Introduction

Many Australian farms involve a mixture of livestock and cropping enterprises, with considerable variability in the extent to which these two enterprises interact. Each enterprise is a ‘system’ in its own right, but the introduction of crop grazing into a previously ‘pasture-only’ grazing enterprise increases the complexity of the system, to the extent that a systems approach is probably the only route toward a better understanding of the crop-pasture grazing system.

A major component of an understanding of a system is a clear appreciation of what the system actually entails. This is certainly the case when dual-purpose crops are introduced into a grazing system. The current interest in dual-purpose crops in Australia focusses on long-season or true ‘winter’ crops, especially winter wheats, which have a marked vernalisation requirement and do not flower until this requirement has been satisfied. Such crops can thus be sown early, so that they can provide a late autumn/winter feed bank, and can then be grazed in winter and subsequently go on to provide a grain/seed crop. The lecture and full paper will discuss how grazing can be achieved with minimal effects on grain production. One must also consider the dual-purpose crop in terms of what part of the system it is replacing. For example, in the cereal-livestock zone, crops are already grown within the mixed farm and dual-purpose crops may simply replace an area that was previously grain-only crop. By contrast, in the high-rainfall zone, dual-purpose crops will more likely replace grazed pasture. This means that the grazing/grain provided by the crop must at least make up for the pasture grazing foregone during crop preparation and growth.

The full paper will also discuss the grazing of long-season brassica crops such as canola. These can be grazed in a manner analogous to dual-purpose cereals, but can also confer major system benefits. For example, introduction of dual-purpose canola provides a break crop to assist disease control in dual-purpose wheat.

Dual-purpose wheat in grazing systems

The impacts of dual-purpose wheat grazing can conveniently be discussed in terms of the effects of the grazing on the crop, and the effects on the grazing animals of the availability of crop forage.

Effect of grazing on the crop

A key component of the use of dual-purpose crops is their early sowing, so that they have time to produce a feed bank for animals by late autumn/winter. Early sowing exposes the crop to greater competition from weeds and fungal disease, which may require greater pre-emergent herbicide or fungicide use. Grazing management of the crop needs to accommodate the withholding periods for these chemicals.

One of the main concerns about the grazing of the developing crop is that grazing might jeopardise subsequent grain yield. Recent data indicate that with appropriate grazing management, this should not be a major concern. Harrison et al. (2011) reviewed the effect of grazing on grain yield and reported that grazing caused a reduction in grain yield of 7±25%. The standard error of 25% implies that in some cases, grazing resulted in an increase in grain yield. Such increases are real and arise from reduced soil-water usage by the crop in winter (due to reduction in canopy mass), which conserves soil water until the grain-ripening stage.

Another system impact of grazing on crop production is that grazing often delays flowering in the crop, such that the possible impact of frosts on grain production are minimised.

In order to achieve rapid early forage production from the early-sown crop, nitrogen supply to the crop is crucial but at the system level, nitrogen management must avoid high nitrate content in crop forage because of the possible risk of nitrite toxicity in grazing stock. This is of particular concern with canola. Nitrogen should not be applied to canola if canola grazing is imminent.

Effect of crop grazing on the animals

To accommodate the ‘winter feed gap’ which often occurs in pasture-only systems, producers must either reduce winter stocking densities or provide supplementary feed or forage. Dual-purpose wheats (and canola) can help fill this feed gap in a cost-effective way, provided they are sown early. The full paper will discuss this in relation to three key questions:

1. When should the crop be sown?
2. When should the crop be grazed, and with what?
3. What stocking rate to use and when to remove stock?

Of all these questions, the decision of when to remove stock is probably the key question in relation to minimising the effects of grazing on crop grain yield.

The forage of dual-purpose wheat is of high nutritive value for grazing livestock, but recent studies have shown that the introduction of such wheats into grazing systems will require producers to pay more attention to the mineral nutrition of livestock grazing the wheat (see Dove et al. 2016), especially in relation to magnesium and sodium. This work will be discussed in more detail in the full paper. Wheat forage is not markedly deficient in magnesium, but often has very high potassium content and very low sodium content, relative to animal requirements. The resultant high forage ratios of potassium:sodium can reduce gut absorption of magnesium (see Dove et al. 2016), and the wheat forage can also be...
considered to be frankly deficient in sodium. As a result, liveweight gain responses of at least 15-25% have been found when livestock grazing wheat are supplemented with either magnesium (MgO) or sodium (NaCl), with somewhat higher responses when both minerals are given (see Dove et al. 2016). There have not been significant liveweight gain responses to these minerals in livestock grazing barley or oats.

