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Contents:

Fall and Winter Grazing of Brassicas - a Value-Added Opportunity for Lamb Producers

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Summary

Fast-growing cold-tolerant brassicas can be grown as a second crop, providing low-cost, high quality forage for fall-grazing lambs. In this study, cultural methods on irrigated fields included species and varieties, establishment method, second-crop planting dates (July 17 to August 12) and volunteer grain control. Brassicas were planted after several primary crops. Studies were conducted at the Powell, WY, Research and Extension Center from 1986 to 1996. Lamb performance was evaluated in seven grazing studies. Brassica forage production declined about 770 kg/ha per week when planted after July 20. Two to 3 metric tons/ha of forage was available in all years, except 1992, when soil fertility was low. Average daily gain (ADG) was similar for turnips and other species (tyfon, rape, radish). Over all studies, lambs grazing brassicas gained 0.18 kg (0.13 to 0.25) per day. During the first month, lambs grazing turnips and other forages gained faster than drylot-fed lambs, but gained slower than drylot-fed lambs after the first month. Average lamb gain/ha was 308 kg. Gains of lambs grazing July-planted brassicas were 41% greater than with August-planted brassicas. The average number of lamb grazing days/ha was 1685. Brassica-grazed lambs gained subsequently as well in drylot as lambs not previously grazed. Carcass characteristics of lambs grazing brassicas were similar to those of lambs fattened in the drylot; however, grazed lambs required longer to reach target weights.

Key words: turnip, tyfon, rape, radish, sheep, weight gains.

Introduction

Each fall many lambs are sent to feedlots because quality forage is lacking. Significant value could be added if even a fraction of these lambs were retained for fall grazing on high-quality pasture for two to three months.

Fields on which irrigated small grains are grown commonly are left idle (fallowed) following harvest in late July or early August with a 2 to 2 $^{1}/_{2}$ month growing season remaining for cold-tolerant crops, such as brassicas. Brassicas include turnips, rape, tyfon (a hybrid of turnip and Chinese cabbage) and related species. Planting turnips, rape and other similar fast-growing, frost-tolerant crops as a second crop can provide extended grazing with high-quality, low-cost forage. Additionally, these species can be used as break crops following plow-out of alfalfa and can be no-till seeded into herbicide-killed sod.

Brassicas require high levels of nitrogen and effectively use residual soil nitrogen from previously-grown alfalfa. In previous studies, with18 to 25 ppm soil nitrate nitrogen, turnips planted in mid-July after plow-out of alfalfa responded to nitrogen fertilizer. Greatest yield of turnips planted after alfalfa was produced with about half (56-67 kg N/ha) that needed after a small grain crop (Koch and Karakaya, 1998). Nitrogen fertilization is very important after malt barley harvest because there is generally little residual soil nitrogen. A soil test can assist in determining amount of nitrogen to apply. Brassicas require high phosphorus and potassium; however, fertilizer needs should be based on soil analyses.

The brassicas are high water-requiring crops; therefore, late-season irrigation is necessary. Although some brassicas are moderately tolerant to salt, turnips are not saline or alkaline tolerant.

Forage brassica varieties have a biennial growth habit, meaning that they produce only vegetative growth the year of planting. Tyfon produces leafy top growth like turnips but smaller fleshy roots than turnips. Both tyfon and turnips are near maximum production in about 60 days whereas rape, which produces a stalk, requires 75 days or more. Tyfon has a larger seed than turnips and requires at least twice the seeding rate for the same density of stand. Rape seed size is intermediate. Rape is potentially more productive than turnips and tyfon; however, animals do not eat its central stalk. Because residual stalks of rape mostly remain standing, rape can be seeded in mixtures with turnips and provide good winter soil protection following grazing.

There is a general lack of high-quality forage for fall grazing in many areas. Growing a second crop is a more efficient use of land, labor and capital than using the whole season to grow brassica crops. In addition to providing inexpensive high-quality forage, brassica grazing can reduce environmental problems associated with feedlots. Two unknowns related to brassica grazing are

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lamb carcass quality and performance of lambs if transferred from grazing to the feedlot.

