Forage brassica use in New Zealand and Australia farming systems

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Abstract

Forage brassica, genus *Brassica*, are annual feed crops grown on farming enterprises throughout New Zealand and Australia. These crops provide a source of high-yielding, high-quality feed, which is particularly useful to complement pasture production during periods when pasture growth is reduced. There are six forage brassica species and subspecies of agricultural importance including bulb turnip, swede, kale, forage rape, leafy turnip, and raphanobrassica. All of these, as well as interspecific crosses and individual cultivars, offer a range of characteristics to fit various environmental and livestock production challenges. Consumption of forage brassica crops in ruminant animals may reduce methane emissions compared to traditional feed sources. Furthermore, recent technological developments using seed mutagenesis in breeding new forage brassica provide increased herbicide control of weed species. As with all feed sources, specific management, crop husbandry and animal health considerations apply. Overall, the use of forage brassica enables increased resilience in typical pasture-based farm systems.

Introduction

Forage brassica are a group of plants from the *Brassica* genus but also includes interspecific hybrids. They exhibit a range of characteristics, whereby some produce primarily root biomass, such as bulb turnips (*B. rapa* syn. *B. campestris*) and swede (*B. napus* spp. *napobrassica*). Others produce mainly leaf and stem such as kale (*B. oleracea* spp. *acephala*), forage rape (*Brassica napus* spp. *biennis*) and leafy turnip (*B. rapa* syn. *B. campestris*). While some produce much leaf but little stem or root, such as the new-to-market raphanobrassica (Dumbleton, Box, Foley, Westwood, & Wright, 2021) (*Raphanus x Brassica*), an intergeneric hybrid, raphanobrassica of kale x radish (*Raphanus raphanistrum* subsp. *sativus*) and cv. Pasja is a fast-growing, early-maturing turnip x Chinese cabbage cross. In New Zealand, forage brassica comprises the largest area of cultivated crops, with approximately 300,000 ha grown annually (de Ruiter, Dalley, Hughes, Fraser, & Dewhurst, 2007).

Australasian farming systems are largely pasture based with animals grazing pastures made up of grass (*Lolium* spp.), clover (*Trifolium* spp.) and chicory-plantain pastures (*Cichorium intybus* and *Plantago lanceolata*) pastures *in situ* almost all year round. However, when the daily growth of pasture is unable to meet the demands of grazing animals for reasons of cold environmental temperatures or low soil moisture, brassicas crops are often used to supplement the supply of pasture to the grazing animal. This paper describes the range of brassica options, their use in Australasian farming systems, the benefits they provide, and their potential contribution to reductions in greenhouse gases.

Species and subspecies

There are six species or subspecies of forage brassica of importance for livestock feeding in Australasia (Figure 1): forage rape, raphanobrassica, leafy turnip, bulb turnip, kale, and swedes. Each species or subspecies, interspecific crosses between and cultivars within these, have varying characteristics which fit into different farming systems (de Ruiter, et al., 2009; Stewart & Charlton, 2003). Sales data from New Zealand Plant Breeders Association show kale and forage rape account for the largest proportion of forage brassica grown at 40% and 35%, respectively; bulb turnip at 10%; and raphanobrassica, leafy turnips and swedes at 5% each.

Forage rape, raphanobrassica and leafy turnips are typically grown as summer feed options, whereas bulb turnips, kale and swedes are commonly utilised in winter. Although, the advent of novel cultivars has improved grazing flexibility and regrazing options in some species. For example, interspecies crosses of forage rape x kale allow multiple grazing events to occur.

