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Estimation of yield losses of wheat (*Triticum aestivum* L.) caused by little seed canai grass (*Phalaris minor* Retz.) competition

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ABSTRACT

Experiments were conducted in soil typic Ustochrepts (Inceptisol) during winter season of 1997-99 to determine the effects of varying densities of little seed canary grass (*Phalaris minor* Retz.) on the grain yield of wheat. As the density of weed increased from 0 to 200/m^2 the yield of wheat was reduced by 23.9 and 32.6% in the first and second year respectively. To predict the yield of wheat, the yield data was fitted to an empirical model based on hyperbolic relationships over *P. minor* densities. The observed and predicted yield losses were close. The relationship between wheat and little seed canary grass was also shown by a non-linear regression model based on relative leaf area of weeds estimated in earlier stage. This single parameter model also gave good fit to the data on yield loss calculated from the observed weed free crop yields. From the yield loss-weed density model the economic threshold of this weed for the herbicide isoproturon was calculated as 13.0 to 19.7 /m^2 for the single season.

Key words : Wheat yield loss, Phalaris minor, yield loss – weed density model.

Phalaris minor Retz. is one of the most predominant and troublesome annual grassy weed of wheat in India. Its morphological similarity with wheat in vegetative stage, occurrence at high density, ability to tiller freely, similar growth period as wheat, high reproductive potential, earlier shedding of seeds and ability of seeds to remain dormant in the soil for several years, have attributed for its strong competitive ability.

Wheat yield losses especially from weed *P. minor* alone are estimated at around 25-50% and in very severe cases, it may go up to 80% to total (Bhan and Sushil Kumar, 1998).

The serious yield reduction caused by this weed and morphological similarity with wheat crop warrant the use of herbicide to control this weed. However, total dependence on herbicide for weed control did not prove useful in long term, as continuous use of isoproturon has led to the development of resistance in some populations of little seed canary grass (Yaduraju and Singh, 1997). The use of herbicide can be minimised if prediction of threshold infestation of *P. minor* is possible. Prediction of threshold infestation of *P. minor* of wheat normally involves the use of regression models, which relate a crop yield loss to some measure of the size of the weed infestation at the time of post emergence control. A number of empirical models have been developed to describe the responses of crop yield to one or more parameters of the weed infestation. The most important parameter being in use is weed density (Cousens, 1985a), which describe crop yield as function of weed density. For a wide range o population, Cousens (1985a) determines th rectangular hyperbole to be an appropriate model anc put forward his yield-density model, which i extensively used for prediction of yield losses and determining economic thresholds. However, relative time of emergence of weed may affect the yield and density relationships. Hence, Kropff and Spitter (1991) introduced another model relating yield loss to relative leaf area of the weeds, which also accounts fo the effect of weed density and also different relativ time of emergence.

However, use of empirical models for crop weed interference studies are seldom undertaken i India. With this perspective the present experimen was conducted to estimate yield losses in wheat cause by *P. minor* competition as a function of density a well as relative leaf area of the weeds and to determin the economic threshold (ET) density limit of *P. minor.*

MATERIALS AND METHODS

An experiment was conducted during winte season of 1997-98 and 1998-99 at the Farm of th Indian Agricultural Research Institute, New Delh located at 28^{0}35'N Latitude and 77^{0}12'E longitude wit an Altitude of 228 m above MSL to estimate the yiel losses in wheat CV. HD 2329 caused by the *P. mino* competition as a function of density as well as relativ leaf area of the weed. The soil was sandy loam (Typi Ustochrepts: order Inceptisol), medium in fertilit

(1164 kg total nitrogen, 19 kg available P and 218 kg available K hectare^{-1}) with pH 8.2. Five densities of *P. minor* (0, 25, 50, 100 and 200 m^{-2}) were assigned in a randomised block design with five replications.

To have significant build up of the seeds of *P. minor* the seeds were uniformly broadcasted before the final land preparation and the seedlings were thinned out to the desirable weed densities according to the treatments in both the years by 35th day. Other associated weeds including the later emerged canary grass, were removed from the field. Wheat crop was sown by manually drawn single row drill at a row spacing of 22.5 cm (*Pora* method). In weed free plot, all the broadlea and grassy weeds were removed by hand pulling as and when emerged. In other plots all the grassy and broadlea weeds excepting the *P. minor* were removed by hand pulling. All standard recommended agronomic practices followed in wheat. The fertilizer N 120 kg/ha, P_2O_5 60 kg/ha and K_2O 40 kg/ha were applied in the form of urea, single super phosphate and muriate of potash, respectively. The entire amount of phosphorus and potassium and half of the nitrogen were applied as basal where as, rest of the nitrogen was top dressed at the time of first irrigation at CRI stage of wheat. Entire dose of phosphorus (60 kg/ha) and potassium (40kg/ha) and half dose of nitrogen (60kg/ha) were as basal and test half done of nitrogen (60kg/ ha) was topdrened at CRI stage of wheat with first irrigation.

