF *Rhynchosia capitata;* AN EMERGING SUMMER WEED IN ASIA[1]

*Avaliação da Capacidade Competitiva de **Rhynchosia capitata**; uma Erva Daninha de Verão Emergente na Ásia*

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ABSTRACT - *Rhynchosia capitata* is a newly emerging threatening weed of summer crops in many Asian countries. We conducted 2-yr experiments to evaluate *R. capitata* competition with mungbean under irrigated conditions. *Rhynchosia capitata* was allowed to compete with mungbean for 0, 3, 4, 5, 6, 7 weeks after planting and for full crop season. The competitive ability of *R. capitata* was assessed by measuring its dry weight, micro and macro nutrient contents and uptake; and its effects on mungbean growth and yield parameters. The results showed that full season weed competition produced highest dry weight of *R. capitata* and its macro and micronutrient contents and uptake. Yield and yield components of mungbean decreased in a linear fashion with increase in competition period of *Rhynchosia capitata*. Full season competition of *R. capitata* reduced the seed yield of mungbean by 49% and 46% during 2011 and 2012 respectively. In conclusion, damaging effect of *R. capitata* intrusion on mungbean yield is associated with duration of its presence in crop, accumulation of dry matter and the nutrient uptake by *R. capitata,* which otherwise should be available to crop.

Keywords: *Rhynchosia capitata*, emerging, infestation, competition, mungbean, nutrients.

*RESUMO - **Rhynchosia capitata** é uma erva daninha recém-emergente e ameaçadora das culturas de verão em muitos países asiáticos. Foram realizados experimentos de dois anos para avaliar a concorrência de **R. capitata** com feijão-da-china ou feijão-mungo sob condições irrigadas. **Rhynchosia capitata** ficou em competição com feijão-da-china ou feijão-mungo por 0, 3, 4, 5, 6, 7 semanas após o plantio e na temporada completa de colheita. A habilidade competitiva de **R. capitata** foi avaliada medindo-se seu peso seco, conteúdo e absorção de micro e macro nutrientes e seus efeitos sobre o crescimento e características de rendimento de feijão-da-china ou feijão-mungo. Os resultados mostraram que a competição com ervas daninhas na temporada completa produziu o mais alto peso seco e seu conteúdo e absorção de micro e macro nutrientes **R. capitata**. O rendimento e os componentes de rendimento de feijão-da-china ou feijão-mungo diminuíram de modo linear com o aumento do período de concorrência de **Rhynchosia capitata**. A concorrência na temporada completa de **R. capitata** reduziu a produção de sementes de feijão-da-china ou feijão-mungo em 49% e 46% durante 2011 e 2012 respectivamente. Em conclusão, os efeitos prejudiciais da intrusão de **R. capitata** no rendimento de feijão-da-china ou feijão-mungo são associados com a duração de sua presença na colheita, acúmulo de matéria seca e a ingestão de nutrientes por **R. capitata**, que, de outro modo, deveria estar disponível para a colheita.*

Palavras-chave: *Rhynchosia capitata*, emergência, infestação, competição, feijão-da-china ou feijão-mungo, nutrientes.

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INTRODUCTION

The genus *Rhynchosia* of Fabaceae family is widely distributed in the mountainous regions of the tropics. *Rhynchosia capitata* (Roth) DC is an emerging annual summer weed in Pakistan (Ali et al., 2013). It is indigenous to India (Dogra et al., 2009), Pakistan and Sri Lanka (ILDIS, 2010). It has invaded the agro-ecosystems of Southern Punjab, Pakistan and is increasingly becoming a problematic weed in farming systems (Ali et al., 2013a). In the field, the weeds emerge through seeds just after irrigation. It is an annual twinning prostrate plant with many branches spreading all around the rootstock and rooting at every node. An approximately 1-mo-old plant starts flowering and the plant has oval-shaped pods with two seeds in each pod (Sharma et al., 1978). The growing season is from May to October with minimum and maximum average temperatures of 29/
21 ± 3 ^{o}C and 39/29 ± 3 ^{o}C, respectively, and average rainfall of 650 mm (Ali et al., 2012). Seeds usually require scarification to germinate. Seed dormancy is an important reason towards the success of this species, due to which seeds of this species persist for long periods in the soil and thus escape the effects of post-emergence weed control measures (Ali et al., 2011). In addition to its competitive effects on major crops, it adversely affects harvest efficiency and crop quality.