Marten and Jordan, 1982, and Heinemann, 1979, reported lower performance with lambs than would be expected from the high nutritive value of turnips and other brassicas. Lambert et al. (1987) found that lambs fed hay, even of poor quality, while grazing brassicas performed better than lambs grazing brassica forage alone. Koch et al. (1987) reported gains of 0.21 to 0.25 kg/day with lambs grazing tyfon no-till seeded into permanent pasture, on which there was an estimated 840 kg dry matter/ha of grass.

One of the limitations of turnips and other brassicas is that they are hosts of the sugarbeet cyst nematode (Koch and Gray, 1999). In a previous study, lambs grazing 'Adagio', a nematode-resistant radish performed as well as lambs grazing turnips (Yun et al., 1999). Fall grazing did not diminish the ability of the radish crop to control soil nematodes. If sugarbeets are to be grown and the field is infested with sugarbeet nematode, a nematode-resistant radish variety should be used.

Materials and Methods

Soil and crop management.
The soil was a Garland clay loam (fine, mixed, mesic Typic Haplargid). All studies were at the Powell (Wyoming) Research and Extension (R&E) Center. Soil pH was 7.6 to 7.9, organic matter was 1.1 to 1.4%, electrical conductivity was 0.6 to 1.1 ds/m, P04-P (except in 1992) was 16 to 20 ppm, K was 178 to 202 ppm, and NO3-N was 11 to 19 ppm. In 1992, soil PO4-P was 9 ppm and both turnips and radishes showed phosphorus deficiency.

Elevation at the Powell R&E Center is 1330 m. Average date of first fall frost (0°C) is September 27; however, the brassicas grow until temperatures reach -7°C or lower. The site receives 19 cm annual precipitation. In all studies brassicas were furrow-irrigated. Annual snowfall is 33 cm, with 17 cm between September and December. In 1989, during grazing, several cm of snow fell and crusted overnight. Hay was fed for four days until the snow softened so that grazing could resume. Snow did not interfere with grazing in any other year.

All brassicas were no-till seeded into the stubble of the previous crop, except in 1990 and 1996 and one of the studies in 1987. The previous crop was 'Tangier' flatpea in 1987, small grains in 1986 and 1992, pea-oat in 1994 and 1995. The second study in 1987 was full-season, with sugar beets grown the previous year. Brassicas were planted after alfalfa was harvested and plowed out in 1990 and 1996 (Table 1). Loose straw from the previous barley grain crop in 1992 was baled and removed. In other years, the initial crop forage was removed as silage. A stubble of 15 to 25 cm, averaging 1075 kg/ha, was left.

Turnips were seeded at 2 to 3, rape at 3 to 5, tyfon at 4 to 6 and radishes at 25 to 28 kg/ha with a double-disk drill. Seeding into a stubble, in contrast to a tilled seedbed, facilitates more timely planting and reduces the cost of production. There is also less surface crusting and less erosion. The stubble also provides lambs with dry matter while grazing. Alternatively, turnips have been established successfully by aerial seeding prior to the last irrigation of the small grain crop. Also, after the previous crop harvest, turnips have been mixed with fertilizer and spun on with a fertilizer spreader or seeded with an air spreader. These broadcast seeding methods, where practical, should be followed with light tillage to improve establishment. Corrugations were cleaned before the first irrigation.

Ammonium nitrate fertilizer was broadcast at the time of brassica planting. Ammonium nitrate, rather than urea, should be used with no-till plantings because urea is subject to considerable loss of nitrogen to the atmosphere. Rates varied from 67 to 112 kg N/ha. Brassicas are high water-requiring crops. Depending on rainfall, they were irrigated two to four times.

