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Nutrient Uptake by Wheat and Weed Under Different Fertilizer Application Methods and Competition Periods

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استهلاك القمح والأعشاب الطفيلية للمواد الغذائية تحت طرق التسميد وفترات التنافس المختلفة

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خلاصة: تم إجراء تجربة حقلية لتقدير الفقد في المواد الغذائية من نبات شعير الفأر في زراعة القمح باستخدام طرق تسميد وفترات تنافس متعددة. اشتملت التجربة على استخدام السماد بطريقة الوضع الجانبي، وطريقة النثر الدمجي وفترات تنافس بلغت ٣ و ٤ و ٥ و ٦ و ٧ و ٨ أسابيع بعد الإنبات وعدم التنافس (تنافس الصفر)، وكذلك فترة تنافس لكل الموسم. كان استهلاك شعير الفأر للنيتروجين و الفسفور والبوتاسيوم بمعدلات ١١,٣٣ و ١,٢٠ و ٨,٣٤ كيلوجرام للهكتار على التوالي في طريقة النثر الدمجي ، في حين أنه نتج عن التنافس لكل الموسم أعلى معدل لاستهلاك النيتروجين بلغ مقداره ٢٨,٤١ كيلوجرام للهكتار و ٣,١٣ كيلوجرام للهكتار من الفسفور بواسطة حشيش شعير الفأر. وصل استهلاك نبات شعير الفار للبوتاسيوم إلى أعلى معدل قدره ١٧,٤٥ كيلوجرام للهكتار في فترة التنافس لثمان أسابيع. كانت نسبة التركيز للنيتروجين والفسفور والبوتاسيوم (NPK) في القمح أعلى باستخدام طريقة الوضع الجانبي عنها في طريقة النثر الدمجي. أظهر القمح في تنافس الصفر نسبة تركيز أعلى للنيتروجين والفسفور والبوتاسيوم (NPK) منها في فترات التنافس الأخرى.

ABSTRACT: A field experiment was conducted to estimate nutrient losses by *Phalaris minor* Retz. in wheat under different fertilizer application methods and competition periods. The study consisted of a side-placement and a broadcast incorporate method of fertilizer application, and competition periods of 0, 3, 4, 5, 6, 7 and 8 wk after emergence (WAE) and full season competition. Nitrogen, P, K, uptake by *Phalaris minor* Retz. was 11.33, 1.20 and 8.34 kg·ha^{-1}, respectively, using the broadcast incorporate method whereas full season competition resulted in a maximum uptake of 28.41 kg·ha^{-1} N and 3.13 kg·ha^{-1} P by *Phalaris minor* Retz. Potassium uptake by *Phalaris minor* Retz. reached a maximum (17.45 kg·ha^{-1}) at 8 wk competition. Nitrogen, P, and K concentrations in wheat were higher in side-placement than in the broadcast incorporate method of fertilizer application. Wheat under zero competition showed higher N,P, and K concentrations than that of the different competition periods.

Weeds, through competition, create moisture and nutrient stress for crop plants. In addition to crop management practices, the magnitude of the stress is also affected by the type, density and duration of weeds. The competitiveness of a particular weed species when it grows individually in wheat may be different from the situation where several types of weeds grow together. Weeds which are in close proximity to fertilizer absorb more fertilizer than crop plants (Alkamper, 1976). Lof (1976) found that *Phalaris minor* Retz. consumed more water and N than *Hordeum murinum* L. Pandey and Singh (1983) reported that weeds when allowed to compete up to harvest depleted fertilizer at rates of 9.6 kg·ha^{-1} N, 1.13 kg·ha^{-1} P_2O_5 and 5.12 kg·ha^{-1} K_2O. Whereas nutrient uptake by wheat kept free of weeds up to harvest was 93.97 kg·ha^{-1} N, 19.11 kg·ha^{-1} P_2O_5 and 83.75 kg·ha^{-1} K_2O. Gill and Blacklow (1984) found that the concentration of N and P in wheat shoots was 4.05% and 0.77%, respectively, in weed free wheat, and that it was reduced to 3.15% and 0.58%, respectively, in wheat infested with *B. diandrus*. This occured over a 71 d growing period and at a density of 400 plants·m^{-2}. Kundra and Singh (1985) observed a loss of 27.4 kg·ha^{-1} N, 3.1 kg·ha^{-1} P_2O_5 and 37.8 kg·ha^{-1} K_2O on account of unchecked growth of weeds. Corresponding values were 21.3, 2.0 and 29.5 kg·ha^{-1} in the subsequent growing season. *Phalaris minor* Retz. had a major share of the total nutrient uptake by weeds during both years. Carlson and Hill (1986) stated that *Avena fatua* L. was better able to utilize N and to compete with wheat plants. Yadav *et al.* (1986) revealed that uptake of N and K_2O by *Phalaris minor* Retz. at 85 days after sowing was considerably greater

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than that of *C. album* L. and *Vicia sativa* L.

The objective of this study was to compare N, P and K uptake by *Phalaris minor* Retz. and wheat under different fertilizer application methods and competition periods.

