Research Article

Response of Wheat to Varying Densities of *Rumex Dentatus* under Irrigated Condition of Dera Ismail Khan, Pakistan

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Abstract | Toothed dock (*Rumex dentatus* L) is a problematic weed found in wheat crop. The study was conducted to investigate the competitive effects of *Rumex dentatus* sown at varying densities in association with wheat (*Triticum aestivum* L.) under field conditions. The experiment was conducted at Agronomic Research Farm, Faculty of Agriculture, Gomal University, Dera Ismail Khan in randomized complete block design having three replications during 2013-2014. The treatments comprised of wheat + *Rumex dentatus* 0 plants m^{-2} (T1), wheat + *Rumex dentatus* 05 plants m^{-2} (T2), wheat + *Rumex dentatus* 10 plants m^{-2} (T3), wheat + *Rumex dentatus* 15 plants m^{-2} (T4), wheat + *Rumex dentatus* 20 plants m^{-2} (T5), wheat + *Rumex dentatus* 25 plants m^{-2} (T6), and wheat + *Rumex dentatus* 30 plants m^{-2} (T7). The results revealed that plant height, spikes m^{-2}, spike length, spikelets $spike^{-1}$, grains $spike^{-1}$, 1000-grain weight, biological yield, grain yield, harvest index and losses in grain yield were significantly affected by *Rumex dentatus* population. All parameters decreased with increasing density of *Rumex dentatus* except loss in grain yield which increased (1.3 to 69.8%) with increasing density of *Rumex dentatus* (from 5 to 30 plants m^{-2}). The threshold level of *Rumex dentatus* was observed in T5 and became worse with further increase in population density of *Rumex dentatus*. It is concluded that yield and yield related parameters were adversely affected in case of higher infestation of *Rumex dentatus* as it competes with the major crop for resources and exhibits auto-toxicity when grown in association with wheat crop.

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Introduction

Average yield of major crops is low in Pakistan (Jabeen and Ahmad, 2009). The reasons for low yield are high inputs cost, limited irrigation water, poor quality seed, old traditional farming methods, imbalanced fertilization and weeds infestation (Nasir and Sultan, 2004). Weeds compete with the crop plants for nutrients, sunlight and moisture and thus reduce the ultimate yield of crops. Therefore, proper control of weeds is vital to avoid or reduce yield losses to the crops (Norris, 1982). Losses to the major crops due to weeds are estimated to be 20 - 30 percent in Pakistan (MINFAL, 2005). Weeds can be effectively controlled with herbicides but they affect environment and their residual effects remain in soil for a longer period having negative impacts on soil microbes (Chung et al., 2003). Weeds can also be controlled manually which is safe from environmental point of view but it is not feasible on large scale particularly during peak labor work in the field. Therefore, the best option is to divert weed crop competition in favor of crop. All major field crops infested with weeds do not need to apply urgent weed control strategy. But it is the threshold level of weeds infestation that indicates as how and which management techniques should be adopted to

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control weeds. Therefore, it is wise to investigate the threshold level of problematic weed that affects wheat productivity if not controlled in time.

Competition of weeds with crops is a major problem in realizing yield potential of wheat. Because crops need large amount of fertilizers and irrigation, both of which favour weed growth (Chhokar et al., 2007). Wheat crop is infested both by grasses and broad-leaved weeds. Among the grasses, *Phalaris minor* Retz. and among broad leaved weeds, *Rumex dentatus* are of major concerns in irrigated wheat (Naseer-ud-Din et al., 2011; Chhokar et al., 2008; Ahmad et al., 1991). *Rumex dentatus* is highly competitive weed that can reduce wheat yield drastically in case of heavy infestation. Therefore, focus of the present research was to investigate the competitive effects of *Rumex dentatus* sown at varying densities in association with wheat crop.

