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SIMULATING THE EFFECT OF EMEX AUSTRALIS DENSITIES AND SOWING DATES ON AGRONOMIC TRAITS OF WHEAT

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Reduction in yield and quality of wheat is major problem caused by the delayed sowing and interference of weeds. The effects of sowing dates (8th Nov, 16th Nov and 24th Nov) and *Emex australis* Steinh. density (0, 1, 2, 3, 4 plants per pot) on growth and yield of wheat were evaluated over two seasons (2005-06, 2006-07). The statistical analysis of data exhibited non-significant effect of weed density on number of days taken to initiate flowering by *E. australis*. Highest values for *E. australis* plant height, dry biomass, number of seed per plant and seed weight were recorded by sowing wheat on 8th November at *E. australis* density of one plant per pot in both years. Maximum number of spike bearing tillers per pot, plant height, number of grains per spike, 1000-grain weight and grain yield were observed in 8th November sowing with zero *E. australis* density and minimum values for these parameters were recorded in late sowing (24th November) at maximum weed density of 4 plants per pot. Early sowing (8th Nov.) and weed free pots increased wheat grain yield compared to later sowings (16th Nov. and 24th Nov.) and higher weed density.
Key words: wheat, *Emex australis*, sowing date, density, grain yield

INTRODUCTION

A range of factors may contribute to wheat cultivars not achieving their potential yield. These factors may include conservative sowing dates, weed competition, germination and establishment difficulties due to hard setting soils and high temperatures which may result in less than potential number of plants per m^2. Optimum sowing dates play an important role in yield production because it would realize optimum season length and achieve high grain yield as a result of suitable weather conditions prevailing through different wheat growth stages. Wheat yield reduces as a consequence of exposure of vegetative and reproductive stage to high temperature if sowing of wheat is delayed up to the end of December; this causes reduced season length (Naceur *et al*., 1999; Eid *et al.*, 1997) and number of tillers (Friend, 1965). Further high temperature during anthesis causes pollen sterility (Rayan *et al*., 1999) and decrease number of grains per spike if it prevailed during early spike development. Duration of grain filling period is reduced at high temperature (Smith and Humphreys, 2001), as well as growth rate with a net effect of lower final kernel weight (Bagga and Rawson, 1977; McMaster and Smika, 1988).

Weeds comprise the most undesirable, aggressive and troublesome element of world's vegetation. Weeds competition is another important factor to hinder the wheat cultivars in achieving their potential yield. Previous studies linked weed density to grain yield (Dew, 1972), by considering crop density (Cousens, 1985) and weed emergence period (Cousens *et al*., 1987). Among the problem caused by weeds, decrease in grain yield is the most serious (Crafts, 1975). One of the major factors affecting the relationship between weeds and crop yield is weed density. Numerous researchers have investigated this factor experimentally, in an attempt to estimate a threshold density level that could be used to decide whether to treat or not (Panell, 1988). Siddiqui and Shad (1991) concluded that grain yield of wheat declined with the increase in weed density both in rainfed as well as irrigated conditions.

Emex australis Steinh. (Spiny emex) is a newly established weed in wheat field and other winter crops. Extensive work has been done on its biology, ecology, and control. However, little is known of the competitive ability of the weed with wheat and no such work has been carried out with interaction of sowing date in Pakistan. In view of the importance of the sowing time and the interspecific competition between wheat and spiny emex an experiment was conducted to investigate the impact of varying sowing dates and emex densities on wheat with the objectives (i) to compare the effect of varying density of spiny emex on the growth and yield of wheat sown at different times and (ii) to find out ideal sowing time which give

competitive advantages to wheat crop over spiny emex.