Glyphosate (Roundup® at 1.75 l/ha) was applied before planting if weeds or volunteer plants were present (1986, 1994, and 1996). A post-emergence herbicide was applied in 1992 to control the large amount of volunteer barley germination. Volunteer forage is highly nutritious; however, if it is dense or if it germinates before brassica seed, it can be excessively competitive. A tank mix of sethoxydim (Poast®) at 1.75 and crop oil at 2.3 l/ha suppressed volunteer plants adequately. In 1987, paraquat (.28 kg active ingredient/ha) was used to control annual weeds and flatpea regrowth before planting. Trifluralin (Treflan®) at 1.75 l/ha was used in 1987 with full-season rape and stock beets and in 1990 for pre-emergent control of annual weeds.

Planting dates were as soon as possible following harvest of the primary crop. Dates ranged from July 17 to August 12. Initial crops harvested as silage allowed an earlier second crop planting than crops harvested as grain. The late date in 1992 (Aug. 12) was the result of later-than-usual maturity of barley, harvested as grain.

Studies were designed to evaluate several alternatives, including turnips vs tyfon, rape, or radishes; turnips vs feedlot diets; and turnips vs sugar beet tops. In two studies (1994 and 1995), lambs were slaughtered directly after grazing in order to evaluate carcass characteristics, compared with drylot-fed lambs. Lambs were slaughtered at a commercial packing company. Warm carcass weights, quality and yield grades were determined. In 1994 and 1995 the effect of turnip and radish grazing on subsequent lamb performance in drylot was studied.

Animal and grazing management.
Individual full weights were taken at the start of trials, at 2-week intervals and when lambs were transferred from grazing to feedlot diets in 1994 and 1995. Lambs were initially allocated to treatments on an equal weight basis. Lambs had been weaned off ewes on pasture. Columbia-Rambouillet crossbred lambs were stocked at 35 to 50 lambs/ha in blocks of about 0.2 ha. Grazing animals received no supplemental feed, except in 1996, when a hay-supplemented group of lambs was included. Rotationally-grazed lambs were moved at approximately 2 weeks (10 to 20 days, dependent on amount of forage and size of lambs). Grazing periods varied from 26 days in 1992 to 84 days in 1995. Lambs were vaccinated for overeating (enterotoxemia) before grazing. All lambs were treated for internal parasites. Drylot comparisons were used in 1986, 1990, 1994, and 1995.

The feedlot diet consisted of 35% corn, 35% barley, 30% chopped alfalfa hay plus 0.36% mineral supplement (same as grazed) plus 1 oz. Bovatec®/ton. The amount of feed increased from 0.23 kg/lamb initially to 1.5 kg/lamb after 11 days. Water and a mineral supplement were provided free-choice to both drylot and grazing animals. In 1996, the hay group of lambs received 0.45 kg ground alfalfa hay/head/day.

Important dates are shown in Table 1. Second crop planting date, over the 7 years, varied from July 17 to August 12 . Grazing of second-crop brassicas was initiated as early as October 6 and as late as November 19. Lambs grazed until January 6 in 1987. On December 14, 1994, and on January 15, 1996 (1995 study), lambs were slaughtered at a commercial packing company. Warm carcass weights, yield grades, and fat depths were obtained. Dressing percentages were calculated as warm carcass weights divided by final pasture or feedlot weight.

Forage analyses.
Forage dry matter was determined with samples hand clipped from three random locations within each 0.2-ha plot. After grinding in a Wiley mill (1-mm screen), forage composition was determined according to A.O.A.C. (1975) procedures for all components, except for acid detergent fiber (ADF), neutral detergent fiber (NDF) and in vitro dry matter disappearance (IVDMD), which were determined according to the procedures of Goering and Van Soest (1970, ADF, NDF) and Tilley and Terry (1963, IVDMD). Forage yields were estimated from six 0.5 m2 samples of forage per pasture taken at the start of the grazing period.

Statistical analysis.
A randomized complete block design was used with all studies, except in 1992. Unreplicated blocks were sampled and grazed in 1992 due to poor overall growth of turnips and radishes. Data (except in 1992) were analyzed with procedures of SAS (1989). Treatment means were separated using LSD procedures when the effect of treatment was significant ($P<0.05$).

