Nutrient removal and movement as a result of different HWSC practices

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Abstract

Harvest weed seed control (HWSC) is a regime of management practices that aim to prevent weed seed movement into the seed bank at harvest. Some HWSC practices target the chaff and straw fraction whilst others only the chaff fraction. To evaluate the impact of these systems on nutrient removal, wheat chaff and straw fractions collected during harvest were analysed to determine the amount of major nutrients (N, P, K and S) contained in these fractions. HWSC practices targeting both straw and chaff removed 8.0 kg of K, 4.7 kg of N, 0.6 kg of S and 0.3 kg of P per tonne of grain harvested. In contrast, systems targeting only the chaff fraction removed 1.1 kg of K, 2.3 kg of N, 0.2 kg of S and 0.1 kg of P per tonne of grain. The removal of nutrients from cropping fields by HWSC systems is often a cost that is not considered when comparing HWSC systems.

Keywords

Harvest weed seed control, herbicide resistance management, nitrogen, phosphorus, potassium, sulphur

Introduction

A large percentage of fields across the Australian cropping regions are now infested with herbicide-resistant weed populations, with multi-resistant annual ryegrass (*Lolium rigidum*) populations extremely common throughout (Boutsalis et al. 2012, Broster et al. 2011; 2013, Owen et al. 2014). Although viable herbicide options are available for the control of resistant weed populations, reducing the reliance on these herbicides will be essential to extending their life and that of any new herbicides.

Harvest weed seed control (HWSC) systems are a suite of harvest residue management techniques that target weed seeds during harvest and, are therefore used to complement in-crop herbicide treatments. The at-harvest targeting of weed seed production prevents seedbank inputs from weeds surviving in-crop to maturity typically due to herbicide resistance. The most frequently herbicide resistant species, annual ryegrass and wild radish, have high seed retention levels at crop maturity (>60%) and are, therefore primary targets for HWSC systems (Walsh and Powles 2014). HWSC systems have been found to greatly improve weed management in cropping systems resulting in high levels of adoption by Australian growers where in 2014 it was estimated that 43% of producers were using one of the available techniques (Walsh et al. 2017). More recently a Kondinin Group report indicated that the level of HWSC adoption by Australian grain growers had increased to 70% (Kondinin Group 2020).

A fundamental difference between HWSC techniques is that some target both the chaff and straw fractions (narrow windrow burning, bale direct) whilst others target only the chaff fraction (chaff lining, chaff tramlining, impact mills). Apart from impact mills, all HWSC systems result in the removal or concentration of harvest residues away from the wider field area. There are high levels of biomass production by some crops and the loss of harvest residues will potentially result in substantial losses of nutrients with the level of nutrient loss depending upon the crop species (Schultz and French 1978). Therefore, this study was aimed at determining the amount of nutrients lost from cropping fields due to the use of HWSC systems that target chaff and straw or chaff only residues.

Methods

In 2014 wheat plants were collected at crop maturity from five farms in southern NSW region, near Wagga Wagga, Rand (x2), Berrigan and Finley. At each location, dry matter cuts (1 m x 3 rows) were taken from eight replicates. These cuts were taken at 15 cm above ground level to replicate the optimum height for HWSC. The samples were then processed to determine crop yield and to determine the weight of the chaff and straw fractions of each sample.

Samples for nutrient analysis were collected using two methods. Wheat plant samples were collected in 1m rows at eight locations (replicates) across the paddock prior to harvest. The straw fraction was collected from each of the eight plant samples and were combined and then a sub-sampled for subsequent analysis. The chaff samples were collected as part of the evaluation of harvester seed collection (Broster et al. 2016) in which plots 20 m long were harvested and the chaff fraction captured in bags made of shade cloth, the eight samples were then sub-sampled and collated to form one sample for analysis at each location.

The samples from each location were then analysed at the Charles Sturt University Environmental and Analytical Laboratory to determine the concentration (mg/kg) of nitrogen (N), phosphorus (P), potassium (K) and sulphur (S) present in the different fractions.

The amount of nutrients removed or destroyed for each of the different HWSC techniques was then determined for each of the five farms from the amount of biomass lost or moved for each method. Nutrient removal for narrow windrow burning and bale direct was calculated by adding the chaff and straw fractions removed plus for narrow windrow burning only, the standing straw under the windrow. For chaff carts and chaff lining/tramlining only the chaff fraction was considered in nutrient removal.

