WHAT ARE THE EFFECTS OF HERBICIDES AND WEEDS ON WHEAT PROTEIN LEVELS?

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Summary The effect of herbicides and weed competition on wheat protein was investigated. Some of herbicides examined increased the grain protein of wheat in the absence of weeds provided there was adequate available nitrogen. These tended to belong to specific mode of action groups; acetolactate inhibitors (Group A), inhibitors of photosynthesis (Group C) and the phenoxy-alkanoic acids of Group I. In general, competition with weeds decreased both the yield and grain protein of wheat.

INTRODUCTION

Australian wheat growers must produce grain to meet export market requirements and end uses. For example, Australian Hard requires a protein percentage of greater than 11.5%, Special Hard greater than 13% and Japanese white noodles between 9.5 and 11.5%. Once a variety has been selected to fall within the specified protein segregation, many factors further affect its grain protein output. The principle factors are seasonal conditions over which the growers have little control (Mason 1987). The other factors which can be controlled by managemental strategies involve a balance between the amount of nitrogen in the plant and the number of grains produced.

Herbicides can affect wheat protein levels by directly affecting the nitrogen uptake by the roots or the nitrogen metabolism and protein synthesis within the plant (Hance 1981, Martin *et al.* 1990 and Pederson *et al.* 1994). The change in wheat protein depends on the mode of action of the herbicide, the amount of nitrogen available in the system and at which growth stage the herbicide is applied. Herbicides can also affect wheat protein by decreasing the wheat's competition for nitrogen with weeds (Ponce *et al.* 1989) and thus is dependant on the relative success of the herbicide to control the weed.

The focus of this paper is to discuss the preliminary findings associated with the direct effects of a variety of herbicides and ryegrass competition on wheat protein. Also to propose several research strategies to investigate these effects further.

MATERIALS AND METHODS

Five trials were completed in 1995/96. Two trials investigated the effects of 13 different herbicide treatments (Table 1) on the yield and grain protein of Amery wheat grown under three fertilizer levels (0, 100 and 200 kg ha^{-1} diammonium phosphate at 17.5% nitrogen and 20% phosphorous (DAP)). Both trials were located in the central wheatbelt of Western Australia, one at Merredin (low rainfall (<325 mm); red loam over clay) and the other at Avondale (high rainfall (450–750 mm); red sandy loam). Another two trials compared Amery wheat yields and grain protein under 23 herbicide treatments and one fertilizer regime (100 kg DAP ha^{-1}). The herbicide treatments were essentially the same as in the first two trials (Table 1) with the additional treatments of chlorsulfuron (9.4 g ha^{-1} IBS), diuron + metolachlor + pendimethalin (500 g + 360 g + 330 g ha^{-1} IBS), triasulfuron (50 g ha^{-1} IBS), tri-allate (400 g ha^{-1} IBS, trifluralin 400 g ha^{-1} IBS, fenoxaprop-p-ethyl (103 g ha^{-1} Z12), metosulam + MCPA + dicamba (3.6 g + 85 g + 20 g ha^{-1} Z13), MCPA + dicamba (170 g + 40 g ha^{-1} Z13), MCPA + diflufenican (250 g + 25 g ha^{-1} Z13), MCPA + bromoxynil + dicamba (280 g + 140 g + 40 g ha^{-1} Z13), metribuzin + bromoxynil + diflufenican (49 g + 50 g + 5 g ha^{-1} Z12), diuron then MCPA amine (175 g ha^{-1} Z13 then 200 g ha^{-1} Z24). These trials were located at Merredin and Mullewa (a low rainfall area (<325mm) of the northern wheatbelt; yellow sand). The final trial examined the effect of competition from a ryegrass population (approximately 160 ryegrass plants m^{-2}) on the yield and protein of 17 wheat varieties at Avondale.

RESULTS

The addition of fertilizer increased both the yield and grain protein of Amery wheat at Avondale and Merredin for all herbicide treatments (Table 1). At the Avondale site, nine of the herbicide treatments further increased grain protein irrespective of yield when compared to the control (nil treatment – without herbicide application) at 100 kg DAP ha^{-1} (Table 1). These herbicides belonged mainly to Group B which inhibit acetolactate synthase (chlorsulfuron, triasulfuron, metsulfuron and metosulam), to Group C which are inhibitors of photosynthesis (diuron and bromoxynil) or Group I (phenoxyalkanoic acids). At 200 kg DAP ha^{-1}, the same herbicides increased grain protein in comparison to the control but with a corresponding decrease in yield. There was little effect of herbicide application on yield or protein where there was no fertilizer application. The application of the same groups of herbicides to Amery wheat at the Merredin site also led to an increase in grain protein

Table 1. The effect of 13 herbicide treatments and three fertilizer rates on the grain yield and protein of Amery wheat at Avondale and Merredin (WA) (mean of three replicates).