Mungbean [*Vigna radiata* (L.) Wilczek] is one of the major pulse crops supplementing the cereal-based diet of poor population in Asia. It is cultivated on irrigated as well as on dry areas of Pakistan. Average yield of mungbean in Pakistan is 800-1,000 kg ha^{-1} against the potential yield of 2,000 kg ha^{-1} for available cultivars (Arshad et al., 2006). The main factors that contribute towards low yield of mungbean include high cost of inputs, conventional sowing methods, sowing on marginal land, low or no use of fertilizers and poor weed management practices. Uncontrolled weeds can cause reduction in mungbean seed yield ranging from 27 to 100% (Malik et al., 2000; Pandey & Mishra, 2003; Raman & Krishnamoorthy, 2005) depending upon type of weeds, density of weeds, duration of weed infestation, time and method of crop sowing, fertilizer application method and other environmental factors (Mansoor et al., 2004).

Weed-crop competition is an important aspect of all biological factors that can considerably reduce the crop yield (Deen et al., 2003). This happens mainly due to higher resource utilization potential of weeds than that of crop (McDonald et al., 2004). Numerous studies have assessed the crop weed competition period in a variety of crops and measured its significance and the timing of optimum weed control (Norsworthy & Oliveira, 2004). For attaining an effective weed control, knowledge of critical period of weedcrop competition is necessary, as it plays a decisive role in weed management (Deen et al., 2003). Mungbean is considered to be a sensitive crop to weed competition (Moody, 1978). Keeping in view the importance of *R. capitata* management in mungbean, the present study was planned to assess the competitive ability of *R. capitata* and the yield losses in mungbean caused by *Rhynchosia capitata* under irrigated conditions.

MATERIAL AND METHODS

The study was carried out in mungbean fields for two consecutive years (2011 and 2012) having a heavy invasion of *R. capitata* since 2005. The experiment was laid out in a randomized complete block design with 4 replications. The treatments comprised zero competition (control), weed crop competition for 3, 4, 5, 6 and 7 weeks after planting and full season competition. The soil was sandy loam with pH of 8.0 and 8.3 and EC of 1.11 and 1.04 dS/m during the first and second years of study, respectively. Organic matter, total N, available P and K were 0.55%, 0.029%, 5.54 mg kg^{-1}, 240 mg kg^{-1} during the first year (2011) and 0.71%, 0.039%, 8.03 mg kg^{-1} and 173 mg kg^{-1} during the second year (2012) of study. During the growing season of mungbean, meteorological data regarding temperature and rainfall (means on a monthly basis) were obtained from the

Agronomic Research Station, Karor, district Layyah, Punjab, Pakistan (Figure 1).

A pre-soaking irrigation was applied before the seed bed preparation. When the soil reached the proper moisture level (field capacity), the seed bed was prepared by cultivating the soil 2-3 times with the tractor mounted cultivator, each time followed by planking. Mungbean (cv. AZRI-2000) was planted at a seed rate of 25 kg ha^{-1} with single row hand drill in 30 cm apart rows. Plant to plant distance of 15 cm was maintained by thinning out the extra plants 10 days after emergence. Net plot size was 1.2 m x 6 m. Three irrigations were applied at three weeks after sowing, at the flower initiation stage and at seed filling stage to avoid drought stress to crop. Nitrogen and phosphorus were applied at 25 and 50 kg ha^{-1} in the form of urea and diammonium phosphate (DAP), respectively at the time of sowing of mungbean. Weeds were removed manually with a hand hoe from the respective plots after the prescribed duration and then kept weed free till harvest.

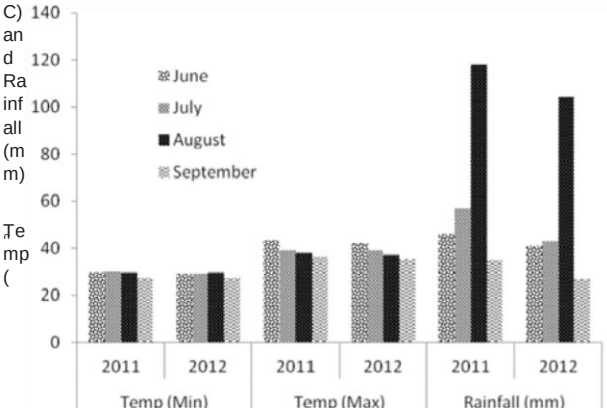


Figure 1 - Climatic data for the growth season of mungbean for 2011 and 2012.