Materials and Methods

A field study of wheat and *P. minor* Retz. competition under different fertilizer application methods and competition periods was conducted using a split plot design having four replications. A field was selected keeping in mind the weed history to ensure the availability of the required weed. The soil contained 0.06% N, 6.5 ppm available P and 214 ppm available K. In the next growing season the values were 0.05% N, 5.5 ppm available P and 180 ppm available K. Wheat was sown in rows 25 cm apart in December of the first growing season and in November of the second growing season using a seed rate of 100 kg·ha^{-1}. Nitrogen and P were used at a rate of 15 kg·ha^{-1}, in the form of urea and single superphosphate. Fertilizer application methods (i.e. side-placement and broadcast incorporate) were randomized in main plots. Side-placement of 57.5 kg·ha^{-1} N and 115 kg·ha^{-1} P was made by hand drill after sowing the wheat. In the second method 115 kg·ha^{-1} P and 57.5 kg·ha^{-1} N was broadcast and incorporated into the soil just before sowing. The remaining half of the N in both methods was broadcasted before the first irrigation.

Different competition periods, i.e. competition for 3 weeks after emergence (WAE), 4 WAE, 5 WAE, 6 WAE, 7 WAE, 8 WAE, full season competition and zero competition were randomized in subplots. Each subplot measured 1.5 m x 7.0 m. After the prescribed competition period each plot was kept free of weeds by hoeing throughout the growing season. Oven dried samples of *P. minor* Retz. taken from a one square meter area, and wheat, 0.25 m long, were ground. Nitrogen, P and K concentrations were then determined as suggested by Williams (1984). Fertilizer concentrations in *P. minor* Retz. and wheat were multiplied by their dry weight to estimate the NPK uptake.

Data collected were analysed statistically using Fisher's analysis of variance technique. The least significant difference (LSD) test was applied at 5% probability to compare treatment means (Steel and Torrie, 1984).

Results and Discussion

NITROGEN CONCENTRATION IN *P. MINOR* AND WHEAT: Data presented in Table 1 indicate that the effect of fertilizer application methods on N concentration of *P. minor* was not significant.

The N concentration of *P. minor* was statistically similar at 3,4,5,6,7 WAE in the first year, whereas in the second year, the results at 4 and 5 WAE were similar. Full season competition resulted in the lowest N concentration of *P. minor* Retz.

TABLE 1

Effect of fertilizer application method and competition period on nitrogen concentration in P. minor and wheat

Treatment	Nitrogen Concentration %			
	P. Minor		*Wheat*	
	Year 1	Year 2	Year 1	Year 2
Fertilizer Application Method				
Side placement	5.01	2.66	4.20	2.37
Broadcast incorporate	5.18	2.75	4.19	2.12
S$\bar{x}$	0.07	0.08	0.06	0.06
LSD 5%	-	-	-	-
Significance^{+}	NS	NS	NS	NS
Competition Period				
Zero competition	-	-	-	-
3 WAE	5.49^{a}	-	5.14^{a}	1.96^{c}
4 WAE	5.78^{a}	3.44^{a}	4.95^{ab}	2.96^{a}
5 WAE	5.62^{a}	3.57^{a}	4.34^{c}	2.88^{a}
6 WAE	5.64^{a}	3.12^{b}	4.17^{c}	2.88^{a}
7 WAE	5.35^{a}	2.80^{c}	4.99^{ab}	2.48^{b}
8 WAE	4.83^{b}	2.53^{c}	4.70^{b}	2.28^{b}
Full season competition	2.98^{c}	0.76^{d}	1.07^{d}	0.27^{d}
S$\bar{x}$	0.16	0.10	0.12	0.08
Significance^{+}	**	**	**	**

+, *, P<0.05; **, P<0.01; NS, not significant.
S$\bar{x}$ standard error of mean
WAE weeks after emergence
^{abcd} means in the same row with different superscipts differ (P<0.05)

Nitrogen concentration of wheat was not significantly affected by fertilizer application method (Table 1). During the second year the results at 4, 5 and 6 WAE were similar with respect to N concentration. It is clear from the data that *P. minor* was much more effective in N absorption than wheat. The high N concentration in *P. minor* and wheat in Year 1 was due to the high fertility status of the soil as the field was fallow before sowing, whereas in Year 2 the crop was sown after maize which had depleted the soil fertility. The minimum N absorption in *P. minor* and wheat in full season competition was probably due to the dilution of N with increased growth. High utilization of N by weeds has also been reported by Lof (1976) who found that *P. minor* consumed more N than *Hordeum murinum* L. According to Carlson and Hill (1986) *Avena fatua* was able to utilize N more effectively than wheat.

NITROGEN UPTAKE BY *PHALARIS MINOR* AND WHEAT: The data on N uptake by *P. minor* and wheat are given in Table 2. There were no significant differences between fertilizer application methods on N uptake by *P. minor* in Year 1 and 2. In Year 1 maximum N uptake was recorded in full season competition, followed by 8 wk competition. In Year 2, 7 and 8 wk competition resulted in a maximum N uptake by *P. minor*.