MATERIALS AND METHODS

A pot experiment was conducted at experimental research farm Department of Agronomy, University of Agriculture, Faisalabad, during 2005-06 and 2006-07. Wheat variety Inqulab-91 was sown in pots, filled with 8 kg of soil, on three sowing dates (8th, 16th and 24th November) with five *Emex australis* densities (0,1,2,3,4 plants per pot). Each pot received 0.6 g nitrogen and 0.85 g P_2O_5 in the form of Urea and DAP, respectively at the time of sowing and 0.6 g nitrogen was applied at tillering stage of wheat. At the time of sowing enough seeds of wheat and *Emex australis* were sown in order to get required 10 plants of wheat and 0, 1, 2, 3 and 4 plants of *Emex australis* per pot according to the treatment. Excess plants of either species were removed by hand pulling. The pots were distributed in the wire house in completely randomized design with split arrangement having four replicates of each treatment. At the end of the experiment the wheat and *Emex australis* plants were harvested separately and their parameters of development and yield were measured. The data collected were analyzed by using the Fisher's analysis of variance function of MSTAT C statistical computer package and LSD at 5% probability was used to compare the treatment means (Steel *et al*., 1997).

RESULTS AND DISCUSSION

Effect of sowing date and *E. australis* densities on *E. australis*

Effect of various sowing dates was significant (P≤ 0.05) on days taken to initiate flowering, plant height, dry weight, number of seeds per plant and seed weight per plant of *Emex australis* (Table 1, 2, 3, 4, 5). Maximum values for these parameters were recorded in plants sown on 8th November and minimum in plants sown on 24th November. *Emex australis* densities per pot induced a significant effect on all the parameters recorded except number of days taken to initiate flowering. Significantly highest values were recorded in pots having one plant of *E. australis* per pot (D_2) while lowest were observed in pots having four plants of *E. australis* per pot (D_5). In 2006-07, similar trend was observed for effect of sowing dates and *E. australis* densities except dry weight of *E. australis*. Interaction of sowing dates and *E. australis* densities affected all the parameters significantly during both years of study. Interaction involving $S_1 \times D_3$ and $S_1 \times D_4$ had taken highest number of days (72.50 and 72.88 in 2005—06 and 2006-07, respectively) to initiate flowering in *E. australis* while interaction $S_3 \times D_2$ and $S_3 \times D_4$ started flowering significantly earlier in 2005-06 and 2006-07, respectively. In 2005-06 significantly maximum plant height (31.25 cm), dry biomass per plant (2.943 g), number of seeds per plant (32.25) and seed weight per plant (1.087 g) was recorded in interaction of $S_1 \times D_2$ which was statistically at par with $S_2 \times D_2$ A similar trend was observed in 2006-07. Interaction $S_3 \times D_5$ resulted in significantly minimum plants height, dry biomass per plants, number of seeds per plant and seed weight per plant in both the years of study (Table 2, 3, 4, 5). *Emex* showed extensive growth, which was the result of its competition for nutrient and water with wheat plant which resulted in reduced thousand grain weight and grain yield. El-Khatib and Hegazy (1999) reported that wild oat compete with wheat for nutrients, water, space and light resulting in reduced yields. Interaction of Italian ryegrass and wheat was quantified by Hasham and Radosevich (1991). They reported that Italian ryegrass had more competitive ability than wheat. The interaction involving the higher *Emex* density and delayed sowing caused lower *Emex* height, dry biomass, number of seeds and seed weight per plant due to interspecific competition with wheat. In addition increase in population of *Emex* plants per pot caused intraspecific competition for nutrients, water space and competition offered by wheat resulted in reduced growth and physiological traits of *Emex* plant.

Effect of sowing date and *E. australis* densities on wheat

Sowing date had a significant (P< 0.05) effect on plant height number of spike bearing tillers, number of grains per spike, 1000-grain weight and grain yield of wheat. The highest values for all the above mentioned parameters were observed in 8th November sowing and lowest values in 24th November sowing during both the years. *Emex australis* densities also showed significant effect on all the parameters recorded. Highest and lowest values for plant height, spike bearing tillers, number of grains per spike, 1000-grain weight and grain yield per pot were recorded in 8th November and 24th November sowing, respectively. Interaction between sowing date and *E. australis* densities was also significant for all the parameters recorded during both years. In 2005-06, significantly (P≤ 0.05) highest spike bearing tillers (16.50), 1000-grain weight (36.22 g) and grain yield (14.97 g) were recorded when wheat was sown on 8th November sowing in *E. australis* free pots.