All the other agronomic practices were kept uniform for all the treatments from sowing till harvesting. In each year, mungbean was manually harvested by sickle in the 2nd week of September at ground level, bundled, air-dried, and weighed.

Standard procedures were adopted for recording the data on various growth and yield parameters of *R. capitata* and mungbean. Ovendried plant samples of *Rhynchosia capitata* were ground with a grinder and NPK contents (%) were determined as suggested by AOAC (1984) and micronutrient contents were determined as suggested by Jan et al. (2011). Individual year data were subjected to statistical analysis by using Fisher's Analysis of Variance techniques (Steel et al., 1997). The polynomial trends across the treatments were compared. Three components of trend in increasing complexity, i.e. linear, quadratic, and cubic were analyzed. Least significant difference (LSD) test was applied at 5% probability level to test the significance of treatment means.

RESULTS AND DISCUSSION

Dry weight of *R. capitata* was considerably affected by varying *R. capitata* competition periods. It showed an increasing tendency as the *R. capitata* competition period was extended (Figure 2). Maximum dry weight (58.25 g, 67.25 gm^{-2} in 2011 and 2012, respectively) of *R. capitata* was observed in plots where *R. capitata* plants were allowed to compete with the mungbean crop for full season. These results are in line with those of Naeem et al. (2000) who also reported a linear increase in weed dry weight with increase in the weed-crop competition period of mungbean.

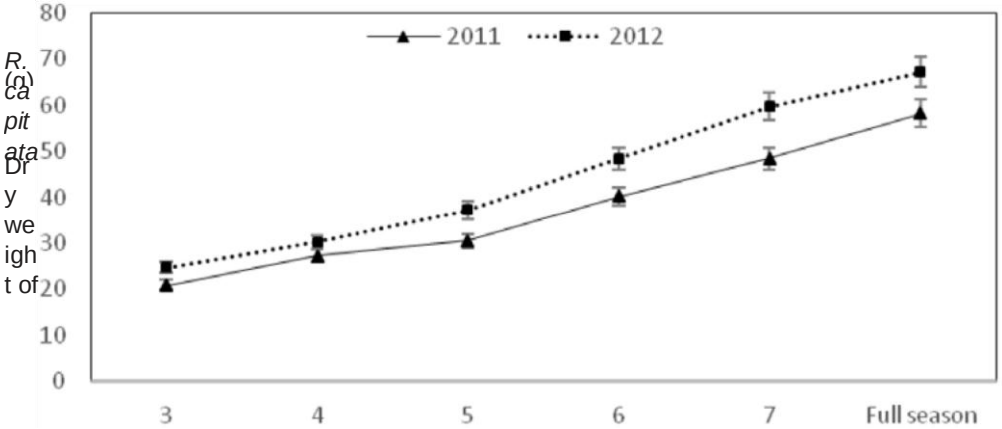


Figure 2 - Effect of the weed crop competition period on the dry weight of *R. capitata.*

Significant differences in NPK contents and uptake by *R. capitata* were observed during both years (Table 1). There was a linear increase in the NPK contents (%) and uptake (kg ha^{-1}) by *R. capitata* with increase in the *R. capitata* competition period. Minimum NPK contents and uptake by *R. capitata* were recorded in the competition period of 3 weeks during both years of the study. During both years of the study, *R. capitata* NPK contents showed an increasing linear response whereas NPK uptake showed a linear as well as a quadratic response to its increasing competition period (Table 1). In competition periods of 3 and 4 weeks, *R. capitata* plants were not fully grown, hence resulting into lesser competition as compared to competition periods of 5, 6 and 7 weeks. Hence, *R. capitata* plants had less NPK contents in the short duration competition period (3-4 weeks) as compared to the longer competition period (5-7 week competition).