Materials and Methods

An experiment was conducted under irrigated condition at Agronomic Research Farm, Faculty of Agriculture, Gomal University, D.I. Khan during 2013-2014 in order to know response of wheat to varying densities of *Rumex dentatus*. The experimental site was a hyperthermic and typic torrifluvents with limited annual rainfall (200-280mm) and needed irrigation for raising crops (Soil Survey, 2009). The soil was silty clay. The meteorological data were collected from the nearby Arid Zone Research Station, Dera Ismail Khan, Pakistan (Table 1). The experiment was laid out in randomized complete block design (RCBD) with three replications using a net plot size of 3 m × 1.8 m (5.4 m^2). The recommended wheat variety Sahar-2006 was sown during mid October, 2013 in rows 30 cm apart with the help of single row man driven hand drill. The seed rate used was125 kg ha^{-1}. The experiment comprised of varying density of *Rumex dentatus* (0, 5, 10, 15, 20, 25 and 30 plants m^{-2}) while the wheat density was kept constant. The density of *Rumex dentatus* was maintained as number of *Rumex dentatus* plants m^{-2} × area of individual plot. N, P, and K were applied at the rate of 120, 90, and 60 kg ha^{-1} from the Fertilizers, urea, TSP, and potassium sulphate, respectively. The whole of the phosphorus, potash and half of the N was applied at sowing while the remaining half of the N was applied in two equal splits with subsequent irrigations. All other weeds were removed manually throughout the crop season on weekly basis.

Table 1: *Mean monthly temperature, evaporation and rainfall during 2013-2014 wheat growing season*

Month	Temperature °C		Pan evaporation mm/day	Rainfall (mm)
	max	min		
Oct	33	21	4.05	5.5
Nov	27	9	2.25	-
Dec	22	6	0.97	1
Jan	21	4	1.64	-
Feb	21	7	1.70	38
Mar	24	12	2.39	50

The crop was irrigated as required. Total of five irrigations were given during the growing season. First irrigation was given 20 days after crop emergence (first week of November). The subsequent irrigations were given with one month interval. Water depth of 5 cm was maintained during irrigation. All other cultural practices were kept normal and uniform for all the treatments. The detail of the experimental treatments were: T1 (Wheat + *Rumex dentatus* 0 plants m^{-2}), T2 (Wheat + *Rumex dentatus* 05 plants m^{-2}), T3 (Wheat + *Rumex dentatus* 10 plants m^{-2}), T4 (Wheat + *Rumex dentatus* 15 plants m^{-2}), T5 (Wheat + *Rumex dentatus* 20 plants m^{-2}), T6 (Wheat + *Rumex dentatus* 25 plants m^{-2}) and T7 (Wheat + *Rumex dentatus* 30 plants m^{-2}). The seed rate of wheat (125 kg ha^{-1}) was kept constant in all the experimental plots. The parameters studied were plant height at maturity (cm), spike length (cm), number of spikes per m^{-2}, number of spikelets $spike^{-1}$, number of grains $spike^{-1}$, 1000-grain weight (g), biological yield (kg ha^{-1}), grain yield (kg ha^{-1}), grain yield losses (t ha^{-1}) and harvest index (%).

Statistical analysis

The data were analyzed statistically using analysis of variance techniques (Steel and Torrie, 1997) and then LSD test was used with the help of MSTATC (Michigan State University, East Lansing) software program (MSTATC, 1991).

Results and Discussion

Plant height

Plant height was significantly affected by various densities of *Rumex dentatus* as given in Table 2. Plant height had the quadratic response to increasing population of *Rumex dentatus* and remained constant at T5 (20 plants of *Rumex dentatus* m^{-2}) and onwards (Figure 1).

Table 2: *Plant height (cm), spikes (m^{-2}), spike length (cm) and spikelets $spike^{-1}$ in wheat as influenced by competitive effects of Rumex dentatus*

Treatments	Plant height	Spikes m^{-2}	Spike length	Spikelets $spike^{-1}$
T1	87.5 a	209.0 a	11.9 a	17.0 a
T2	82.5 b	208.3 a	10.9 b	17.0 a
T3	79.3 c	192.7 b	9.6 c	14.3 b
T4	77.5 d	187.0 b	8.4 d	12.7 bc
T5	72.7 e	154.0 c	7.7 e	11.3 cd
T6	72.1 e	150.0 c	6.6 f	11.3 cd
T7	72.0 e	122.0 d	6.3 f	10.7 d
$LSD_{0.05}$	1.6588	7.0983	0.5049	1.9084