The leaf area of wheat and canary grass were determined at 45 DAS by a LI 3100 Lear Area Meter.

Crop yield vs. *P. minor* density model:

The effect of canary grass on yield of wheat was evaluated using simple empirical model. The data were fitted to non linear equation using an iterative procedure available in the 'SPSS' statistical package and estimated the parameters. The rectangular hyperbola model discussed by Cousens (1985 a) in the form of

$$Y = Y_{wf} \left[1 - \frac{id}{100\,(1 + id/A)} \right] \quad \text{--- (1)}$$

was used to relate wheat yield (Y) to canary grass density (d), where 'A' is the asymptotic value of percentage yield loss 'd' approaches infinity and 'i' is the yield loss unit $^{-1}$ weed density as 'd' approaches zero and 'Y_{wf}' is the estimated weed free yield. The data and fitted curves are presented graphically in terms of percentage yield loss using the equation (Cousens, 1985 b) in the form of

$$Y_L = \frac{id}{1 + id/A} \quad \text{----- (2)}$$

Crop yield vs. *P. minor* leaf area model:

The empirical model of Kropff and Spitters (1991), which relates crop yield loss to relative leaf area of the weed with respect to the crop, was also used to evaluate crop yield losses due to *P. minor* competition. The model is in the form of

$$Y_L = \frac{qL_w}{1 + (q-1)L_w}$$

in which Y_L is the yield loss, L_w is the relative leaf area of the weed (leaf area of weeds divided by the total area of the crops and weeds per unit area) and 'q' the relative damage coefficient.

Economic Threshold (ET) density of *P. minor*:

The economic threshold (ET) values were calculated using the equation as suggested by Cousens (1987)

$$1 + \left(\frac{i}{A}\right)\left[2 - H\frac{YPAH}{C}\right]T + \left(\frac{i}{A}\right)^2 (1 - H)\,T^2 = 0 \quad \text{---(3)}$$

where 'i' and A as calculated from equation number 1 and 2, Y is the weed free yield, P is unit price of wheat, H is the efficacy of herbicide application, C is cost of weed control and T the ET density. The ET values were calculated for a post emergence application of isoproturon @ 750 g ha^{-1}.

RESULTS AND DISCUSSION

The yield of wheat declined progressively with increase in *P. minor* density. There was significant reduction in wheat yield even at low *P. minor* density of 25/m^2 (4.0 and 6.0% in the first and second year respectively). The yield losses at the maximum density were 23.9 and 32.6% in the first and second year respectively.

Prediction of yield losses:

Wheat yield – *P. minor* density relationship:

As the yield density response is asymptotic (Cousens, 1985a), a non-linear hyperbolic regression model was used to analyse the relationship between the yield of wheat and *P. minor* density. The hyperbolic equation, which relates yield to *P. minor* density, was fitted to the observed grain yield data in Table 1. The estimated parameters are given in Table 2. A good fit to the data was obtained in both the years with the hyperbolic model ($R^2 > 0.98$). The observed and predicted values in the first year were almost same in different *P. minor* densities.

From the estimated parameter values in the Table 2 it could be seen that higher 'i' and 'A' values were observed in 1998-99 as compared to its previous year. According to Cousens (1985a), 'A' is very sensitive to weed density. The 'A' value was 73.95% in 1997-98 and 84.64% in 1998-99. In general, from the values of the parameters and quotient 'i/A' it is obvious that the weed even in 200/ m^2 density levels did not too exert much competition and caused only 23.9 and 32.6% yield losses during 1997-98 and 1998-99, respectively.

The parameter values Y_{wf}, the weed free yield, i, the initial slope of the curve (the % yield loss per unit weed density as density approaches zero) and A, the asymptotic yield loss (the % yield loss as density approaches infinity) were greater in 1998-99 year than 1997-98.

The predicted yield and yield loss, using the model, are given in the Table 1. The predicted yield loss was close to observed yield loss in both the years.