With regards to N uptake by wheat, side-placement resulted in maximum uptake by wheat (Table 2). Nitrogen uptake by wheat significantly varied among competition periods. Maximum N uptake by wheat occurred after 8 wk in year 1 and in full season competition in Year 2. Higher N uptake by *P. minor* and wheat in the first year was due to the presence of more biomass and a higher N concentration. Moreover, the emergence of *P. minor* in Year 2 was also late. A minimum N concentration in *P. minor*. in full season competition resulted in a decreased N uptake in Year 2. In side-placement, fertilizer was applied at a specific location so that weeds away from that location could not have access to more N. Better utilization of N fertilizer nearer to wheat uptake by wheat. Higher N uptake by wheat compared to *P. minor* was due to its greater biomass. These results are in agreement with those of Pandey and Singh (1983). They stated that associated weeds when allowed to compete with wheat up to harvest depleted 9.6 kg·ha^{-1} N. Kundra and Singh (1985) also observed variation in N uptake by weeds. A loss of 27.4 kg·ha^{-1} N in Year 1 and 21.3 kg·ha^{-1} N in Year 2 was observed on account of unchecked growth of weeds.

TABLE 2

Effect of fertilizer application method and competition period on uptake of nitrogen by P. minor and wheat

Treatment	Nitrogen Uptake (kg·ha^{-1})			
	P. minor		*Wheat*	
	Year 1	Year 2	Year 1	Year 2
Fertilizer Application Method				
Side placement	10.64	3.14	50.75^{a}	33.57^{a}
Broadcast incorporate	11.33	3.88	45.85^{b}	28.19^{b}
S$\bar{x}$	0.65	0.26	0.35	0.85
LSD 5%	-	-	1.59	3.84
Significance^{+}	NS	NS	*	*
Competition Period				
Zero competition	-	-	-	-
3 WAE	2.33^{e}	-	20.41^{f}	7.07^{e}
4 WAE	3.11^{e}	1.24^{d}	29.09^{e}	19.13^{d}
5 WAE	3.83^{e}	2.91^{bc}	30.50^{e}	31.55^{c}
6 WAE	8.22^{d}	2.69^{c}	45.43^{d}	38.36^{b}
7 WAE	12.52^{c}	5.07^{a}	72.34^{b}	37.58^{b}
8 WAE	18.51^{b}	5.45^{a}	84.20^{a}	37.83^{b}
Full season competition	28.41^{a}	3.70^{a}	63.11^{c}	44.67^{a}
S$\bar{x}$	0.91	0.31	1.56	1.42
LSD 5%	2.60	0.90	4.47	4.09
Significance^{+}	**	**	**	**

+, *, P<0.05; **, P<0.01; NS, not significant.
S$\bar{x}$ standard error of mean
WAE weeks after emergence
abcdef means in the same row with different superscipts differ (P<0.05)

PHOSPHORUS CONCENTRATION IN *P. MINOR* AND WHEAT: The phosphorus concentration in *P. minor* was significantly higher in the broadcast incorporate method of fertilizer application (Table 3). Phosphorus concentration of *P. minor* was also significantly affected by the competition period. *P. minor* at 4 WAE, showed a maximum phosphorus concentration in Year 1. It was followed by phosphorus concentrations at 3 and 5 WAE. In Year 2 the maximum P concentration in *P. minor* was recorded at 6 WAE. This was followed by 4, 5 and 7 wk competition. There was no significant effect of fertilizer application method on the phosphorus concentration of wheat (Table 3). Among the competition periods, wheat under full season competition showed a maximum phosphorus concen-tration in Year 1.

One possible reason for the higher phosphorus concentration in *P. minor* and wheat in Year 1 could be the initial fertility status of soil. The significantly higher P concentration of wheat in full season competition during Year 1 might be due to increased absorption of rainfall (Fisher, 1980). The relatively higher P concentration in *P. minor* confirms the findings of Alkamper (1976) who stated that weeds usually absorb fertilizer faster and in relatively larger amounts than crops.

PHOSPHORUS UPTAKE BY *P. MINOR* AND WHEAT: Phosphorus uptake by *P. minor* did not vary significantly under different fertilizer application methods (Table 4). Full season competition resulted in the highest P uptake by *P. minor* in both years. Phosphorus uptake by wheat under different fertilizer application methods was significant only in Year 2 with maximum value in side-placement. Full season competition resulted in a relatively higher phosphorus uptake by wheat in Year 1 and at 8 wk competition in Year 2.