Table 1. Effect of sowing dates and different densities of *E. australis* on days taken to flower initiation by *E. australis*.

Emex Density	2005-06				2006-07			
	Sowing Date							
	S_1=8 Nov	S_2=16Nov	S_3=24Nov	Mean	S_1=8 Nov	S_2=16Nov	S_3=24Nov	Mean
D_1=0	-	-	-	-	-	-	-	-
D_2=1	71.75 a	66.25 b	58.75 c	65.58	70.50 b	66.00 c	62.25 d	66.25
D_3=2	72.50 a	66.00 b	59.63 c	66.04	72.50 ab	66.75 c	62.38 d	67.21
D_4=3	71.35 a	66.18 b	59.42 c	65.65	72.88 a	67.17 c	61.50 d	67.18
D_5=4	72.07 a	66.03 b	60.08 c	66.06	71.98 ab	67.57 c	62.20 d	67.25
Mean	71.92 a	66.11 b	59.47 c		71.96 a	66.88 b	62.08 c	
LSD (P<0.05)	Sowing date =1.676 Interaction =2.175		Weed density =NS		Sowing date =1.627 Interaction =2.300		Weed density =1.328	

Values within a column followed by the same letter do not differ significantly at 5 % probability level.
LSD = Least significant difference

Table 2. Effect of sowing dates and different densities of *E. australis* on plant height (cm) of *E. australis*.

Emex Density	2005-06				2006-07			
	Sowing Date							
	S_1=8 Nov	S_2=16Nov	S_3=24Nov	Mean	S_1=8 Nov	S_2=16Nov	S_3=24Nov	Mean
D_1=0	-	-	-	-	-	-	-	-
D_2=1	31.25 a	28.20 ab	20.67 def	26.71 a	32.80 a	30.52 ab	23.98 de	29.10 a
D_3=2	27.80 abc	24.75 bcd	21.30 def	24.62 a	31.55 ab	28.80 abc	23.05 de	27.80 ab
D_4=3	23.80 cde	21.70 def	18.42 f	21.31 b	29.35 abc	27.02 bcd	20.95 e	25.77 b
D_5=4	21.50 def	19.70 ef	17.63 f	19.61 b	25.77 cd	23.00 de	20.05 e	22.94 c
Mean	26.09 a	23.59 b	19.51 c		29.87 a	27.34 b	22.01 c	
LSD (P<0.05)	Sowing date =1.733 Interaction =4.376		Weed density =2.526		Sowing date =1.767 Interaction =4.653		Weed density =2.687	

Values within a column followed by the same letter do not differ significantly at 5 % probability level.
LSD = Least significant difference

Table 3. Effect of sowing dates and different densities of *E. australis* on dry weight (g) plant^{-1} of *E. australis*.

Emex Density	2005-06				2006-07			
	Sowing Date							
	S_1=8 Nov	S_2=16Nov	S_3=24Nov	Mean	S_1=8 Nov	S_2=16Nov	S_3=24Nov	Mean
D_1=0	-	-	-	-	-	-	-	-
D_2=1	2.943 a	2.540 ab	2.155 bcd	2.546 a	3.415 a	3.237 ab	2.360 def	3.004 a
D_3=2	2.390 bc	2.335 bc	2.000 cde	2.242 b	2.872 bc	2.730 cd	2.217 efg	2.607 b
D_4=3	2.415 bc	2.148 bcd	1.822 de	2.128 b	2.405 de	2.395 de	2.013 efg	2.271 c
D_5=4	2.240 bcd	2.230 bcd	1.612 e	2.027 b	2.277 ef	1.975 fg	1.827 g	2.027 d
Mean	2.497 a	2.313 ab	1.898 b		2.743 a	2.584 b	2.104 c	
LSD (P<0.0	Sowing date =0.4344 Interaction =0.4542		Weed density =0.2622		Sowing date =0.1338 Interaction =0.3947		Weed density =0.2279	