Results

Effect of planting date.
Planting date is probably the biggest factor in the productivity of turnips and other brassicas. Each day delay in planting results in a significant decline in dry matter accumulation. Average second crop planting date for the 14 plantings in Wyoming since 1986 was July 29 (July 17 to August 12). July plantings of turnips averaged 3900 and August plantings averaged 2500 kg dry matter/ha. Decline in production for each week delay in planting after July 20 averaged 700 kg/ha or about 25% of potential productivity per week. Thus, yield from an August 15 planting will likely be half that of a July 20 planting.

Turnips vs other brassica (tyfon, rape, radishes and beet tops) production.
Turnips were as productive as other brassicas, even though as much as half of the productivity in late fall was in the fleshy roots (Koch, 1995). Whereas perhaps 25% of turnip fleshy roots are aboveground, the bulk of roots are ungrazed, unless roots are mechanically removed before the ground freezes. Roots that are frozen solid and subsequently thaw soften and deteriorate rapidly. The grazing value of leafy growth, as long as it is not matted to the ground, will be preserved longer than that of roots.

In 1986 and 1987, turnip variety Green Globe was compared with tyfon. Shoot (top) growth was greater for tyfon; however, fleshy root growth was greater for Green Globe turnips (Table 2). Tyfon produces small fleshy roots, compared with turnips. In 1987 (Study 1), sugar beet tops provided a similar number of lamb grazing days, gain per animal and gain per hectare as turnips and tyfon (Table 3), even though sugar beet tops were lower in crude protein (CP) and IVDMD and higher in NDF (Table 4).

Turnips and radishes were compared in 1992, 1994 and 1995 (Table 2). In 1992, yields of both species were low due to low soil fertility. In 1994 and 1995, radishes produced about 1260 kg/ha more shoot or top growth than turnips; however, turnips produced as much fleshy root growth as tops (2.92 vs 2.56 tons/ha for roots and tops, respectively). Delayed grazing results in a translocation of dry matter from tops to roots, as shown in 1994 from October to November.

Tilled vs no-till seedbed.
In previous studies, turnips were more productive when planted into a tilled seedbed than when no-till planted (Koch, 1990). At Torrington (Wyoming) R&E Center, turnips planted July 29 into a tilled seedbed yielded nearly 5600 kg/ha of tops and fleshy roots, whereas turnips drilled into barley stubble produced nearly 4500 kg/ha. Most of the difference in production was in fleshy root growth. The 20% lower production with stubble planting is less than the average loss in production from a delay of one week in planting turnips. It may require a week, or more, to prepare a clean tilled seedbed, offsetting the advantage of clean tillage. A tilled seedbed is also more expensive and leaves no straw and generally no volunteer growth. For this reason, it may be desirable to supply high-fiber hay or other dry forage to animals grazing brassicas grown on a tilled seedbed.

Forage availability and utilization.
Five to 8 metric tons/ha of forage (dry matter) were available in all years except 1992, when production was poor due to low soil fertility (Table 2). One-half to more than 1 metric ton/ha of the total forage available was high-fiber regrowth of a previous crop and/or straw. In 1994, a typical year, between 85 and 90% of turnip and radish tops were consumed (Table 5). About half of turnip roots were utilized, even though roots were not removed from the ground. An estimated 1/3 of the roots of turnips grew above ground. Very few radish roots were consumed by lambs. More than 90% of regrowth (mostly oats) and more than half of the straw was consumed.

Brassica forage quality.
Over four different studies, turnip tops sampled in October averaged 13.1% (CP), but ranged from 11.5% in 1994 to 17.7% in 1991 (Table 4). Turnip roots averaged 10.0% and varied from 7.2 to 13.2% CP. By comparison, radish tops tested an average 11.9% CP (2 years) and sugar beet tops tested 8.8% CP (one year only). In 1992, a year when fertility was low, the CP of turnips was 7.2% (data not shown), clearly indicating an N deficiency. Over about 6 weeks (early October to mid-November), turnip tops and roots lost 3.4 and 1.1 per-

centage units of CP, respectively. In 1991, CP content of turnip tops declined from 17.7% on October 3 to 10.9% on January 6. Turnips were sampled just before being grazed. Crude protein content varied much more from study to study than other forage quality components. The relationship between brassica forage quality and soil nitrogen fertility and nitrogen fertilization was not studied.