The P concentration of *P. minor* and wheat was less in full season competition than early competition periods with the exception of wheat during Year 1. The increased biomass of both *P. minor* and wheat over time contributed towards higher P uptake. A high variation in P uptake by wheat in full season competi-

TABLE 3

Effect of fertilizer application method and competition period on phosphorus concentration P. minor and wheat

Treatment	Phosphorus Concentration (%)			
	P. minor		*Wheat*	
	Year 1	Year 2	Year 1	Year 2
Fertilizer Application Method				
Side placement	0.46[b]	0.39[b]	0.50	0.39
Broadcast incorporate	0.51[a]	0.46[a]	0.47	0.34
S$\bar{x}$	0.01	0.01	0.02	0.01
LSD 5%	0.03	0.04	-	-
Significance[+]	*	*	NS	NS
Competition Period				
Zero competition	-	-	-	-
3 WAE	0.51[c]	-	0.48[b]	0.36[c]
4 WAE	0.60[a]	0.47[b]	0.43[bc]	0.46[a]
5 WAE	0.55[b]	0.42[bc]	0.44[bc]	0.42[ab]
6 WAE	0.50[cd]	0.57[a]	0.40[c]	0.43[ab]
7 WAE	0.46[de]	0.48[b]	0.46[b]	0.39[bc]
8 WAE	0.45[e]	0.22[d]	0.48[b]	0.45[a]
Full season competition	0.33[f]	0.39[c]	0.68[a]	0.04[d]
S$\bar{x}$	0.02	0.03	0.19	0.02
LSD 5%	0.05	0.07	0.06	0.05
Significance[+]	**	**	**	**

+, *, P<0.05; **, P<0.01; NS, not significant.
S$\bar{x}$ standard error of mean
WAE weeks after emergence
[abcd] means in the same row with different superscipts differ (P<0.05)

TABLE 4

Effect of fertilizer application method and competition period on phosporus uptake by P. minor and wheat

Treatment	Phosphorus Uptake (kg·ha^{-1})			
	P. minor		*Wheat*	
	Year 1	Year 2	Year 1	Year 2
Fertilizer Application Method				
Side placement	1.01	0.65	10.31	4.83a
Broadcast incorporate	1.20	0.77	9.06	4.04b
S$\bar{x}$	0.04	0.04	0.68	0.10
LSD 5%	-	-	-	0.48
Significance[+]	NS	NS	NS	*
Competition Period				
Zero competition	-	-	-	-
3 WAE	0.22[e]	0.17[f]	1.91	1.29[e]
4 WAE	0.32[e]	0.27[f]	2.53[e]	2.97[d]
5 WAE	0.35[e]	0.34[ef]	3.07[e]	4.61[c]
6 WAE	0.74[d]	049[e]	4.40[de]	5.77[b]
7 WAE	1.26[c]	0.86[d]	6.72[bc]	5.90[b]
8 WAE	1.74[b]	0.51[e]	8.84[a]	7.13[b]
Full season competition	3.13[a]	1.90[a]	40.35[a]	3.39[d]
S$\bar{x}$	0.11	0.09	1.03	0.22
LSD 5%	0.32	0.27	2.97	0.65
Significance[+]	**	**	**	**

+, *, P<0.05; **, P<0.01; NS, not significant.
S$\bar{x}$ standard error of mean
WAE weeks after emergence
[abcd] means in the same row with different superscipts differ (P<0.05)

tion during both years was observed. A higher P uptake by *P. minor* in Year 1 may have been due to a higher soil phosphorus concentration and weed dry weight. These results are supported by the findings of Pandey and Singh (1983) who noted a depletion of 1.13 kg·ha^{-1} P_2O_5 by weeds up to harvest. Similar results were reported by Kundra and Singh (1985) who recorded a loss of 3.1 kg·ha^{-1} P to weeds up to harvest.

POTASSIUM CONCENTRATION IN *P. MINOR* AND WHEAT: Data given in Table 5 reveal no significant effect of fertilizer application method on the potassium concentration in *P. minor*. Harvested weed at 5, 7 and 8 wk after emergence showed similar potassium concentration in Year 1. In the same year the concentration was lower in full season competition than in all other competition periods.

A significantly higher potassium concentration was observed with side-placement of fertilizer in both years (Table 5). The K concentration in wheat reached a maximum at 8 wk and 7 wk competition in Years 1 and 2, respectively. Better utilization of soil K (214 ppm available) could be the reason for the high K concentration in *P. minor* and wheat during Year 1. A low K concentration at 3 and 4 wk competition might be due to low availability of K or a low plant growth rate (Gasser and Thorburn, 1972; Kemmler, 1983).

POTASSIUM UPTAKE BY *P. MINOR* AND WHEAT: In Year 1, K uptake by *P. minor* was significantly higher in broadcast incorporate than side-placement. However, in Year 2 the effect of fertilizer application method was no longer significant (Table 6). *P. minor* showed an increase in K uptake with increasing competition period up to 8 WAE in Year 1. But in Year 2 *P. minor* showed maximum K uptake at full season competition. Potassium uptake by wheat was affected significantly by fertilizer application method (Table 6). Side-placement of fertilizer resulted in higher uptake by wheat during both years. A maximum K uptake by wheat was observed at 8 WAE

TABLE 5

Effect of fertilizer application method and competition period on potassium concentration in P. minor and wheat