The linear increase in the NPK contents with the enhancement of *R. capitata* competition periods may possibly be due to more use of light, water and nutrients by *R. capitata*. More biomass observed in the weedy check could be the outcome of a higher N uptake by *R. capitata* as weed plants remained in the field throughout the cropping season. These results are supported by the research findings of Anjum et al. (2007) and Ikram et al. (2012) who reported that N uptake by weeds have increased in weedy check. More P uptake by *R. capitata* during 2012 than during 2011 was due to better climatic conditions during 2012 as more rainfall was received during 2012 (Table 1). The same could have happened for K as its uptake also increased with the increase in weed-crop competition periods. These results are also in accordance with the research findings of Anjum et al. (2007) who reported that K uptake by *T. portulacastrum* was the highest in the treatment where weeds were allowed to grow throughout the cropping season. The faster growth of weeds compared to crops causes quick depletion of nutrients from soil. Weeds removed 72.19 kg ha^{-1} of K_2O in weedy plots (Gaikwad & Pawar, 2003).

Micronutrient contents of *R. capitata* were also significantly affected by different crop competition periods (Tables 2 and 3). The highest Fe, Mn, Na, Zn, Ca, Cu and Mg contents and their subsequent uptake was observed in the plots where *R. capitata* plants were allowed to compete with mungbean

Table 1 - Macronutrient contents and uptake by *R. capitata* at different competition durations with mungbean

Duration of weed-crop competition (WAP)**	N				P				K			
	Content (%)		Uptake (kg ha^{-1})		Content (%)		Uptake (kg ha^{-1})		Content (%)		Uptake (kg ha^{-1})	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
3	1.37*f	1.49 f	3.12 e	3.70 e	1.39 d	1.40 e	2.92 e	3.50 e	2.16 e	2.23 f	4.54 e	5.52 f
4	1.72 e	1.82 e	4.95de	5.49 e	1.49 d	1.51 e	4.06 d	4.57 e	2.27 e	2.36 e	6.19 de	7.15 e
5	2.13 d	2.27 d	6.95 d	8.43 d	1.65 c	1.75 d	5.07 d	6.54 d	2.49 d	2.53 d	7.57 d	9.46 d
6	2.56 c	2.71 c	10.92 c	13.18 c	1.80 b	1.94 c	7.27 c	9.44 c	2.66 c	2.72 c	10.72 c	13.20 c
7	3.03 b	3.16 b	15.31 b	18.89 b	1.98 a	2.19 b	9.63 b	13.12 b	2.92 b	2.99 b	14.18 b	17.89 b
Full seasons	3.47 a	3.88 a	22.66 a	26.19 a	2.11 a	2.42 a	12.29 a	16.31 a	3.15 a	3.26 a	18.36 a	21.98 a
LSD (0.05)	0.272	0.217	2.397	1.895	0.138	0.166	1.119	1.477	0.134	0.085	1.824	1.516
Trend comparison of different weed-crop competition periods (3 to 7 weeks)												
Linear	**	**	**	**	**	**	**	**	**	**	**	**
Quadratic	NS	NS	**	**	NS	NS	NS	**	NS	NS	**	**
Cubic	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

WAP: Weeks after Planting. Means followed by the same letter in a column did not differ significantly according to LSD test ($P < 0.05$). NS, * and ** indicate non-significant, significant at $P \leq 0.05$ level of probability, respectively.

Table 2 - Micronutrient contents (Cu, Mg, Na, Ca) and uptake by *R. capitata* at different competition durations with mungbean