Wheat yield – relative leaf area of weeds relationship:

The relative leaf area of weeds (L_w) determined at 45 DAS was used to relate yield loss using the empirical model. The estimated single model parameter q, the relative damage coefficient is given in the Table 4. This model also gave good fit to the observed and predicted data on yield loss ($R^2 > 0.98$) in both the years of study, although the values of the relative damage coefficient differed between the years. The *P. minor* was more aggressive in the second year than in the first year as revealed by the value of the q. the predicted yield loss was very close to observed yield loss in both the years (Table 3). If these models are to be useful for general purposes, the parameters of both the models must be estimated over a wide range of weather condition and soil types.

Economic Threshold (ET):

Economic thresholds are given in Table 5 as a function of treatment costs C, efficacy or per cent control (H) and for a wheat procurement price for 1998 – 1999, Rs. 5.25/kg. The damage coefficients were estimated from the yield loss- weed density model as described above. ET values as calculated for a post emergence herbicide isoproturon varied between 12.9 and 19.7 *P. minor*/m^2. The difference in ET values was due to the variation in the yield loss function during the years and the efficacy of the herbicide.

Table 1 Predicted yield and yield loss with observed yield and yield loss simulated through model using *P. minor* density

P. minor density (No./m^2)	Observed yield (kg/ha)		Predicted yield* (kg/ha)		Observed yield loss (%)		Predicted yield loss** (%)	
	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99
0	4697	4491	4698	4473	0	0	0	0
25	4508	4213	4502	4213	4.0	6.18	4.17	5.82
50	4321	3926	4327	3984	7.99	12.57	7.89	10.93
100	4030	3657	4028	3602	14.19	18.56	14.26	19.49
200	3574	3027	3574	3041	23.90	32.58	23.92	32.01

- By fitting the equation $Y = [1 - \frac{id}{100(1+id/A)}]$

By fitting the equation $Y_L = \frac{id}{1+id/A}$

Table 2 Observed weed free wheat yield and estimated parameter for the yield loss – weed density model for *P. minor* fitted to the data in Table –1

Year	Observed weed free yield (kg ha^{-1})	Parameter estimates**			
		Ywf (kg ha^{-1})	i (%)	A (%)	R^2
1997-98	4697	4698 (5.8229)*	0.1768 (0.0045)	73.950 (3.9049)	0.99
1998-99	4491	4473 (53.2223)*	0.2490 (0.0445)	89.646 (29.1841)	0.98

* Standard errors of the Parameter estimates are in Parenthesis
** Ywf is weed free yield; i is the percentage yield loss per unit weed density as density approaches 0 and A is the % yield loss as density approaches infinity.

Table 3 Observed and Predicted yield loss of wheat due to *P. minor* competition by fitting the relative leaf area (Lw) – yield loss regression model

P. minor density (No./m^2)	Lw* (at 45 DAS)		Observed yield loss (%)		Predicted yield loss** (%)	
	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99
0	0	0	0	0	0	0
25	0.0136	0.186	4.0	6.18	4.17	5.82
50	0.0260	0.0340	7.99	12.57	7.89	10.93
100	0.0430	0.0527	14.15	18.56	14.26	19.49
200	0.0670	0.0836	23.90	32.58	23.92	32.01

* Lw, relative leaf area of weeds $= \dfrac{\text{Weed LAI}}{\text{Weed LAI + Crop LAI}}$ ** By fitting the equation $Y_L = \dfrac{q\,Lw}{1+(q-1)\,Lw}$

Table 4 Estimated parameter values of the relative leaf area – yield loss model fitted to the grain yield data in the Table – 1

Year	q (relative damage coefficient)	R^2
1997-98	3.955 ± 0.232	0.99
1998-99	4.617 ± 0.323	0.99

Table 5 Economic Threshold $(ET)_{1,2}$ in relation to Cost (C) and efficacy (H) of the treatment

Treatment	Cost (Rs/ha)	Efficacy (H) (%)			
		1997-98		1998-99	
		80	90	80	90
Isoproturon (0.75 kg a.i./ha)	650.00	19.72	17.51	14.57	12.97

1, ET obtained by solving the following equation

$$1 + i/A\,[2\text{-}H\text{-}(YPAH/C)]T + (i/A)^2\,(1\text{-}H)\,T^2 = 0$$

(P = Rs. 5.25 per kg, i = 0.1768%; A = 73.95% and Ywf = 4698 kgha^{-1} for the first year and P = Rs. 5.25 per kg, i = 0.249%; A = 89.646% and Ywf = 4473 kg ha^{-1} for the second year)

2, ET is the number of *P. minor*/ m^2

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