Treatment	Potassium Concentration (%)			
	P. minor		*Wheat*	
	Year 1	Year 2	Year 1	Year 2
Fertilizer Application Method				
Side placement	3.52	1.49	3.69^{a}	1.69^{a}
Broadcast incorporate	3.64	1.60	3.58^{b}	1.39^{b}
S$\bar{x}$	0.03	0.01	0.01	0.05
LSD 5%	-	-	0.02	0.23
Significance^{+}	NS	NS	*	*
Competition Period				
Zero competition	-	-	-	-
3 WAE	3.06^{d}	-	3.85^{cd}	1.09^{e}
4 WAE	3.81^{c}	0.67^{f}	4.14^{b}	1.59^{bc}
5 WAE	4.28^{ab}	1.14^{e}	3.81^{d}	1.47^{b}
6 WAE	4.14^{b}	2.08^{b}	4.04^{bc}	1.70^{b}
7 WAE	4.25^{ab}	2.37^{a}	4.07^{bc}	2.11^{a}
8 WAE	4.45^{a}	1.40^{d}	4.43^{a}	1.27^{de}
Full season competition	1.12^{f}	1.63^{c}	1.13^{e}	1.37^{cd}
S$\bar{x}$	0.07	0.05	0.08	0.08
LSD 5%	0.22	0.16	0.23	0.22
Significance^{+}	**	**	**	**

+, *, P<0.05; **, P<0.01; NS, not significant.
S$\bar{x}$ standard error of mean
WAE weeks after emergence
^{abcd} means in the same row with different superscipts differ (P<0.05)

TABLE 6

Effect of fertilizer application method and competition period on potassium uptake by of P. minor and wheat

Treatment	Potassium Uptake (kg·ha^{-1})			
	P. minor		*Wheat*	
	Year 1	Year 2	Year 1	Year 2
Fertilizer Application Method				
Side placement	6.51^{b}	2.97	47.35^{a}	33.84^{a}
Broadcast incorporate	8.34^{a}	3.17	42.96^{b}	29.16^{b}
S$\bar{x}$	0.18	0.25	0.90	0.79
LSD 5%	0.81	-	4.08	3.57
Significance^{+}	*	NS	*	*
Competition Period				
Zero competition	-	-	-	-
3 WAE	1.32^{e}	-	15.16^{f}	3.97^{f}
4 WAE	2.04^{de}	0.24^{e}	24.39^{e}	10.41^{e}
5 WAE	2.89^{d}	0.96^{de}	26.86^{e}	18.43^{d}
6 WAE	6.04^{c}	1.86^{cd}	44.39^{d}	22.76^{c}
7 WAE	11.60^{b}	4.30^{b}	59.11^{c}	31.72^{b}
8 WAE	17.45^{a}	3.04^{c}	79.41^{a}	20.23^{cd}
Full season competition	10.56^{b}	7.90^{a}	66.79^{b}	113.01^{a}
S$\bar{x}$	0.44	0.41	2.19	1.19
LSD 5%	1.28	1.20	6.28	3.42
Significance^{+}	**	**	**	**

+, *, P<0.05; **, P<0.01; NS, not significant.
S$\bar{x}$ standard error of mean
WAE weeks after emergence
^{abcd} means in the same row with different superscipts differ (P<0.05)

in Year 1. Whereas during Year 2 K uptake reached a maximum at full season competition.

An increase in K uptake by *P. minor* and wheat with an increase in competition period was due to the increased dry weight. The low K uptake by *P. minor* and wheat during Year 1 in full season competition could be attributed to the low P concentration compared to other competition periods in the same year. A high K uptake by wheat in full season competition during Year 2 was probably due to a high biomass. A high soil concentration of K during Year 1 may be the reason for better potassium uptake by *P. minor* and wheat in the same year. Similar results were recorded by Pandey and Singh (1983) who found that 5.12 kg·ha^{-1} K_2O was taken up by weeds in wheat up to harvest.Similarly, Kundra and Singh (1985) reported that 37.8 and 29.5 kg·ha^{-1} K in Year 1 and Year 2 respectively, was removed by weeds. They also concluded that *P. minor* had a major share of the total nutrient uptake.

COMPARISON OF NITROGEN CONCENTRATION IN WHEAT IN ZERO COMPETITION WITH WHEAT UNDER DIFFERENT FERTILIZER APPLICATION METHODS AND COMPETITION PERIODS: A slightly higher N concentration was found in wheat in side-placement compared to the broadcast incorporate method of fertilizer application during both years (Figures 1A and 1B). A decrease in N concentration observed up to 6 WAE with a further decline at 7 WAE in Year 1. In the following year an increase was noted in the N concentration of wheat between 3 and 4 WAE followed by a gradual decline up to final harvest (Figure 1B). The response of different competition periods on N concentration in both years was almost the same as in the fertilizer application methods (Figures 1C and 1D).

Wheat kept free of weeds gave a higher N concentration at all competition periods. A reduction in N concentration in wheat as a result of weed competition has also been reported by Gill and Blacklow (1984).

COMPARISON OF PHOSPHORUS CONCENTRATION IN WHEAT IN ZERO COMPETITION WITH WHEAT UNDER DIFFERENT FERTILIZER APPLICATION METHODS AND COMPETITION PERIODS: In the first year an increase in P concentration was observed with both fertilizer methods after 6 wk (Figure 2A). The P concentration in Year 2 varied considerably at various stages but was higher at the initial stage and lowest at maturity (Figure 2B). The P concentration was higher in side-placement during both years. The trend under different competition periods showed a similarity to fertilizer application methods (Figure 2C and 2D). The maximum P concentration in wheat just before harvesting (Figure 2A and 2C) might be due to rainfall which would have increased phosphorus absorption.