Duration of weed-crop competition (WAP)**	Cu				Mg				Na				Ca			
	Content (mg kg^{-1})		Uptake (g ha^{-1})		Content (mg kg^{-1})		Uptake (mg kg^{-1})		Contents (kg mg^{-1})		Uptake (g ha^{-1})		Contents (kg mg^{-1})		Uptake (g ha^{-1})	
	2011	2012	2011	2011	2012	2011	2012	2012	2011	2012	2011	2012	2011	2012	2011	2012
3	5.94 f	6.41 d	1.24 e	1.59 e	23.53 f	26.82 d	4.91 e	1.40 e	14.58 d	17.14 e	3.02 d	4.16 e	0.59 d	0.75 d	1.24 e	1.89 f
4	6.45 e	7.14 d	1.75 de	2.16 e	26.25 e	30.48 cd	7.16 de	2.50 de	16.76 cd	20.18 de	4.53 cd	6.03 e	0.66 cd	0.89 c	1.83 de	2.71 e
5	7.06 d	8.17 c	2.15 d	3.04 d	29.50 d	34.73 c	9.00 d	3.97 d	19.50 c	24.74 cd	5.95 c	9.17 d	0.74 c	1.06 b	2.26 d	3.99 d
6	7.60 c	9.06 b	3.06 c	4.39 c	32.75 c	40.36 b	13.17 c	7.90 c	23.50 b	28.50 bc	9.47 b	13.81 c	0.89 b	1.24 a	3.59 c	6.04 c
7	8.27 b	9.74 ab	4.01 b	5.83 b	35.50 b	44.41 ab	17.21 b	12.88 b	26.75 b	32.16 ab	15.62 a	19.20 b	1.02 ab	1.30 a	4.99 b	7.76 b
Full season	8.87 a	10.47 a	5.16 a	7.05 a	39.67 a	47.17 a	23.18 a	18.34 a	32.16 a	34.95 a	15.49 a	23.49 a	1.10 a	1.34 a	6.45 a	9.03 a
LSD(0.05)	0.139	0.858	0.527	0.782	2.702	4.585	2.941	1.679	3.400	5.799	1.689	2.070	0.137	0.104	0.945	0.785
Trend comparison of different weed-crop competition periods (3 to 7 weeks)																
Linear	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**
Quadratic	NS	NS	**	NS	NS	NS	**	**	NS	NS	**	**	NS	NS	NS	**
Cubic	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

WAP: Weeks after Planting. Means followed by the same letter in a column did not differ significantly according to LSD test ($P < 0.05$). NS, * and ** indicate non-significant, significant at $P \leq 0.05$ level of probability, respectively.

throughout the crop growing season. In trend comparisons of different weed-crop competition periods, only the linear trend was significant with respect to *R. capitata* micronutrient content. However, regarding micronutrient uptake by *R. capitata*, both the linear and quadratic trends were significant. As with the extension in competition period, the uptake of micronutrient by *R. capitata* also increased. Hence the mungbean plants had fewer micronutrients available for their better growth and development with the increase in *R. capitata* competition duration. These results are similar to the findings of Khattak et al. (2006), who found that Fe, Mn, Zn, Ca, Cu and Mg contents of Amarnath (*Amaranthus retroflexus*) were 28.7, 3.8, 4.3, 721.2, 1.1 and 654.8 per 100 g dry weights, respectively. The contents of these minerals in wild onion (*Allium stellatum*) were 0.46, 0.56, 2.98, 45.5, 2.98 and 154.7 mg per 100 g dry weight, respectively.

Number of pods per plant, number of seeds per pod and 1000-seed weight of mungbean were significantly affected by different *R. capitata* competition periods during both years of study (Table 4). The highest number of pods per plant, number of seeds per pod and 1000-seed weight of mungbean wer observed in weed-free plots during both years. Trend comparison of different weed-crop competition periods with respect to these yield components showed that a linear trend was significant. Increased yield indices like number of pods, number of seeds per pods and 1000-seed weight in weed free and short duration competition were due to more availability of light, water etc. and nutrient reserves for mungbean under these conditions, while *R. capitata* plants competing with mungbean for 6-7 weeks or entire season obtained the highest opportunity to make use of nutrient reserves available to the crop, eventually resulted in lower yield indices of mungbean. These results are supported by the findings of Naeem et al. (2000), who reported that the number of pods per plant of mungbean was severely affected by the prolonged competition of weeds and Pascua (1988) also reported that increasing the weed competition period causes a remarkable decrease in the number of pods in mungbean.