**Dual-purpose canola in grazing systems**

The issues which arise when grazing dual-purpose canola are generally similar to those for cereals. In the high-rainfall zone, early-sown winter canola varieties can provide feed of high nutritive value, with high forage yield and little impact of grazing on seed production. Measurements of diet selection and intake in sheep grazing canola have shown that, contrary to frequent producer perceptions, animals spend >85% of their time grazing the canola, which constitutes >85% of their total DM intake.

In relation to mineral supplementation of sheep grazing canola, magnesium/sodium supplementation is not required and may even be contra-indicated. This will be discussed in more detail in the fill paper.

**Further impacts of dual-purpose crops in the whole-farm system**

Dual-purpose crops such as long-season wheat or canola can be grazed separately or in sequence, and provided stock are removed before critical growth stages, these crops can be grazed more than once in a season. If the crops are managed so as to minimise reductions in grain yield arising from grazing, increased profits can accrue. However, there are even greater benefits for the whole-farm system, resulting from complementarities between the cereal and the canola, and from the spelling of pasture which occurs in winter, when livestock are grazing the crops. Dove and Kirkegaard (2014) identified the following benefits, which will be discussed in detail in the full paper.

**Impact on crop disease**

Early-sown winter wheat is at greater risk of wheat-streak mosaic virus (WSMV), which can severely reduce yields. Producer perception was that this was due to the virus being spread by grazing. However, the increased WSMV infection is actually related more to crop/weed hygiene over the previous summer. As part of the whole cropping/grazing system, producers in areas prone to WSMV will have to pay more attention to crop/weed hygiene, or must consider sowing the wheat after canola; both approaches can avoid or greatly reduce the virus problem. At the systems level, the dual-purpose canola thus not only provides useful winter forage in its own right, but it also functions as a break crop to reduce the chance of WSMV infection in a subsequent wheat crop.

Canola itself is at risk of the fungal disease ‘blackleg’. Using canola as a grazing resource can increase the severity of blackleg infection, but much less so in canola cultivars which are blackleg resistant. A cropping/grazing system involving canola should thus be based on canola cultivars which are already highly resistant to blackleg.

**Weed management**

Producers have recognised that the incorporation of dual-purpose crops into a grazing system can be a key component of an integrated weed management system on-farm. However, this aspect has not received the research attention it deserves. Examples of the impact of crop grazing on whole-farm weed management will be discussed. In general, careful attention to the management of weeds in dual-purpose crops will be needed to ensure that weed infestations do not arise from the introduction of crops into the grazing system. Rather, the aim should be to use the cropping phase as part of the whole-farm weed management plan.

**Pasture spelling**

When livestock are removed from pasture to graze one or more crops as part of winter pasture management, the pastures are ‘spelled’ and theoretically should provide increased pasture production in late winter. This is especially the case if different crops are grazed in sequence, and/or grazed more than once. Under these circumstances, the livestock may be off pasture for an extended period. Dove and Kirkegaard (2014) showed that, relative to pasture grazing only, the grazing of a single crop (either wheat or canola) could provide 800-1200 extra sheep grazing days, while the grazing of both crops in sequence provided over 2000 extra sheep grazing days. However, taking the crop and pasture components together, the grazing of crops resulted in about 1600 (one crop) or 3500 (both crops grazed) extra sheep grazing days. Hence, of the total extra sheep grazing days accruing from the introduction of crops into the grazing system, no less than 30-40% of the benefit arose from the extra pasture which accumulated during crop grazing. Further work is needed with other pasture-based systems and with cattle grazing, to fully quantify the ‘pasture-spelling’ benefits arising from the used of grazed crops.

**Crop residue management**

Since grazing usually delays crop flowering and thus grain harvest, and since an early sowing is required to make best use of dual-purpose crops in the following year, there is a limited period in which to utilise/dispose of crop residues. There is a need for much more research on this aspect, to optimise crop utilisation in grazing systems.

**Increased farm carrying capacity**

The extra grazing provided by crop grazing and by pasture spelled during crop grazing means that winter carrying capacities can be increased. Such increases, while real, will decline once the winter stocking rate exceeds that which can be maintained over summer. This is a major issue for the design and management of pasture/crop grazing systems, and much more work needs done in this area. The modelling of grazing systems would seem an ideal approach to explore this aspect, and extend it to other systems and regions.

**References**