COMPARISON OF POTASSIUM CONCENTRATION IN WHEAT IN ZERO COMPETITION WITH WHEAT UNDER DIFFERENT FERTILIZER APPLICATION METHODS AND COMPETITION PERIODS: The potassium concentration in wheat was slightly higher in side-placement reaching a maximum value at 8 WAE in Year 1 and at 7 WAE in Year 2 (Figures 3A and 3B). Zero competition also gave a higher K concentration in wheat. The trend was similar to that in fertilizer application methods.

GRAIN YIELD: There was a significant effect of fertilizer application method and competition period on grain yield (Table 7). During both years, side-placement out yielded the broadcast incorporate method. The grain yield of wheat was statistically at par in no competition, and competition for 3 and 4 wk in Year 1. It was followed by 5 and 6 wk competition which gave a statistically similar yield. In the second year grain yield did not vary significantly between no competition and competition for 3, 4 and 5 wk.

A higher grain yield in side placement of fertilizer was probably due to better nutrient uptake since plant roots were closer to the applied fertilizer. An increased number of spike bearing tillers contributed towards a higher grain yield in side placement. These results are in conformity with those of Kirillova and Shakirova (1984). In the present study there was a minimum

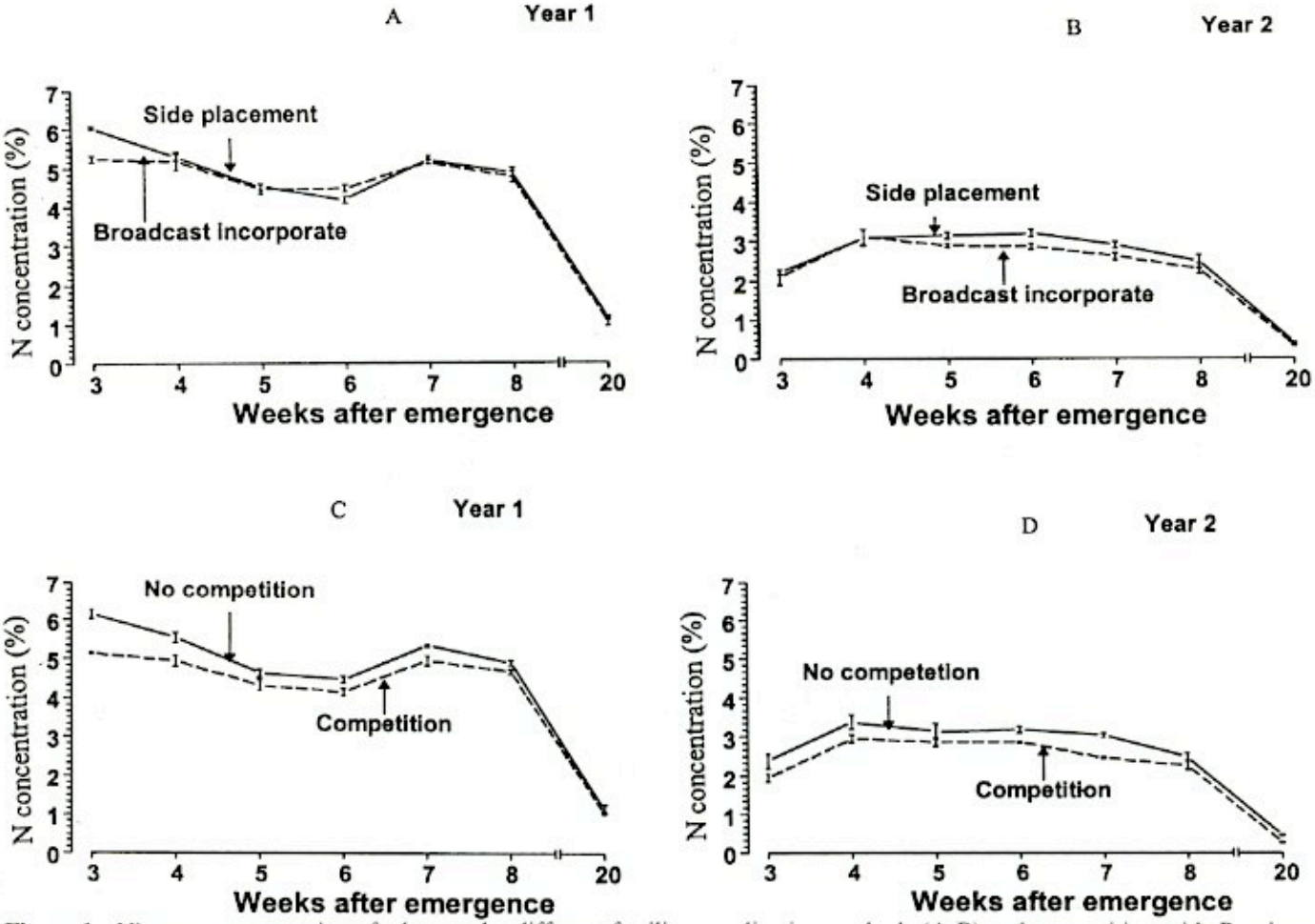

Figure 1. Nitrogen concentration of wheat under different fertilizer application methods (A,B) and competition with *P. minor* (C,D), n=4, error bars denote ±SEM.