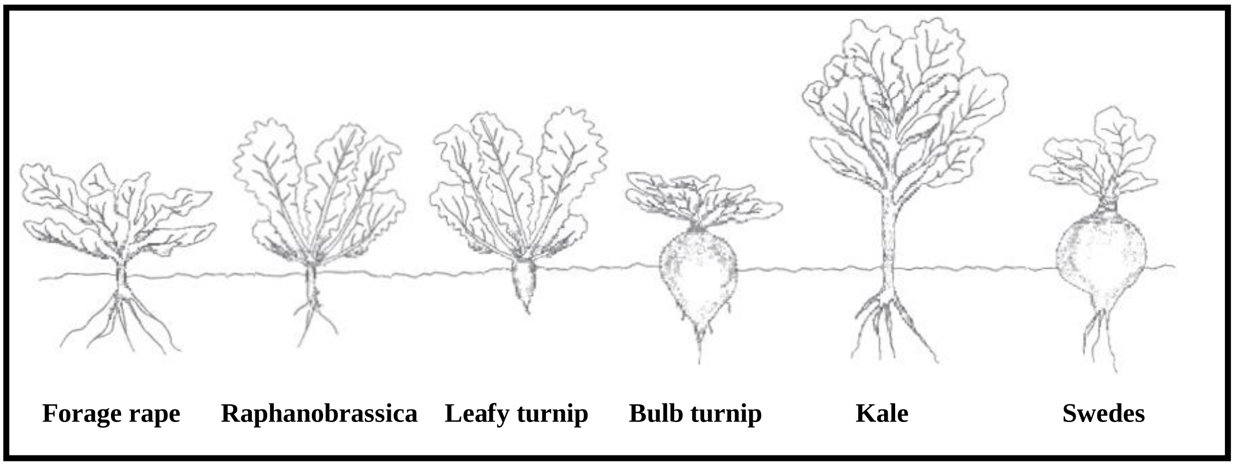

Figure 1: Emblematic growth habit of six major brassica feeds grown for livestock consumption in Australasia adapted from Stewart & Charlton (2003) and Stewart, Kerr, Lissaman, & Rowarth (2014).

Breeding

The first major systemic plant breeding programme with forage brassica appears to be that of John and Robert Garton in the United Kingdom in the late 1800s, titled 'Scientific Farm Plant Breeding'. Gartons Limited released five swede cultivars and three turnip cultivars by 1900. Over time, forage brassica breeding has developed with a core focus on dry matter yield. However, reliability of dry matter yield depends on disease resistance; therefore, disease resistance is the primary goal of a forage brassica breeding programme. The main diseases affecting forage brassica are clubroot (*Plasmodiophora brassicae*), black leg (*Leptosphaeria maculans*) and powdery mildew (*Erysiphe cruciferarum*). Kale and turnips and swedes and rapes differ in breeding methodology because they are outbreeders and inbreeders, respectively. Swedes and forage rapes are predominantly self-pollinated under field conditions, with over 80% self-pollinating (Gowers, 1981). Swedes and forage rapes are generally tolerant to inbreeding, whereby Davey and Lang (1938) found that a third of inbred material was inferior to the original cultivar from which they were obtained, a third was equal, and a third was slightly better. Turnips and kale are predominantly cross pollinators and the general method used for most kales and turnips breeding has been inter-crossing of desirable parents and then simple mass selection or progeny selection for desirable traits (Davik, 1997; Frandsen, 1958; Shattuck & Proudfoot, 1990). Considerable increases in dry matter yield have been exhibited in F1 hybrids (Frandsen, 1958; Josefsson, 1948). Although *Brassica napus* is generally considered self-compatible, there does appear to be evidence of self-incompatible plants in the species (Olsson, 1960). Cytoplasmic male sterility is also available in *Brassica rapa*, either derived from cytoplasms used in oilseed rape (Hu, Chen, & Li, 1997; Sovero, 1988; Verma, et al., 2000) or from new cytoplasms (Deol, Shivanna, Prakash, Banga, & Robbelen, 2003; Matsuzawa, et al., 1999; Okawa, 1985).

Agronomy

Forage brassica are considered high-yielding crops with good nutritive values comparable to those of traditional spring pastures. They can accumulate large yields of 4 – 12 t DM/ha within a relatively short timeframe of 5 – 6 months (Fletcher & Chakwizira, 2012; Fletcher, Wilson, Maley, McCallum, & Shaw, 2010; Gowers & Armstrong, A comparison of the yield and utilisation of six kale cultivars, 1994; Jacobs, Ward, McDowell, & Kearney, 2001; Jung, Kocher, & Gilica, 1984; Rao & Horn, 1986). Brassica crops grown for summer feed, such as forage rape, raphanobrassica and leafy turnip typically yield 8 – 10.5, 16, and 11 t DM/ha, respectively (de Ruiter, et al., 2009; Dumbleton, Box, Foley, Westwood, & Wright, 2021). Common yields of winter brassica crops, such as bulb turnips, kale, and swedes, are approximately 10.5, 12.- 17 and 12 – 16 t DM/ha, respectively (DairyNZ; de Ruiter, et al., 2009). Producing short-lived, high-yielding crops as part of a pastoral rotation can provide increased resilience in Australasian farming systems.