Values within a column followed by the same letter do not differ significantly at 5 % probability level.
LSD = Least significant difference

Table 4. Effect of sowing dates and different densities of *E. australis* on number of seeds plant^{-1}of *E. australis.*

Emex Density	2005-06				2006-07			
	Sowing Date							
	S_1=8 Nov	S_2=16Nov	S_3=24Nov	Mean	S_1=8 Nov	S_2=16Nov	S_3=24Nov	Mean
D_1=0	-	-	-	-	-	-	-	-
D_2=1	32.25 a	31.25 ab	23.50 cd	29.00 a	35.00 a	30.00 ab	25.50 bcd	30.17 a
D_3=2	24.25 cd	25.38 bcd	21.38 cd	23.67 b	28.88 abc	27.75 bcd	22.75 cde	26.46 ab
D_4=3	26.25 abc	23.10 cd	19.68 de	23.01 bc	25.08 bcde	24.67 bcde	21.58 de	23.77 bc
D_5=4	23.33 cd	22.65 cd	14.10 e	20.02 c	24.15 bcde	18.90 e	18.90 e	20.65 c
Mean	26.52 a	25.59 ab	19.66 b		28.27 a	25.33 b	22.18 c	
LSD (P<0.05)	Sowing date =6.156 Weed density =3.614 Interaction =6.260				Sowing date =2.488 Weed density =3.774 Interaction =6.537			

Values within a column followed by the same letter do not differ significantly at 5 % probability level.
LSD = Least significant difference

Table 5. Effect of sowing dates and different densities of *E. australis* on seed weight (g) plant^{-1} of *E. australis*.

Emex Density	2005-06				2006-07			
	Sowing Date							
	S_1=8Nov	S_2=16Nov	S_3=24Nov	Mean	S_1=8 Nov	S_2=16Nov	S_3=24Nov	Mean
D_1=0	-	-	-	-	-	-	-	-
D_2=1	1.087 a	1.033 ab	0.745 cd	0.955 a	1.060 a	0.998 ab	0.828 bcde	0.962 a
D_3=2	0.810 c	0.828 bc	0.678 cd	0.772 b	0.928 abc	0.915 abcd	0.733 defg	0.858 b
D_4=3	0.843 bc	0.755 cd	0.568 de	0.722 bc	0.868 abcde	0.770 cdef	0.688 efg	0.775 b
D_5=4	0.760 cd	0.708 cd	0.455 e	0.641 c	0.818 bcde	0.610 fg	0.553 g	0.660 c
Mean	0.8750 a	0.8306 a	0.6112b		0.9181 a	0.8231 b	0.7000 c	
LSD (P<0.05)	Sowing date =0.1926 Weed density =0.1214 Interaction =0.2103				Sowing date = 0.06195 Weed density =0.1124 Interaction =0.1947			

Values within a column followed by the same letter do not differ significantly at 5 % probability level.
LSD = Least significant difference

Table 6. Effect of sowing dates and different densities of *E. australis* on plant height (cm) of wheat.

Emex Density	2005-06				2006-07			
	Sowing Date							
	S_1=8 Nov	S_2=16Nov	S_3=24Nov	Mean	S_1=8 Nov	S_2=16Nov	S_3=24Nov	Mean
D_1=0	85.22 a	83.82 ab	78.45 cde	82.50 a	85.98 a	84.80 ab	80.93 cd	83.90 a
D_2=1	83.05 ab	79.07 cd	73.90 fg	78.68 b	84.20 ab	81.53 cd	76.88 e	80.87 b
D_3=2	81.32 bc	76.53 def	71.05 g	76.30 c	85.55 bc	80.57 cd	73.55 fg	78.89 c
D_4=3	78.93 cd	75.35 f	67.25 h	73.84 d	81.18 cd	75.38 ef	67.78 h	74.78 d
D_5=4	75.63 ef	71.20 g	63.17 i	70.00 e	79.82 d	72.55 g	65.22 i	72.53 e
Mean	80.83 a	77.19 b	70.76 c		82.75 a	78.96 b	72.87 c	
LSD (P<0.05)	Sowing date =1.231 Weed density =1.725 Interaction =2.988				Sowing date = 0.9020 Weed density =1.361 Interaction =2.358			

Values within a column followed by the same letter do not differ significantly at 5 % probability level.
LSD = Least significant difference

Table 7. Effect of sowing dates and different densities of *E. australis* on number of spike bearing tillers per pot of wheat.