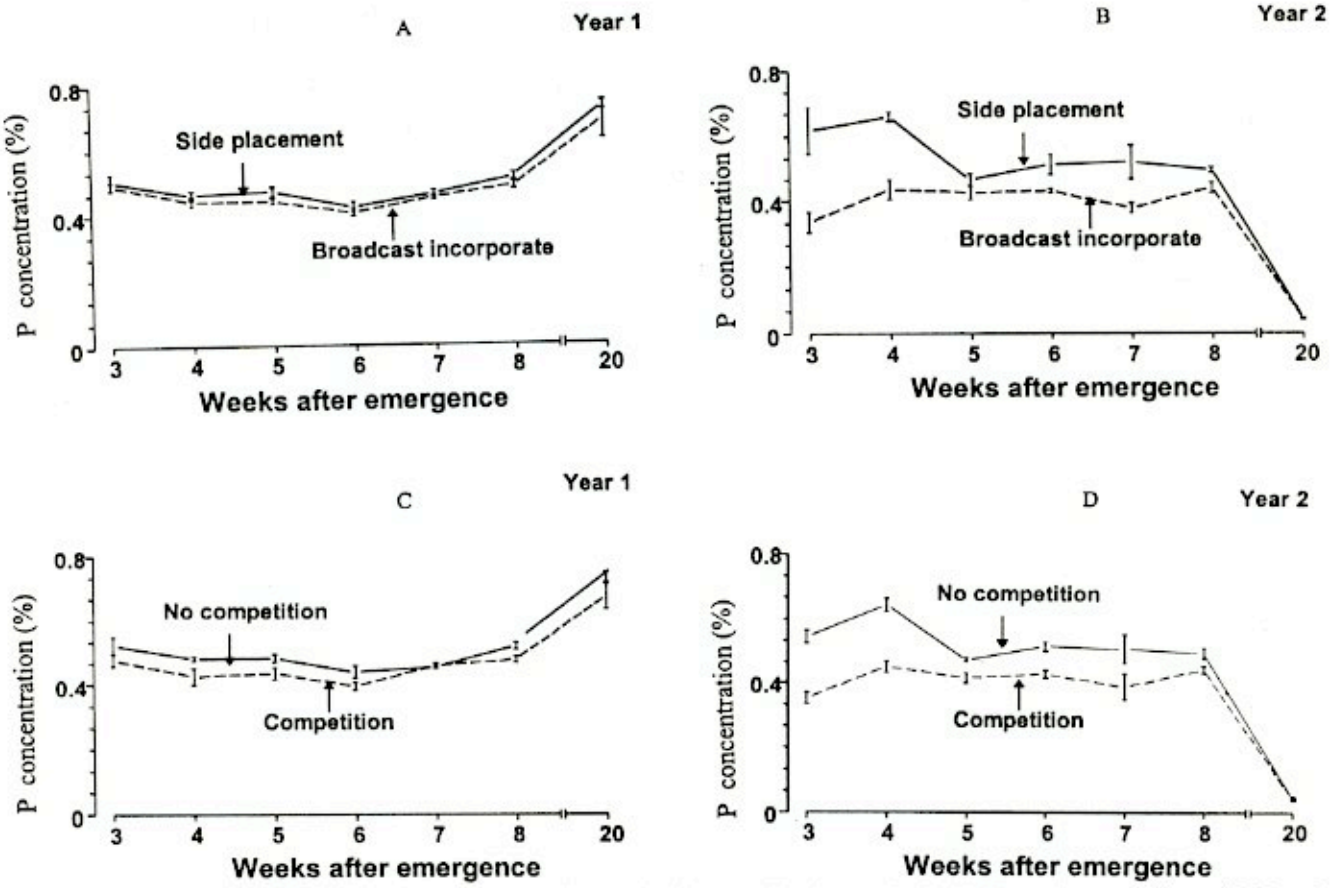

Figure 2. Phosporus concentration in wheat under different fertilizer application methods (A,B) and competition with *P. minor* (C,D).