Note: *Means followed by common letters do not differ significantly at P≤0.05.*

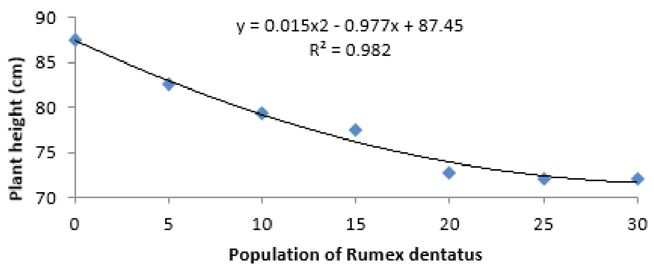

Figure 1: *Plant height as affected by various population of Rumex dentatus*

The highest plant height (87.5 cm) was achieved from weeds free plots having zero population of *Rumex dentatus*. The lowest plant height was obtained from T5 (72.7 cm), T6 (72.1 cm) and T7 (72.0 cm) plots infested with 20, 25, and 30 plants m^{-2} of *Rumex dentatus*, respectively. Our results are in agreement with that of (Panneerselvam and Lourduraj, 2000) who reported that plant height was negatively affected by growing density of weeds.

Spikes m^{-2}

Data regarding spikes m^{-2} was significantly affected by varying densities of *Rumex dentatus* (Table 2). Data revealed that spikes m^{-2} reduced with increase in *Rumex dentatus* population and showed quadratic response (Figure 2). Higher spikes were obtained from T1 and T2 as against T7 having lowest number of spikes m^{-2}. The results revealed that competitive effects of *Rumex dentatus* were more pronounced in T5, T6, and T7 compared to T1, T2, T3 and T4. These results indicate that *Rumex dentatus* is more harmful in reducing fertile tillers if population exceeds 20 plants m^{-2}. The results are in conformity with those of (Chandramohan et al., 2002) who reported that weeds compete with crops for resources such as light, nutrients, moisture, and space and hence reduce tillering capacity of crop plants.

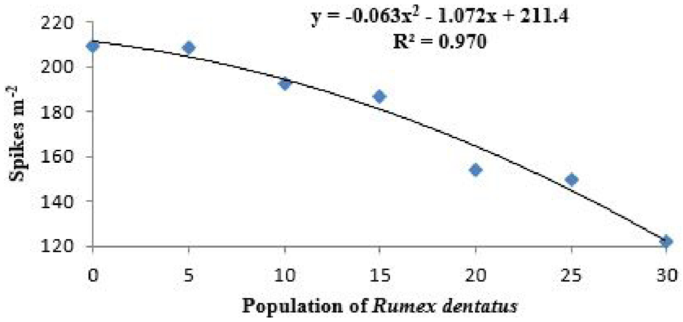

Figure 2: *Spikes (m^2) as affected by various population of Rumex dentatus*

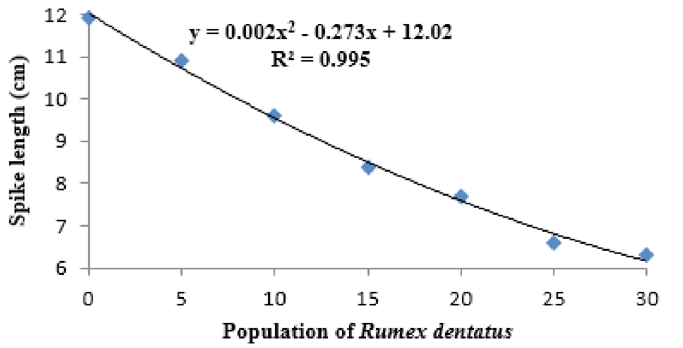

Figure 3: *Spike length (cm) as affected by various population of Rumex dentatus*

Spike length

Spike length was significantly affected by varying densities of *Rumex dentatus* (Table 2). Spike length had curvilinear response to the gradual increase in population of *Rumex dentatus* (Figure 3). The longest spikes could be achieved from T1 as against T6 and T7 both treatments with shortest spikes. The results revealed that higher density of *Rumex dentatus* resulted in shorter spikes due to more competitive effects of weeds for resources. Similar findings were obtained by (Bertholdsson, 2004) who reported that important yield traits may be negatively affected in presence of severe weeds infestation.