Emex Density	2005-06 Sowing Date				2006-07 Sowing Date			
	S_1=8 Nov	S_2=16Nov	S_3=24Nov	Mean	S_1=8 Nov	S_2=16Nov	S_3=24Nov	Mean
D_1=0	16.50 a	14.50 b	12.75bcde	14.58 a	17.25 a	16.00 ab	13.50 def	15.58 a
D_2=1	14.00 bc	12.50 cde	11.25 efg	12.58 b	15.75 abc	14.00 de	11.50 gh	13.75 b
D_3=2	13.00 bcd	12.00 def	10.50 fgh	11.83 b	14.75 bcd	12.50 efg	10.50 hi	12.58 c
D_4=3	11.50 def	11.00 efg	9.500 gh	10.67 c	13.25 defg	11.50 gh	9.500 ij	11.42 d
D_5=4	11.00 efg	10.50 fgh	8.750 h	10.08 c	12.00 fgh	10.50 hi	8.000 j	10.17 e
Mean	13.20 a	12.10 b	10.55 c		14.60 a	12.90 b	10.60 c	
LSD (P<0.05)	Sowing date =0.8379 Weed density =1.112 Interaction =1.926				Sowing date =0.8986 Weed density =1.012 Interaction = 1.753			

Values within a column followed by the same letter do not differ significantly at 5 % probability level.
LSD = Least significant difference

Table 8. Effect of sowing dates and different densities of *E. australis* on number of grains per spike.

Emex Density	2005-06 Sowing Date				2006-07 Sowing Date			
	S_1=8 Nov	S_2=16Nov	S_3=24Nov	Mean	S_1=8 Nov	S_2=16Nov	S_3=24Nov	Mean
D_1=0	41.65 a	39.70 ab	35.30 de	38.88 a	39.85 a	39.40 a	33.90 c	37.72 a
D_2=1	38.20 bc	36.20 cd	31.35 fg	35.25 b	36.95 b	36.90 b	31.15 de	35.00 b
D_3=2	36.30 cd	32.60 f	30.00 g	32.97 c	34.00 c	32.75 cd	28.65 f	31.80 c
D_4=3	33.20 ef	29.65 g	24.85 h	29.23 d	31.40 de	29.60 ef	26.10 gh	29.03 d
D_5=4	29.45 g	26.95 h	22.35 i	26.25 e	28.50 f	27.95 fg	24.45 h	26.97 e
Mean	35.76 a	33.02 b	28.77 c		34.14 a	33.32 a	28.85 b	
LSD (P<0.0	Sowing date =1.150 Weed density =1.258 Interaction =2.178				Sowing date =0.8330 Weed density =1.218 Interaction =2.110			

Values within a column followed by the same letter do not differ significantly at 5 % probability level.
LSD = Least significant difference

Table 9. Effect of sowing dates and different densities of *E. australis* on 1000-grain weight (g) of wheat.

Emex Density	2005-06 Sowing Date				2006-07 Sowing Date			
	S_1=8 Nov	S_2=16Nov	S_3=24Nov	Mean	S_1=8 Nov	S_2=16Nov	S_3=24Nov	Mean
D_1=0	36.22 a	35.72 a	34.05 cd	35.33 a	36.65 a	36.05 b	34.90 cd	35.87 a
D_2=1	35.03 b	35.05 b	33.33 ef	34.47 b	36.13 ab	35.42 c	34.05 e	35.20 b
D_3=2	34.25 c	34.13 c	32.47 g	33.62 c	34.80 d	34.72 d	32.85 f	34.13 c
D_4=3	33.83 cde	32.92 fg	31.40 h	32.72 d	33.92 e	33.67 e	31.17 g	32.92 d
D_5=4	33.42 def	32.40 g	30.45 i	32.09 e	33.65 e	33.05 f	30.67 g	32.46 e
Mean	34.55 a	34.05 b	32.34 c		35.03 a	34.58 b	32.73 c	
LSD (P<0.0	Sowing date =0.4034 Weed density =0.3740 Interaction =0.6477				Sowing date =0.2579 Weed density =0.3291 Interaction =0.5700			