The NDF content of turnip tops and roots averaged 23.8 and 20.9%, respectively, (Table 4) compared with an expected 40% NDF with alfalfa in late bud-early flower. Sugar beet tops were about 10 units higher (34.5% NDF) than turnip tops in 1987. There is an inverse relationship between NDF and animal intake of forage. The ADF content of turnip tops and roots averaged 19.8 and 17.2%, respectively. This compares with an expected ADF of high-quality alfalfa of 30% ADF. Sugar beet top ADF content in 1987 was 23.9%. There is an inverse relationship between ADF and digestibility. Turnips would be expected to be quickly digested in the rumen.

The IVDMD content of turnip tops and roots were high, averaging 85.7 and 86.4%. This is related to the low fiber content of tops and roots. Beet top IVDMD in 1987 was 80.4%. In 1991, ADF and NDF of turnip tops increased about four units each from October 3 to January 6 and IVDMD declined about seven units during the same period; however, forage quality was still relatively high on the latter date. In 1994 and 1995, radish tops sampled on the same dates were similar to turnip tops in all forage quality components, indicating that radishes should be a good substitute for turnips on land where the latter should not be grown.

In 1994, estimated availability of total forage was about 8 metric tons/ha of dry matter. Overall, about 2/3 of the total forage was consumed. Top growth of both turnips and radishes was more than 87% utilized. Lambs consumed very little radish roots and about half of turnip roots. Removal of roots from the ground would improve turnip root utilization. Regrowth of the previous crop (mostly oats) was more than 90% utilized, whereas dead straw stubble of the previous pea-oat crop was over half utilized.

Lamb performance on turnips.
Turnips were evaluated in seven lamb grazing trials (Table 3). One hundred ninety-one lambs grazed a total of 4690 days. Over all studies, average daily gain (ADG) of lambs was 0.183 kg. Greatest gain was in 1990 (0.25 kg/day) when lambs grazed turnips planted after plow down of alfalfa. The comparative gain of drylot lambs during the same 39-day grazing period was 0.23 kg/day. Least gain on turnips was in 1994 (0.13 kg/day). In 1994, lambs remained longer on paddocks relative to the amount of forage available than in other years, utilizing more than 88% of turnip tops (Table 3), compared with about 75% in previous years. Gain at the midpoint (35 days) was 0.16 kg/day in 1994. Average gain for lambs grazing turnips was 308 kg/ha.

In most years, turnips grow until early October. Fields planned for early-planted crops the next year (barley, beets) can be grazed first, so that fields can be fall tilled.

Turnips vs other forages.
Lamb gains/ha were similar for grazed turnips and tyfon in1986 and 1987; similar for turnips and sugar beet tops (1987); and similar for turnips and radishes in 1992, 1994 and 1995 ($P>0.05$) (Table 3).

Well-fertilized and irrigated turnips and other brassicas should carry an average of 50 lambs/ha for 30 days. Carrying capacity for 50 lambs declined from 37 days/ha with July seedings (average July 21 planting date) to 29 days/ha with August seedings (average August 6 planting date). Actual carrying capacity depends on amount of forage and size of lambs.

Grazing turnips vs drylot.
With periods of less than 1 month, liveweight gains were greater for lambs grazing turnips and other forages (data not shown) than for drylot-fed lambs. Lambs with previous grazing experience, as in these studies, needed no adjustment to turnips and other forages, even though they were more succulent, in most cases than previously grazed forages. Until they were on full feed, drylot lambs gained less per day than pastured lambs. Averaged over four years, lambs grazing turnips for 39 days gained 0.18 kg/day, and drylot lambs gained 0.20 kg/day (Table 3). After 35-40 days, rate of gain on turnips and other grazed forage decreased, whereas rate of gain in drylot increased.