Results

There were large variations in wheat yields, 1.1 to 3.1 t/ha (mean 2.4) and biomass productions, 3.5 to 8.0 t/ha (mean 6.5) across the five southern NSW sampling sites (Table 1). Despite these variations, the harvest index values (grain/total biomass) were reasonably consistent at around 0.4. The commonly used harvest height of 15cm resulted in the collection of 55% of the total wheat straw production. Therefore, when the chaff and grain fractions are included, it is estimated that on average 80% of crop biomass is collected and processed during wheat harvest.

Table 1. Grain, chaff, straw and harvested straw fractions of total biomass and the harvest index for wheat crops at five locations in southern NSW in 2014. Numbers in brackets are the standard errors of the mean of eight values.

Location	Total biomass	Grain	Straw	Chaff	Harvested straw*	Harvest index
			t/ha			
Wagga Wagga	8.0 (0.344)	2.8 (0.142)	4.2 (0.172)	1.1 (0.04)	2.5 (0.199)	0.34 (0.005)
Rand A	6.9 (0.344)	2.3 (0.081)	3.6 (0.226)	1.1 (0.081)	1.6 (0.198)	0.33 (0.007)
Rand B	6.9 (0.377)	3.0 (0.161)	2.4 (0.164)	1.5 (0.057)	1.4 (0.155)	0.43 (0.003)
Berrigan	6.9 (0.364)	3.1 (0.222)	2.1 (0.159)	1.7 (0.074)	1.3 (0.161)	0.44 (0.014)
Finley	3.5 (0.148)	1.1 (0.059)	1.5 (0.077)	0.8 (0.021)	0.8 (0.021)	0.34 (0.006)
Average	6.5	2.4	2.8	1.2	1.5	0.37

* at a 15 cm harvest height

Nutrient analyses of the harvest residues identified substantially higher levels of K and S in straw material with greater concentrations of N in chaff (Table 2). The largest difference in nutrient concentration between the residues was for K where there were five times higher levels of this nutrient in the straw. There were also approximately double the concentration of S in straw than in chaff material. In contrast, there was approximately 20% more N in chaff than in straw.

Substantially higher amounts of nutrients are removed by HWSC systems that target straw as well as chaff residues compared with those that only target the weed seed containing chaff material (Figure 1). The bale direct and narrow windrow burning systems similarly collect and remove or burn all the straw and chaff material above a low harvest height of 10 to 15 cm. This results in substantially higher amounts of phosphorous, potassium, nitrogen, and sulphur being removed from the field during harvest. Systems that target just the chaff material, such as chaff carts and chaff lining/tramlining also cause nutrient removal from across the field when this material is concentrated into lines or heaps. Based on the average amounts chaff and straw collected during the harvest of wheat crops at the five sample sites the use of chaff and straw targeting HWSC systems would have removed 10.0, 0.7 18.8 and 1.4 kg/ha of N, P, K and S, respectively during harvest. In contrast, the use of chaff only targeting systems would have removed 4.8 0.3, 2.5, and 0.5 kg/ha of N, P, K and S, respectively. This represents substantially reduced losses of N, P, K and S of 51%, 56%, 86%, and 66% respectively following the use of HWSC systems that remove only the chaff fraction.