Leaf material of forage brassica is highly digestible (Westwood & Mulcock, 2012) and bulb-producing species, such as bulb turnips and swedes, provide a form of readily available carbohydrates (de Ruiter, Dalley, Hughes, Fraser, & Dewhurst, 2007). Forage brassica tend to have a relatively low proportion of dry matter (DM) at 10 – 14% (de Ruiter, Dalley, Hughes, Fraser, & Dewhurst, 2007) and an energy content of 10 – 13 MJ ME/kg DM (de Ruiter, Dalley, Hughes, Fraser, & Dewhurst, 2007; Westwood & Mulcock, 2012). However, feed quantity and nutritive values vary between species and can be inconsistent due to suboptimal harvest timing (Dumbleton, Box, Foley, Westwood, & Wright, 2021), environmental conditions, crop management and husbandry (Keogh, McGrath, & Grant, 2011).

Recently, the development of a range of forage brassica resistant to chlorsulfuron herbicide (Dumbleton, et al., 2012) has provided increased flexibility to control weeds, especially those in the brassica genus. This weed management system represents a new tool for Australasian farmers which is likely to expand the use of forage brassica crops into more marginal areas which historically have had difficult to control weed problems.

Farm systems

Brassica crops are primarily used to offset feed shortages, which often occur in pasture-based systems due to reduced pasture growth during periods of low winter temperatures or low soil moisture (Dumbleton, et al., 2012). These feed shortages are often at important times within the production cycle, for example, mating, and their use may provide significant benefits to annual production.

Kale and swedes are often used as winter diets in environments where pasture growth is very slow. Diets typically would include a majority of brassica, approximately 75%, and would be accompanied with hay or silage (Judson & Edwards, 2008). At a systems level, forage brassica used in this way would allow a higher winter stocking rate to be maintained, essentially flattening out the feed production curve.

Forage rapes, turnips and more recently raphanobrassica are considered useful feed sources through dry summer periods (Judson, Ferguson, Cutts, & Moorhead, 2013). These crops use spring soil moisture to grow and hold large volumes of quality feed for use in a dry period. Therefore, these crops may support and even extend lactation in dairy systems; may provide quality feed for young growing animals; and provide a lift in energy intake prior to mating in sheep and deer systems particularly.

Animal performance

Animal performance often reflects the high digestibility of the forage. Not only are forage brassica crops a high-quality forage per-se, but they are also typically much higher than comparable autumn-saved pasture in winter, or drought-affected pasture in summer (Westwood & Mulcock, 2012). As with all feeds, there is some animal health considerations when brassica crops account for a large proportion of the diet. Many cases of animal disease, such as bloat or acidosis, may be a function of poor stock adaptation to dietary change (Dalley, et al., 2015). Best management practices should be followed.

Recently, reductions in methane emission were achieved by feeding forage brassica, especially winter forage rape, to sheep and cattle. Pure forage rape fed as a winter crop resulted in 37% lower methane yields than pasture. Increasing the proportion of forage rape in the diet of sheep fed pasture linearly decreased methane yield. Feeding forage rape to cattle also resulted in 44% lower methane yield than feeding pasture (Sun, Pacheco, & Luo, 2016).

Conclusion

Forage brassica crops are grown to complement pasture-based systems throughout Australasia. Feed deficits often exist due to the seasonality of pasture growth, presenting an opportunity to produce alternative crops, such as forage brassica. The high-yields and high nutritional quality of forage brassica crops provides a better match to animal energy demands at key times of the animal production cycle and a more even distribution of feed throughout the year. Different forage brassica provide an assortment of characteristics that suit a range of farm systems. Some limitations to forage brassica include crop management and animal health considerations. Forage brassicas provide additional tools for increasing resilience on farm.

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