Effect of previous crop.
Greatest lamb gains per day and per hectare were on turnips planted following plow-out of aged alfalfa stands (0.25 kg/day and 419 kg/ha in 1990 and 0.21 kg/day and 439 kg/ha in 1996). Part of the reason for the greater gains was the earlier planting of turnips and greater production of dry matter. Turnips were planted on July 23 and July 17 in 1990 and 1996, respectively. Although turnips were planted into a tilled seedbed in 1990 and 1996, in contrast to planting into stubble in other years, previous studies showed little difference in yield for turnips planted into tilled seedbeds and turnips seeded no-till into stubble.

Effect of fiber.
As previously mentioned, providing fiber in the form of hay to lambs grazing succulent pasture, such as turnips and other brassicas, may improve performance. In these studies, turnips and other fall-grazed forages were planted into stubble of the previous crop. Estimated average stubble was 1200 kg/ha. In 1996, turnips were planted into a clean-tilled seedbed. One group of lambs grazed turnips as the sole diet, while the other group of lambs grazed turnips and was fed 0.45 kg ground alfalfa hay/head daily. Both groups of lambs gained 0.21 kg/day (Table 3), indicating that additional fiber was not necessary for the 48-day duration of this study, contrary to the results of Lambert et al., 1987.

Effect of parasite treatments.
In 1990, two parasite treatments were compared. Half of each group of lambs (54) were treated with either Ivomec® or SafeGuard®. Average daily gains for Ivomec- and SafeGuard-treated lambs were 0.227 and 0.22 kg/day, respectively, and did not differ ($P>0.05$).

Effect of turnip grazing on later drylot gains.
Groups of lambs grazed either turnips or radishes for 10 weeks in 1994 and 12 weeks in 1995; other groups grazed turnips or radishes for 5 weeks (1994) and 6 weeks (1995) and were transferred to a drylot diet for the remaining 5 or 6 weeks. An additional group of lambs received a feedlot diet for the full 10 or 12 weeks (Table 1).

During the initial 5-week grazing period in 1994 and 6-week period in 1995, lambs that grazed radishes and turnips gained similarly (0.13 to 0.17 kg ADG) (data not shown). Lambs on a feedlot diet had the best ADG for 10 weeks (0.23 kg) and lambs grazing turnips and radishes continuously for 10 weeks in 1994 had the poorest ADG (0.12 to 0.13 kg). In 1995, lambs continuously grazing turnips or radishes for 12 weeks and lambs in the feedlot for 12 weeks performed similarly (0.15 to 0.17 kg/day). Lamb gains in the feedlot (0.15 kg/day) were lower than usually obtained. Also, lambs grazing turnips and radishes gained better in 1995 than in 1994, possibly because of larger grazing areas in 1995. Lambs transferred to the feedlot after grazing turnips or radishes for 10 weeks in 1994 or 12 weeks in 1995 performed similarly to lambs continuously in the feedlot (data not shown).

Effect on carcass characteristics.
Carcass weights were greater for feedlot lambs than for lambs grazing radishes and turnips for 10 weeks in 1994 (Table 6). There were no differences among carcass weights in 1995. Dressing percentage was greatest with lambs in the feedlot and least with lambs grazing turnips in 1994. In 1995, dressing percentage was greater than 50% for continuous feedlot lambs and less than 50% for lambs grazing continuously. Yield grade and fat depth of lambs in the feedlot were greater than for lambs that grazed turnips in 1994; however, there were no differences in 1995. Lambs grazing turnips and radishes, without a concentrate, produced acceptable market size and carcass grade but they required more time than feedlot lambs to reach similar weight.

The tendency for less fat, as with grazed lambs, is increasingly desired by consumers and the delay in reaching market weight, as with brassica grazing, might also be a benefit if as a result lambs are marketed off-peak season. Estimated cost of growing and grazing turnips and other brassicas is $220 to $250/ha, resulting in $0.72 to $0.79/kg of gain. Utilizing even a portion of the otherwise fallow acreage of irrigated small grains to grow and graze brassicas could result in significant value added to the lamb crop each year.