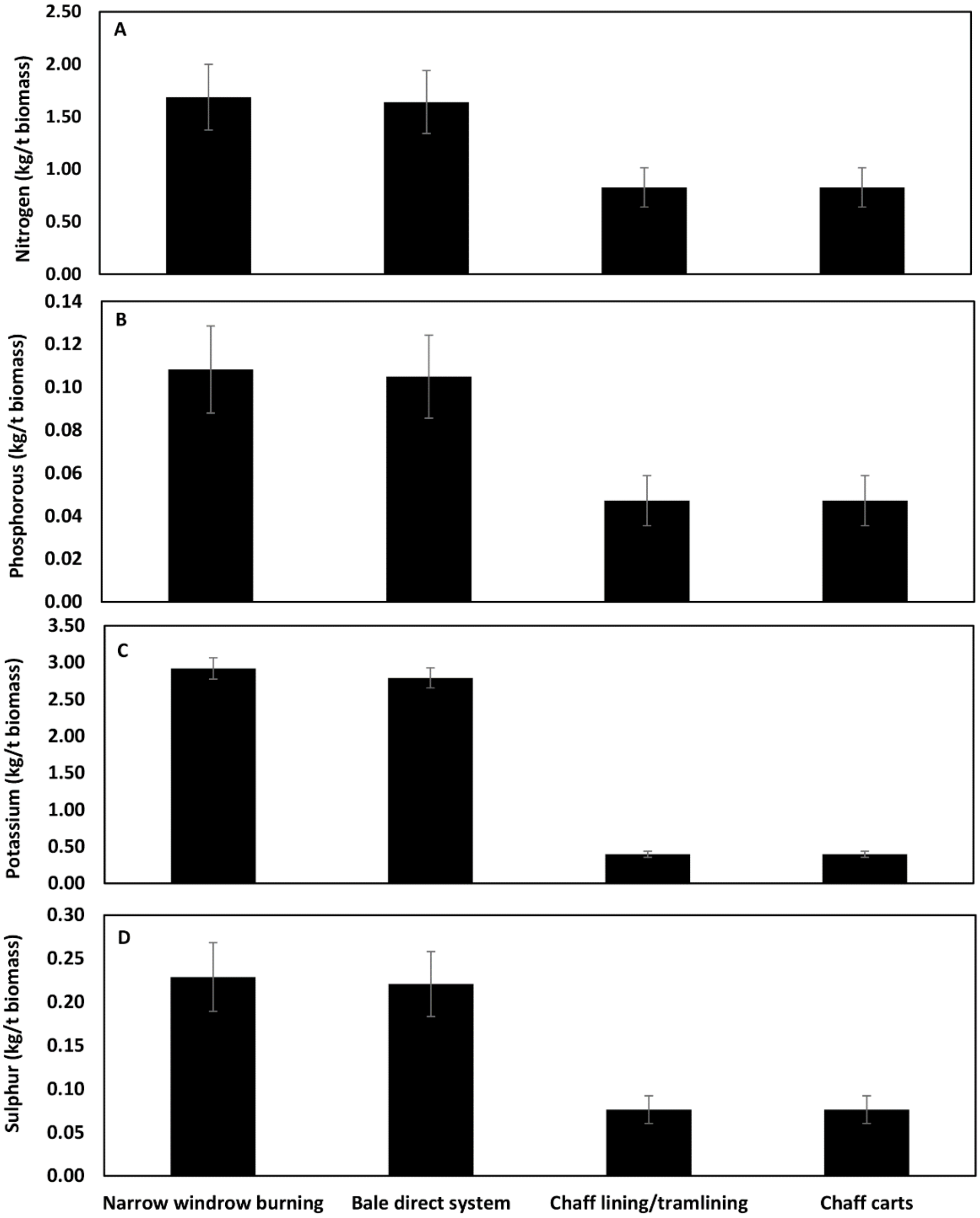

Figure 1. Removal of (A) nitrogen, (B) phosphorus, (C) potassium and (D) sulphur from the field due to the use of four harvest weed seed control systems. Bars represent the standard error of the mean of nutrient values from five sites.

Table 2. Average levels of Nitrogen, Phosphorus, Potassium and Sulphur present in wheat straw and chaff fractions collected at five locations at crop harvest near Wagga Wagga in 2014. Numbers in brackets are the standard errors of the mean of five sites.

Nutrient	Straw	Chaff
	(mg/kg)	
Nitrogen	3440 (560)	4086 (534)
Phosphorous	242 (45)	232 (34)
Potassium	10376 (251)	2038 (163)
Sulphur	628 (92)	383 (50)

Conclusion

Harvest weed seed control is an accepted management practice for many cropping farmers across southern Australia to assist in the management of herbicide resistant weeds. Previous research has shown all HWSC treatments are equally effective in reducing ryegrass emergence in the next year (Walsh et al. 2017). Therefore, a major factor in the decision of what form of HWSC to use is the cost of the various systems and its suitability for the farmer's management system. However, this work shows that the impact the different systems have on nutrient removal also needs to be considered by farmers when choosing which HWSC system to implement.

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