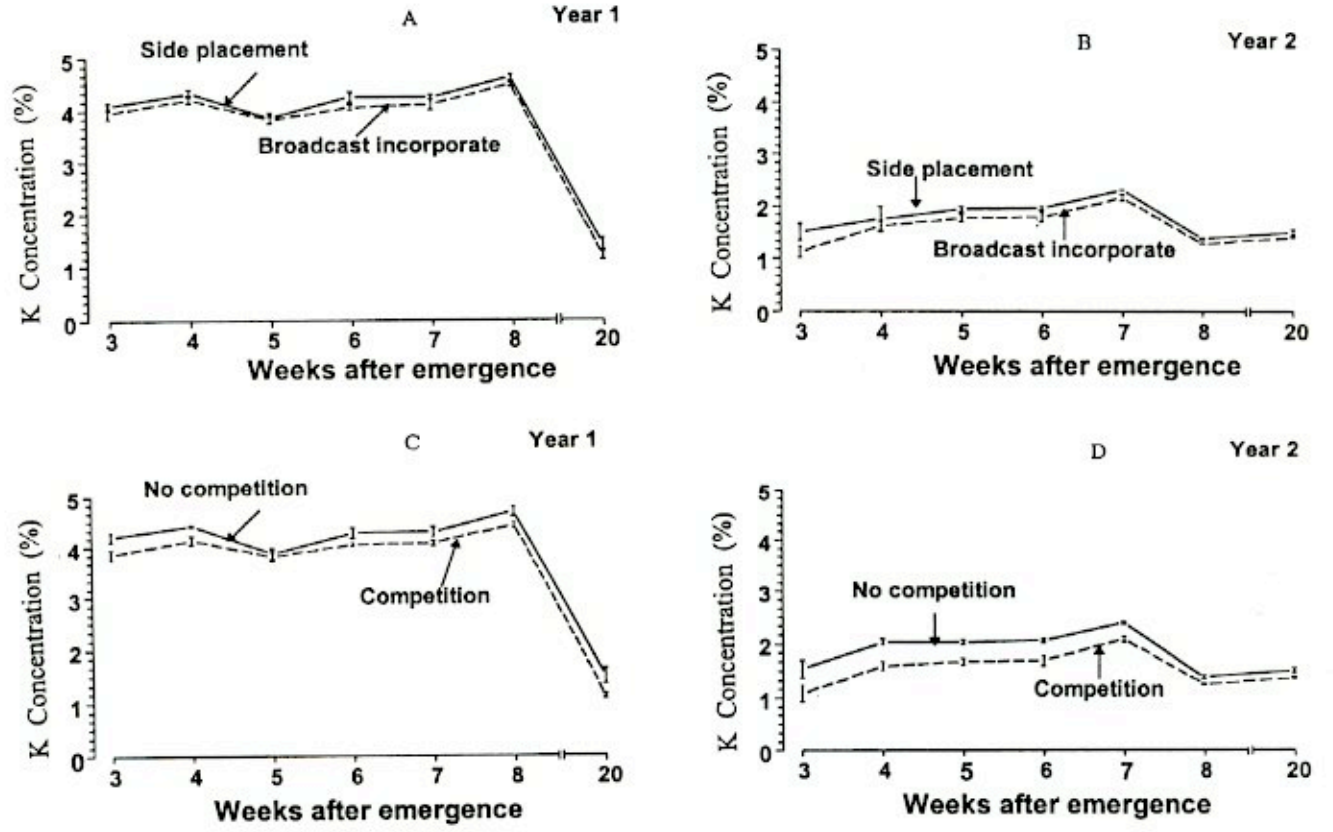

Figure 3. Potassium concentration of wheat under different fertilizer application methods (A, B) and competition with *P. minor* (C, D)., n=4, error bars denote ± SEM.

TABLE 7

Effect of fertilizer application method and competition period on grain yield of wheat in competition with P. minor

Treatment	Grain Yield ($kg \cdot ha^{-1}$)			
	Year 2		Year 1	
Fertilizer Application Method				
Side Placement	5086[a]		5790[a]	
Broadcast incorporate	4715[b]		5484[b]	
S$\bar{x}$	20		36	
LSD 5%	90		162	
Significance[+]	**		*	
Competition Period				
Zero competition	5521[a]	-	6057[a]	-
3 WAE	5493	(0.5)*	6046[a]	(0.2)*
4 WAE	5346[a]	(3.2)	6003[a]	(0.9)
5 WAE	4840[b]	(12.3)	5998[a]	(1.0)
6 WAE	4715[b]	(14.6)	5443[b]	(10.1)
7 WAE	4497[c]	(18.6)	5378[bc]	(11.2)
8 WAE	4442[c]	(19.5)	5173[cd]	(14.6)
Full season competition	4351[c]	(21.2)	4992[d]	(17.6)
S$\bar{x}$	75	-	89	-
LSD 5%	213	-	250	-
Significance	**	-	**	-

[+], *, $P<0.05$; **, $P<0.01$; NS, not significant.
S$\bar{x}$ standard error of mean
WAE weeks after emergence
[abcd] means in the same row with different superscipts differ ($P<0.05$)

decrease in grain yield in early competition. With an increase in competition duration beyond 4 wk there was a progressive decrease in grain yield due to greater competition of weeds with wheat for growth factors. Competition of wheat with *P. minor* resulted in up to a 21.2 and 17.6 % reduction in grain yield in years 1 and 2, respectively. These results are in line with the findings of Nayyer *et al.* (1994) who stated that allowing weeds to grow beyond 4 wk till maturity resulted in a significant decrease in grain yield. They also reported 4-6 wk as the most critical period for weed control.

Conclusions

Nitrogen, P and K losses to *P. minor* were less in side-placement than in the broadcast incorporate method of fertilizer application. Generally there was an increase in nutrient losses with increased competition periods. Side-placement of fertilizer should be carried out to maximise nutrient uptake by wheat.

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