Table 3 - Micronutrient contents (Fe, Mn, Zn) and uptake by *R. capitata* at different competition durations with mungbean

Duration of weed-crop competition (WAP)**	Fe				Mn				Zn			
	Content (%)		Uptake (kg ha^{-1})		Content (%)		Uptake (kg ha^{-1})		Content (%)		Uptake (kg ha^{-1})	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
3	39.97 d	47.60 d	8.45 e	11.84 e	31.02 f	38.77 e	6.59 e	9.45 f	16.90 d	20.15 e	3.02 d	4.16 e
4	47.59 d	58.97 cd	12.89 de	17.52 e	35.42 e	48.06 d	9.61 de	14.43 e	18.50 d	24.30 d	4.53 cd	6.03 e
5	61.25 c	72.45 c	18.68 d	27.08 d	40.25 d	60.49 c	12.20 d	22.47 d	21.25 c	28.93 c	5.95 c	9.17 d
6	75.06 b	87.74 b	30.22 c	42.56 c	47.80 c	72.63 b	19.23 c	35.19 c	23.50 bc	33.72 b	9.47 b	13.81 c
7	90.99 a	100.29 ab	44.06 b	59.86 b	57.05 b	79.75 ab	27.66 b	47.67 b	25.75 b	35.53 b	15.62 a	19.20 b
Full season	97.50 a	112.25 a	57.09 a	75.47 a	63.50 a	83.14 a	36.92 a	55.91 a	29.75 a	40.51 a	15.49 a	23.49 a
LSD (0.05)	8.864	14.77	8.925	6.542	3.707	7.725	3.232	3.293	2.602	3.310	1.689	2.070
Trend comparison of different weed-crop competition periods (3 to 7 weeks)												
Linear	**	**	**	**	**	**	**	**	**	**	**	**
Quadratic	NS	NS	**	**	NS	NS	**	**	NS	NS	**	**
Cubic	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

WAP: Weeks after Planting. Means followed by the same letter in a column did not differ significantly according to LSD test ($P < 0.05$). NS, * and ** indicate non-significant, significant at $P \leq 0.05$ level of probability, respectively.

Table 4 - Effect of the weed competition periods on yield and yield parameters of mungbean

Weed-crop competition (WAP)	Number of pods per plant		Number of seeds per pod		1000-seed weight (g)		Seed yield (kg ha^{-1})	
	2011	2011	2011	2011	2011	2012	2011	2012
0	38.50 a	29.50 a	10.50 a	9.75 a	54.00 a	47.25 a	1688.6 a	1495.5 a
3	36.00 b	25.25 b	10.25 ab	9.25 ab	50.50 b	46.00 ab	1582.0 b	1404.0 b
4	34.25 b	23.00 b	9.75 ab	8.75 bc	48.25 b	43.75 b	1477.8 c	1300.3 c
5	31.50 c	20.25 c	9.50 bc	8.12 c	44.00 c	40.50 c	1308.3 d	1187.3 d
6	29.50 c	18.50 cd	8.75 cd	8.00 c	40.75 d	37.75 d	1155.6 e	1036.3 e
7	27.25 d	17.00 d	8.25 d	8.00 c	37.00 e	35.50 d	975.8 f	878.8 f
Full season	23.25 e	14.00 e	8.000 d	8.12 c	34.75 e	30.50 e	869.3 g	803.8 g
LSD	2.2225	2.395	0.999	0.830	2.977	2.538	46.899	52.739
Trend comparison of different weed-crop competition periods (3 to 7 weeks)								
Linear	**	**	**	**	**	**	**	**
Quadratic	NS	NS	NS	NS	NS	NS	NS	NS
Cubic	NS	NS	NS	NS	NS	NS	NS	NS

WAP: Weeks after Planting. Means followed by the same letter in a column did not differ significantly according to LSD test ($P < 0.05$). NS, * and ** indicate non-significant, significant at $P \leq 0.05$ level of probability, respectively.

Weed competition duration had a significant effect on mungbean seed yield per hectare during both years. Increasing *R. capitata* competition period considerably decreased the seed yield of mungbean (Table 4). Moreover, mungbean seed yield response to increasing *R. capitata* competition duration was linear during both experimental years. During both years, the highest seed yield was recorded in weed-free plots and the declining yield was observed as the competition period was prolonged. In the weedy check (competition for full season), 49 and 46% yield losses were observed for 2011 and 2012, respectively, and minimum yield losses (6%) were observed in the 3 week competition

period (Figure 5). Correlation analysis has showed that seed yield of mungbean had a strong negative association with the *R. capitata* competition period (Figure 3) and *R. capitata* dry weight (Figure 4) during both years of study.

adverse effect on the yield potential of mungbean. These results are in great agreement with those of Naeem et al. (2000),

Competition period (weeks)

Figure 3 - Regression analysis of effect of the competition period on seed yield of mungbean.

