APPENDIX 4.

Soil Nutrient Change in the Soil Beneath Treatments of the Additive Series Experiment.

Quackgrass is considered to be a luxuriant consumer of nutrients. Researchers have observed that quackgrass is one of the most effective plants for reclaiming nutrients from sprayed-on municipal sewage effluent (Mitich, 1987; Adriano *et al*, 1975). Analysis of soil from pots in which quackgrass was grown has shown reductions in the levels of available nitrate nitrogen and potassium (Plhak, 1987). In pot studies, established quackgrass plants were more effective than adjacent alfalfa or oat plants in withdrawing nutrients from a nutrient solution; particularly nitrogen, and to a lesser degree phosphorus and potassium (Ohman and Kommedahl, 1964). In pot studies where adequate light and water were provided, wheat and quackgrass competed for nutrients, most likely nitrogen (Williams, 1969). In pot studies with quackgrass and sugar beet it was determined that competition for nitrogen was more important than competition for potassium (Welbank, 1964). The relative importance of various nutrients to quackgrass competition in the field has not been determined.

Experimental Design

Soil nutrient status below the additive replacement series was monitored to determine if the changes in nutrient status could be related to competition for available nitrogen, phosphorous or potassium by quackgrass in wheat. The general experimental layout and procedures for the additive replacement series experiment have been described elsewhere (Manuscript 1).

Nutrient Use

Prior to planting and immediately after harvest 2.5 cm diameter soil cores were removed from each plot to a depth of 60 cm. The soil cores from each block were then air-dried and bulked by treatment and submitted for analysis to the Manitoba Provincial Soil Testing Laboratory[24]. Additionally a set of cores was removed 1.5 m from each block that served as unplanted checks. Samples were analyzed for sodium-bicarbonate extractable nitrate-nitrogen, sodium-bicarbonate extractable phosphorous and ammonium-acetate exchangeable potassium. The change in soil nutrient status as a result of treatment was determined as the difference between at-planting soil nutrient content and at-harvest nutrient content minus the same difference in unplanted check plots. The calculated change in nutrient status values for each treatment were analyzed by ANOVA as a randomized complete block design with each years data considered a replicate. When determined significant by ANOVA at $\alpha = 0.05$ the means were separated by the LSD test at $\alpha=0.05$.

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Results and Discussion

The levels of available nitrate nitrogen, phosphorous and potassium under all treatments at all sampling times was high (Tables 27,28 and 29). This high nutrient status would minimize the competition for nutrients by quackgrass in wheat.

Reduction in soil nutrient levels from planting to harvest occurred but were not related to treatments (analysis not presented). There was natural variability in soil nutrient levels from treatment to treatment. This is demonstrated by variability in the at-planting nutrient levels which in theory should be relatively uniform (Tables 27,28 and 29). The natural variability within plots may have obscured detection of any treatment differences.

Soil is a dynamic substrate and nutrient levels present are more than just a function of plant uptake. In situations with abundant nutrients, exchangeable ions removed by roots will be rapidly replaced from the soil colloids. For example it has been observed that available nitrate levels in soils that were depressed by quackgrass growth recovered after 14 days rest to the levels that were present in a control soil (Plhak, 1967). Through nitrification NO_3 can be released from mineral and organic matter in the soil. Potassium can be released from clay minerals and phosphorous can be re-solubilized.

Another source of soil nutrient variability in this experiment is the highly mobile nature of nitrate nitrogen. There could have been horizontal movement of nitrate from unplanted areas outside these relatively small plots to the sampled areas inside the plots. There was evidence of horizontal water movement into plots (Appendix 2). Vertical movement of NO_3 could also occur as it moves upward with the soil water as evaporation dries the soil surface.

Table 27. Average available nitrate nitrogen in the soil beneath each treatment of the wheat-quackgrass additive series in 1987 and 1988.

Total Stand Density	Mixture Proportion Wheat	Quackgrass	Available Nitrate Nitrogen (0 - 60 cm) 1987 At Planting	1987 At Harvest	1988 At Planting	1988 At Harvest
(# m^{-2})	(%)		($kg\ ha^{-1}$)			
75	0	100	465	208	239	299
75	25	75	465	170	328	353
75	50	50	640	123	353	307
75	75	25	410	93	353	307
75	100	0	515	160	353	290
150	0	100	750	192	299	312
150	25	75	330	176	292	299
150	50	50	580	154	304	233
150	75	25	350	185	363	421
150	100	0	510	129	312	301
300	0	100	700	138	296	330
300	25	75	745	192	368	389
300	50	50	655	115	388	339
300	75	25	610	106	372	403
300	100	0	480	146	380	315
	Unplanted		547	369	340	328

Table 28. Average available phosphorus in the soil beneath each treatment of the wheat-quackgrass additive series in 1987 and 1988.

Total Stand Density	Mixture Proportion		Available Phosphorous (0 - 15 cm)			
			1987		1988	
	Wheat	Quackgrass	At Planting	At Harvest	At Planting	At Harvest
(# m^{-2})	(%)		(kg ha^{-1})			
75	0	100	106	87	138	176
75	25	75	106	41	187	152
75	50	50	134	108	214	109
75	75	25	96	59	198	97
75	100	0	140	62	141	65
150	0	100	132	62	147	99
150	25	75	114	78	187	102
150	50	50	141	120	129	109
150	75	25	103	49	198	126
150	100	0	188	56	143	93
300	0	100	96	50	216	96
300	25	75	147	105	169	108
300	50	50	184	138	257	85
300	75	25	161	67	214	100
300	100	0	112	55	284	103
	Unplanted		132	155	188	112

Table 29. Average available potassium in the soil beneath each treatment of the wheat-quackgrass additive series in 1987 and 1988.

Total Stand Density	Mixture Proportion		Available Potassium (0 - 15 cm)			
			1987		1988	
	Wheat	Quackgrass	At Planting	At Harvest	At Planting	At Harvest
(# m^{-2})	(%)		(kg ha^{-1})			
75	0	100	1665	1445	2204	1862
75	25	75	1510	1445	2417	1854
75	50	50	1535	1535	2257	1573
75	75	25	1370	1370	2120	1588
75	100	0	1670	950	1930	1588
150	0	100	1600	1240	1915	1558
150	25	75	1445	1445	2204	1619
150	50	50	1650	1475	2219	1581
150	75	25	1460	1270	2219	1839
150	100	0	1520	1480	2090	1710
300	0	100	1445	1270	2409	1710
300	25	75	1445	1545	2143	1748
300	50	50	1590	1560	2090	1725
300	75	25	1550	1370	2090	1824
300	100	0	1510	1400	2022	1816
	Unplanted		1528	1670	2155	1766

The results of this investigation illustrate the problems and ineffectiveness of monitoring soil nutrient changes over the whole growing season for determining the extent of nutrient competition by quackgrass on wheat. Future investigations should utilize plant nutrient analysis, as others have done (Welbank, 1964), to provide discrimination between treatments. Plot sizes should also be larger than those of this experiment to minimize the potential for nitrate movement outside the plots to the sampling areas. The multi-facetted dynamics of the soil system will always make determination of soil nutrient competition between species in the field particularly difficult.