Spikelets spike^{-1}

Spikelets spike^{-1} were also significantly affected by competitive effects of *Rumex dentatus* as evident from (Table 2). Spikelets spike^{-1} showed declining trend with increasing population of *Rumex dentatus* (Figure 4) The results revealed that T1 and T2 had the highest number of spikelets spike^{-1} while sharp decline in spikelets spike^{-1} initiated from T5 and onwards. This shows that *Rumex dentatus* threshold level starts from T5, where 20 plants of *Rumex dentaus* had quite negative impact on yield attributes as reported by other researchers (O'Donovan et al., 2000).

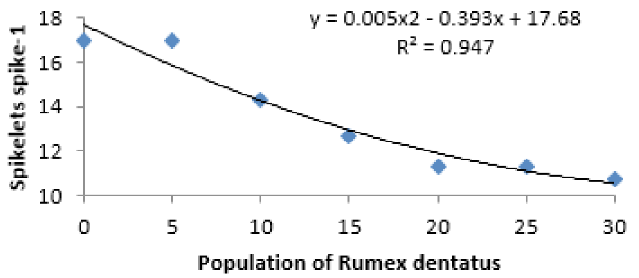

Figure 4: *Spikelets spike^{-1} affected by various population of Rumex dentatus*

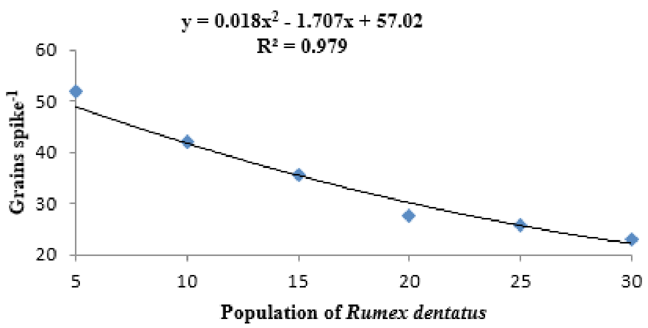

Figure 5: *Grains spike^{-1} as affected by various population of Rumex dentatus*

Grains spike^{-1}

Data on grains spike^{-1} was significant for varying population of *Rumex dentatus* (Table 3). There was decreasing trend in grains spike^{-1} with incremental increase in population of *Rumex dentatus* with the highest value recorded in T1, weed free plot (Figure 5). The lowest numbers of grains spike^{-1} were obtained from T6 and T7. The results revealed that pronounced competitive effects of *Rumex dentatus* initiated in T6 and reached to climax in T7. The results indicate that tough competition between crop and weed started when weeds population exceeded above 20 plants m^{-2}.

Table 3: *Grains spike^{-1}, 1000-grain weight and biological yield of wheat as affected by varying densities of Rumex dentatus.*

Treatments	Grains spike^{-1}	1000-grains weight (g)	Biological yield (kg ha^{-1})
T1	55.0 a	44.8 a	16306 a
T2	52.0 a	43.9 ab	16269 a
T3	42.0 b	43.3 b	14516 b
T4	35.7 c	42.9 bc	11481 c
T5	27.7 d	42.0 cd	10387 d
T6	25.7 de	41.8 d	8349 e
T7	23.0 e	41.1 d	8341 e
$LSD_{0.05}$	3.5580	1.0661	711.79

Note: *Means followed by common letters do not differ significantly at P≤0.05.*

Similar findings were reported by other weed scientists (siddiqui et al., 2010).

1000-grain weight

Thousand grains weight had significant response to varying population of *Rumex dentatus* when sown in association with wheat crop (Table 3). The 1000-grains weight adopted similar trend as presented for grains spike^{-1} (Figure 6). The highest grain weight could be achieved from weed free treatment while lowest grain weight was recorded in T7 (densely populated weed infested treatment). The results indicate that like other yield attributes 1000-grain weight was also negatively affected when there was competition for resources such as moisture and nutrients as reported by other researchers (Javaid et al., 2007; Oerke et al., 1994).