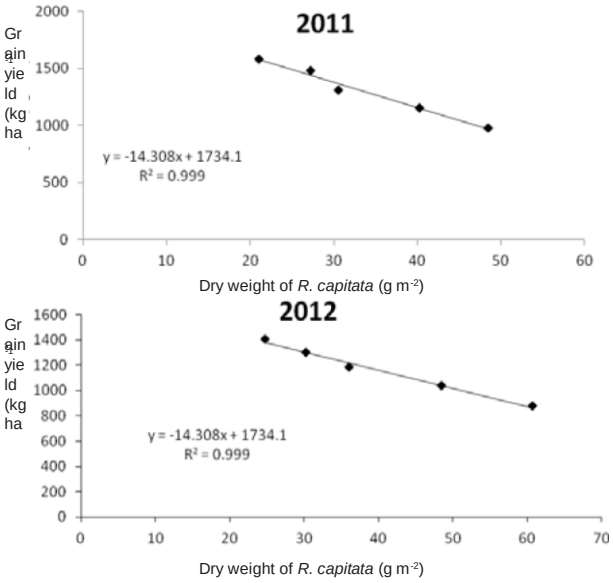
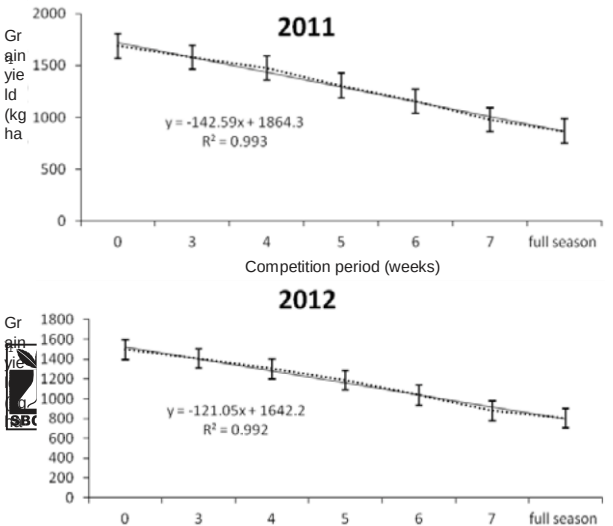


Figure 4 - Correlation between the dry weight of *R. capitata* and seed yield of mungbean.

The decrease in seed yield with increase in the competition period was due to a decrease in the major yield components like number of pods per plant, number of seeds per pod and 1000-seed weight. The results further led to the conclusion that *R. capitata* competition with crop up to 3 weeks after planting of mungbean crop had little effect on growth and development of mungbean, while extended *R. capitata* competition duration had an who found that weed competition duration had a significant effect on final seed yield per hectare in mungbean. Utomo (1989) also reported that the mungbean crop was very sensitive to competition from weeds during 3 to 6 weeks after planting. Malik et al. (2000) also reported that weed competition with mungbean decreased seed yield by 81% and according to Raman & Krishnamoorthy (2005) weed-crop competition for the whole mungbean crop season decreased the mungbean seed yield by 35%. It was also observed in these experiments that the *R. capitata* completes its growth stages with the mungbean crop and a great quantity of *R. capitata* seed was dispersed into the soil before the crop was harvested. If *R. capitata* will be eliminated or disturbed earlier than its seed set, the mungbean yield losses will be lessened in the long run. *Rhynchosia capitata* can significantly decrease the seed yield of mungbean up to 49% if left uncontrolled for the whole crop season; therefore its early management is crucial.



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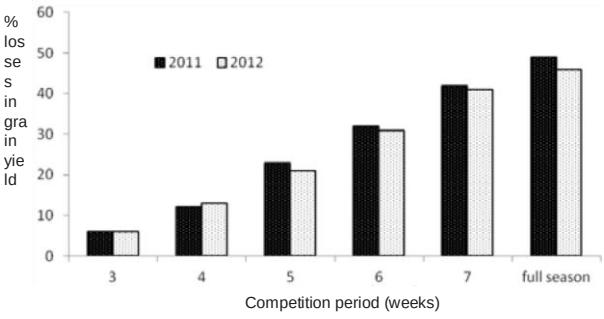

Figure 5 - Yield losses (%) in mungbean with increasing *R. capitata* competition periods.

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