Herbicide	DAP	Avondale		Merredin	
(Rate ha^{-1}, Time of application)	(kg ha^{-1})	Yield (kg ha^{-1})	Protein (%)	Yield (kg ha^{-1})	Protein (%)
Nil	0	1694.7	9.9	522.6	10.1
	100	1815.1	10.2	1228.1	10.9
	200	2326.5	10.5	1227.1	10.5
Chlorsulfuron	0	1594.5	10.0	811	10.6
15 g, IBS[A]	100	2045.7	10.7	1325.2	11
	200	2015.6	11.0	1324.8	11.1
Pendimethalin	0	1474.1	10.1	454.5	10.6
660 g, IBS	100	2446.9	10.7	1253.8	11.5
	200	2105.9	11.1	1247.4	11.1
Triasulfuron	0	1664.7	9.9	603.1	10.4
26 g, IBS	100	1845.2	10.7	1475.5	11.3
	200	2045.7	10.7	1647.6	10.9
Diclofop methyl	0	1805.1	10.1	642.1	10.4
562 g, Z12[B]	100	1744.9	10.3	1282.1	10.8
	200	2176.1	10.8	1484.3	11.3
Metsulfuron	0	1654.6	10.3	696.2	10.6
methyl	100	1674.7	10.5	1265.5	11.3
3 g, Z12	200	2045.7	10.9	1442.9	11.4
Bromoxynil +	0	1253.5	9.9	846.4	10.7
diflufenican	100	1885.3	10.7	1291.4	11.7
250 g + 25 g, Z12	200	1955.5	10.8	1358.6	11.1
Diuron	0	1754.9	10.3	701.2	10.3
500 g, Z12	100	1614.5	10.9	1113.1	10.9
	200	1764.9	11.4	1383.1	10.9
Metosulam	0	1624.5	9.8	882.9	10.5
5 g, Z13	100	1815.1	10.4	1398.6	11.1
	200	2406.7	10.8	1468.6	11
Tralkoxydim	0	1444.0	10.1	787.9	10.2
150 g, Z13	100	1845.2	10.4	1254.3	11.3
	200	2005.6	10.6	1310.5	10.9
Diuron	0	1694.7	10.4	927.6	10.5
+ MCPA	100	1714.8	10.8	1213.1	11.3
175 g + 200 g, Z13	200	1995.6	10.9	1275	10.9
2,4-D amine	0	1444.0	10.1	649	10.3
500 g, Z15	100	1644.6	10.5	1059	11.1
	200	2156.0	10.8	1450	11.1
MCPA amine +	0	1253.5	9.9	807.6	10.6
dicamba	100	1975.5	10.6	1185.2	11.4
340 g + 80 g, Z15	200	2015.6	10.8	1196.2	10.9
LSD (P=0.05)	208	0.25	197.8	0.49	

[A] IBS incorporated at seeding.
[B] Zadok's scale.

(Table 1) but the effects were observed mainly at the highest fertilizer level. Both sites reported a low weed burden and were described as having an average season with a dry finish.

At Mullewa and Merredin, the 22 herbicides had little effect on the grain protein percentages compared with the control except for chlorsulfuron at Merredin. The Mullewa site was planted late in the season and was quite dry throughout. There were very few weeds at either site.

The addition of ryegrass to the wheat plots at Avondale resulted in a reduction in yield of all 17 varieties tested and a reduction in grain protein of between 0.3 and 1% for 12 of the varieties. The correlation between the percentage in yield reduction and protein reduction however, was poor (r^2<0.1).

DISCUSSION

There was an increase in protein content of Amery grain observed when some herbicides were applied. This response to herbicides only occurred after the application of fertilizer containing nitrogen. As nitrogen is an integral part of proteins, the final grain protein level of wheat is dependant on the amount of available nitrogen, the level of nitrogen uptake and the grain yield response to that nitrogen (Mason 1992).

Although herbicides are applied to control the target weeds they can also affect the nitrogen uptake and/or metabolism of the wheat plant (Hance 1981) and may finally affect grain protein. The herbicides which increased grain protein in these trials predominantly belonged to the herbicide modes of action Groups; B, C and I. Group B herbicides inhibit amino acid synthesis e.g. metsulfuron and can increase grain protein by possibly restricting nitrogen uptake early in the season and allowing increased levels available later on (Pederson *et al.* 1994). Other herbicides can affect the nitrate accumulation by perhaps altering the cyclic to non-cyclic photophosphorylation ratio and increasing translocation of nitrogen into the grain (Group C herbicides) or by possibly affecting the enzyme nitrate reductase (phenoxyalkanoic acids) (Hance 1981, Bil *et al.* 1985 and Pandey and Srivastava 1986).

Wheat protein did not increase after herbicide application in all of the trials. Many factors other than herbicides can affect grain protein and some of these include the seasonal conditions, the soil type, the time of planting and cultivation (Mason 1987). Any one of these factors may have overridden the effect of herbicides resulting in little change in wheat protein.

The introduction of a competitive weed such as ryegrass into the wheat cropping program decreased the final grain protein. The presence of weeds are another factor which can decrease grain protein. Under nitrogen limited soil conditions, weeds compete with the crop for the available nitrogen (Ponce *et al.* 1990, Mason 1992).

Future work for the 1996/97 season includes investigation into the effects of herbicides on grain protein of two wheat varieties including Amery under different nitrogen status, different herbicide application times and different weed competition levels. The nitrogen status of the soil and the crop throughout the growing season will be included.

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