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Table 1. Agronomic and animal data for grazing studies conducted at the Powell Research and Extension Center, 1986-1995.

Year	1986	1987	1987	1990
Previous crop	Barley (silage)	Flatpea (silage)	Sugar beets	Alfalfa
Planting date	July 23	Aug 4	May 10	July 23
Varieties	Green Globe turnip; tyfon	Green Globe turnip; tyfon	Emerald rape; Stock beets	Green Globe turnip; Emerald rape
Weed control, l/ha	Roundup®, 1.75	Paraquat®, 1.17	Treflan®, 1.75	Treflan®, 1.75
Fertilizer, N-P-K, kg/ha	112-0-0	112-0-0	280-100-0	140-84-0
Tillage	Stubble seeded	Stubble seeded	Fall plowed	Plowed following first cutting of alfalfa
Irrigation	2x	4x	4x	3x
Treatment comparisons	Turnips; tyfon; drylot	Turnips; tyfon; sugar beet tops	Rape; stock beets	Rape, full season; rape, following alfalfa; turnip following alfalfa
Design[1]	RCB 3 groups of 10	RCB 3 groups of 8	RCB 3 groups of 10	RCB 3 groups of 9
Grazing period	Oct 24-Dec 1	Nov 4-Jan. 6	July 28-Sept 28	Nov 9-Dec 18

Year	1992	1994	1995	1996
Previous crop	Barley (grain)	Pea-oat (silage)	Pea-oat (silage)	Alfalfa (hay)
Planting date	Aug 12	July 20	Aug 02	July 17
Varieties	Green Globe turnip; Adagio radish	Purpletop turnip; Adagio radish	Purple top turnip; Adagio radish	Purpletop turnip
Weed control, l/ha	Poast® (1.75)+ crop oil conc. (2.4)	Roundup®, 1.75	Roundup®, 2.35	Roundup® + 2,4-D, 1.2 each
Fertilizer, N-P-K, kg/ha	112-0-0	67-0-0	84-56-0	112-0-0
Tillage	Stubble seeded	Stubble seeded	Stubble seeded	Plowed following first cutting of alfalfa
Irrigation	2x	3x	3x	4x
Treatments	Turnip; radish	Continuous radish and turnip grazing; radish and turnip grazing, followed by feedlot; continuous feedlot		Turnips; turnips + hay
Design[1]	Unreplicated	RCB	RCB	RCB
		3 groups of 10	3 groups of 10	3 groups of 10
Grazing period	Nov 19-Dec 15	Oct 6-Dec 14	Oct 24-Jan 15	Oct 30-Dec 17

[1]Randomized complete block.

Table 2. Estimated availability of brassicas and other forages.

Seeded forage	Sampling date	Seeded species: Shoots	Seeded species: Roots	Previous crop regrowth[1]	Straw[2]	Total forage
				metric tons d.m./ha		
Turnip	Oct 1, 1986	3.88 a	1.80	0.49 a	0.67	6.84 a
Tyfon	Oct 1, 1986	4.29 a	-	0.56 a	0.67	5.52 b
Turnip	Nov 4, 1987	3.41 b	2.69	0.61 a	0.67	7.38 a
Tyfon	Nov 4, 1987	5.43 a	-	0.54 a	0.67	6.64 a
Turnip	Oct 23, 1992	1.14	0.67	0.47	0.45	2.73
Radish	Oct 23, 1992	1.77	-	0.18	0.45	2.40
Radish	Oct 6, 1994	4.74 a	1.35 b	0.92 b	0.90	7.91 a
Turnip	Oct 6, 1994	3.43 b	2.47 a	1.30 a	0.90	8.10 a
Radish	Nov 15, 1994	3.73 a	1.80 b	0.88 b	0.90	7.31 a
Turnip	Nov 15, 1994	1.84 b	4.27 a	1.32 a	0.67	8.10 a
Radish	Oct 18, 1995	2.99 a	1.12 b	0.74 a	1.35	6.20 a
Turnip	Oct 18, 1995	2.20 b	2.02 a	0.83 a	1.12	6.17 a

Means within columns and years with common letters do not differ, P>0.05. The 1992 study was unreplicated.