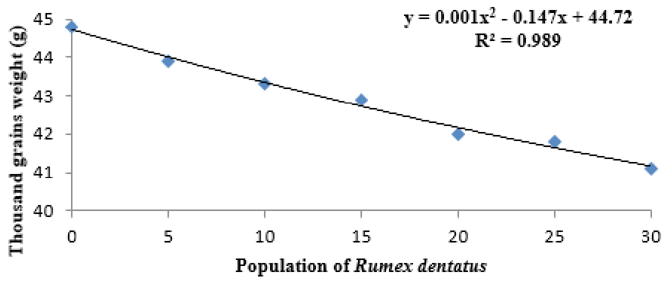

Figure 6: *Thousand grains weight as affected by various population of Rumex dentatus*

Biological yield

Biological yield was significantly modified by varying densities of *Rumex dentatus* (Table 3). The highest biological yield could be realized in T1 (weed free plot) and T2 (lowest population of *Rumex dentatus*).

On the other hand higher density of *Rumex dentatus* led T6 and T7 to the lowest biological yield probably due to more weed-crop competitions. The results revealed that biological yield declined with an increase in population density of *Rumex dentatus* (Figure 7). However, active competition between weeds and crop initiated when weed density exceeded 20 plants m^{-2}. The competition for resources became more severe in T7 (at the highest density of *Rumex dentatus*). These results are in conformity with those of (Chhokar and Malik, 2002) who reported that wheat yield may be declined by 80% depending on weed density.

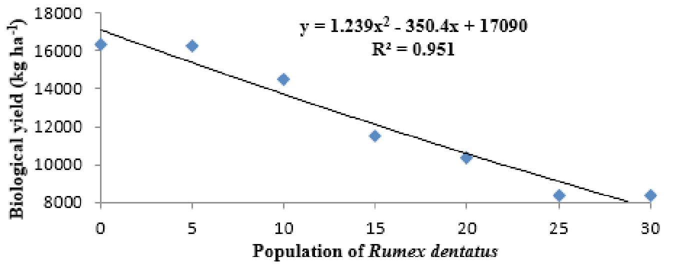

Figure 7: *Biological yield as affected by various population of Rumex dentat*

Grain yield

Grain yield was significantly affected by weed-crop competition (Table 4). The treatments T1 (6463 kg ha^{-1}) and T2 (6381 k ha^{-1}) had the highest grain yield while T6 (2116 kg h^{-1}) and T7 (1949 kg ha^{-1}) had lowest grain yield. Generally, there was a decreasing trend in grain yield with an increase in weed density (Figure 8). The data revealed that threshold level of *Rumex dentatus* was observed in T5 to T7 as these treatments severely affected grain yield probably due to tough competition between *Rumex dentatus* and crop plants. The results also revealed that population density of *Rumex dentatus* was not alarming in T1, T2, and T3 as the competition was in favor of crop rather than weed. These results are supported by Singh et al. (2013) who communicated that grain yield was least affected when competition was diverted in favor of crop rather than weed.

Grain yield losses

Data on grain yield losses were significantly affected by various population densities of *Rumex dentatus* (Table 4). All treatments infested with *Rumex dentatus* showed variable percentage of grain yield losses with the highest value recorded in T7, densely populated treatment with *Rumex dentatus*. Since T1 was weed free plot, hence no losses were recorded in this treatment. The results revealed that more pronounced grain yield losses occurred at threshold level of weeds density that normally occurred in T5, T6, and T7. Since infestation was less in T2 and T3, therefore, losses in these treatments were also less accordingly. The results revealed that grain yield losses were considerable in T5, T6, and T7 due to severe weed- crop competition and hence must be paid due attention when weed control strategy is adopted. Regression analysis revealed that grain yield losses were more with increasing population of *Rumex dentatus* (Figure 9).