Values within a column followed by the same letter do not differ significantly at 5 % probability level.
LSD = Least significant difference

Table 10. Effect of sowing dates and different densities of *E. australis* on grain yield (g pot^{-1}) of wheat.

Emex Density	2005-06				2006-07			
	Sowing Date							
	S_1=8 Nov	S_2=16Nov	S_3=24Nov	Mean	S_1=8 Nov	S_2=16Nov	S_3=24Nov	Mean
D_1=0	14.97 a	13.92 ab	12.52 cd	13.80 a	14.40 a	13.82 a	11.43 de	13.22 a
D_2=1	13.18 bc	12.18 cde	11.01 fg	12.12 b	12.85 b	12.48 bc	10.93 ef	12.08 b
D_3=2	11.70 def	11.11 efg	9.610 h	10.81 c	11.98 cd	11.40 de	9.375 h	10.92 c
D_4=3	10.79 fg	10.29 gh	7.800 i	9.627 d	10.88 ef	10.30 fg	7.950 i	9.708 d
D_5=4	10.09 gh	9.458 h	6.710 j	8.751 e	10.02 gh	9.350 h	6.925 j	8.767 e
Mean	12.14 a	11.39 b	9.529 c		12.02 a	11.47 b	9.320 c	
LSD	Sowing date =0.5415		Weed density =0.6262		Sowing date =0.4410		Weed density =0.4115	
	Interaction =1.085				Interaction =0.7127			

Values within a column followed by the same letter do not differ significantly at 5 % probability level.
LSD = Least significant difference

Significantly lowest plant height (63.17cm), spike bearing tillers (8.75), number of grains per spike (22.35), 1000-grian weight (30.45 g) and grain yield (6.710 g) was recorded in interaction of $S_3 \times D_5$. In 2006-07, significantly (P≤ 0.05) highest spike bearing tillers (17.25), 1000-grain weight (36.65 g) and grain yield (14.40 g) were recorded in interaction involving 8th November sowing and *E. australis* free pots. Significantly lowest spike bearing tillers (8.00), plant height (65.22 cm), number of grains per spike (24.45), 1000-grian weight (30.67 g) and grain yield (6.925 g) was recorded in interaction of $S_3 \times D_5$.

The results indicate that highest number of spike bearing tillers was recorded in early sowing (S_1) where *Emex* density is zero. The increased number of tillers could be due to lower temperature and no weed competition that encouraged tiller production during the early growth period and maximum number of tillers was reached by the end of the vegetative phase after which it declines (Khalifa *et al*., 1977). The treatments where sowing was delayed and *Emex* density was high, tillers were significantly reduced because of the short period for tillering stage and in addition competition from weed plants restricted the wheat plant to less number of tillers per pot. The fact that the number of tillers was affected by the length of the duration of tiller initiation as well as by plant density suggests that interaction between sowing date and plant population density were bound to influence yield (Dennett, 1999). Interaction of late wheat sowing and *Emex* densities reduced wheat grain yield and yield components during both the years. This was due to the shorter growth period with added effect of *Emex* competition.

CONCLUSION

The results depicted that wheat sown on 8th November was significantly better compared to 16th November and 24th November for studied aspects of growth and yield of wheat. *Emex* densities even at lower levels (1 plants pot^{-1}) showed significant reduction in yield. Thus wheat plantation is best in the first weak of November and *Emex* must be controlled, even at low densities, as early as possible in order to get maximum grain yield.

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