Table 4: *Grain yield, grain yield losses and harvest index of wheat as affected by varying densities of Rumex dentatus*

Treatments	Grain yield (kg ha^{-1})	Grain yield losses (%)	Harvest index (%)
T1	6463 a	-	39.6 a
T2	6381 a	1.3 e	39.2 ab
T3	5399 b	16.5 d	37.2 ab
T4	4131 c	36.1c	36.0 b
T5	3135 d	51.5 b	30.2 c
T6	2116 e	67.3 a	25.3 d
T7	1949 e	69.8 a	23.4 d
$LSD_{0.05}$	472.6	6.436	3.566

Note: *Means followed by common letters do not differ significantly at P≤0.05.*

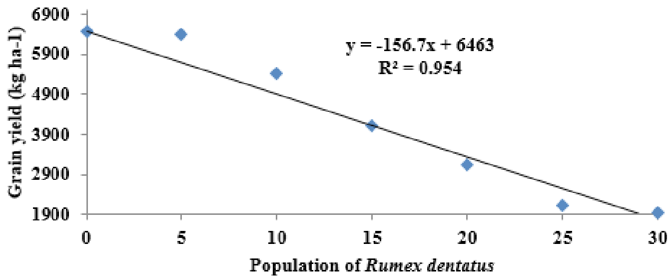

Figure 8: *Grain yield (kg ha^{-1}) as affected by various population of Rumex dentatus*

Harvest index

Harvest index was significantly affected by competitive interaction of weeds and crop plants (Table 4). The results revealed that harvest index was at par for treatments T1, T2 and T3 being in the range of 37.2 to 39.8%. The lowest harvest index was recorded in highly infested treatments i.e. T6 (25.4%) and T7 (23.4%). The results revealed that weed crop active competition affected assimilate partitioning to grains and hence more weeds infested treatments resulted in lower harvest index. There was a declining trend in harvest index with increasing population of *Rumex*

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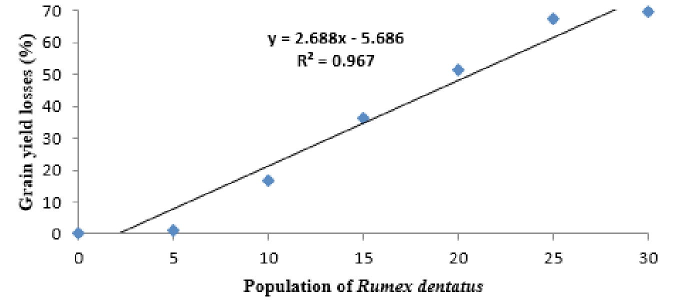

Figure 9: *Grain yield losses (%) as affected by various population of Rumex dentatus*

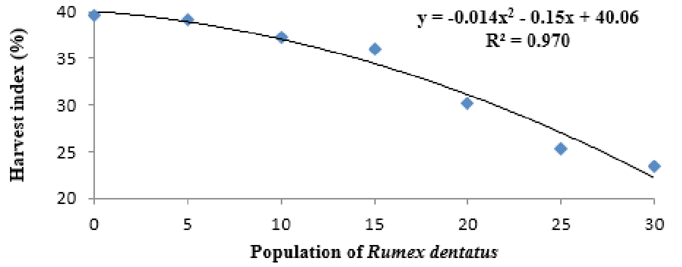

Figure 10: *Harvest index (%) as affected by various population of Rumex dentatus*

dentatus (Figure 10). These results are in agreement with those of other researches (Singh et al., 2013) who reported that limited assimilates are partitioned to grain development in case of tough weed-crop competition.

Conclusion

The threshold level of *Rumex dentatus* was observed at 20 weed plants m^{-2}. The active decline in yield and yield related parameters was initiated at this stage and became worse with further increase in *Rumex dentatus* population. The highest yield and yield attributing traits could be obtained from T1 (weeds free plot) and plot with lowest *Rumex dentatus* population (T2) while lowest yield and yield related traits were realized in T6 and T7 both densely infested weeds plots. Similar was the trend for grain yield losses. Highest grain losses occurred in T6 and T7 highly infested with *Rumex dentatus*. It is therefore concluded that *Rumex dentatus* density of 20 plants m^{-2} or above is the threshold level and hence may cause yield reduction if not properly managed.

Authors Contribution

Zafar Waheed is the principal author who conducted this research. Khalid Usman is corresponding author. Iftikhar assisted in preparation of the draft of this paper.

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