[1] Barley, flatpea, barley, and pea-oat regrowth or volunteer for 1987, 1992, 1994 and 1995, respectively.

[2] Dead stubble from the previous crop.

Table 3. Live weight gains of lambs grazing turnips and other forages.

Grazing trial	No. of lambs	No. of days	Initial weight	Final weight	Average gain per day	Average gain per ha	Lamb grazing days/ha
			kg				
1986							
Turnips	30	38	34.7	41.4	0.18 a	389 a	2198
Tyfon	30	38	34.7	42.1	0.20 a	419 a	2198
Drylot	30	38	34.7	42.0	0.19 a	-	-
1987							
Study 1:							
Turnips	24	41	34.5	43.3	0.21 a	360 a	1680
Tyfon	24	41	34.9	43.3	0.20 a	335 a	1680
Sugarbeet tops	24	41	35.3	43.4	0.20 a	333 a	1680
Study 2:							
Rape, full-season	30	62	33.4	46.3	0.21 a	616 a	2954
Stock beets, full-season	30	48	33.4	39.4	0.13 b	301 b	2324
1990							
Rape, full-season	27	39	34.6	41.7	0.19 b	308 b	1680

Grazing trial	No. of lambs	No. of days	Initial weight	Final weight	Average gain per day	Average gain per ha	Lamb grazing days/ha
Rape, following alfalfa	27	39	32.9	42.9	0.26 a	370 a	1680
Turnips, following alfalfa	27	39	35.8	45.6	0.25 a	419 a	1680
Drylot	13	39	34.6	43.7	0.23 a	-	-
1992							
Turnip	20	26	39.6	43.2	0.14	87	622
Radish	20	26	38.0	42.6	0.18	110	622
1994							
Radish[1]	15/30	35/70	38.7	47.3	0.14 b	221 a	1588
Turnip[1]	15/30	35/70	38.8	47.5	0.13 b	206 a	1549
Drylot	30	70	39.0	54.9	0.23 a	-	-
1995							
Radish[2]	15/30	42/84	37.7	44.1	0.15 a	300 a	1974
Turnip[2]	15/30	42/84	37.5	43.6	0.14 a	321 a	1074
Drylot	30	84	37.4	43.9	0.15 a	-	-
1996							
Turnip	35	48	36.1	46.3	0.21 a	439 a	2075

Grazing trial	No. of lambs	No. of days	Initial weight	Final weight	Average gain per day	Average gain per ha	Lamb grazing days/ha
Turnip with hay	35	48	36.6	46.9	0.21 a	445 a	2075

[1] 30 lambs for 35 days; 15 lambs for 70 days.

[2] 30 lambs for 42 days; 15 lambs for 84 days.

Means within years and studies with the same letter are not significantly different (P>0.05). The 1992 study was unreplicated.

Table 4. Forage nutritive value of turnips and other forages.

Study year	Sampling date	Seeded species	Component			
			CP	ADF	NDF	IVDMD
			%, c.m. basis			
1987	Oct 14	Turnip tops	11.0 ab	25.1 a	24.0 b	89.7 a
		Tyfon tops	9.3 bc	23.2 a	23.3 b	87.6 a
		Beet tops	8.8 c	23.9 a	34.5 a	80.4 b
1991	Oct 3	Turnip tops	17.7 a	20.9 b	22.7 c	90.4 a
	Nov 26	Turnip tops	15.5 b	23.6 a	25.1 b	86.6 ab
	Jan 6	Turnip tops	10.9 cd	24.6 a	26.9 a	83.4 b
	Oct 3	Turnip roots	13.2 c	23.7 a	24.9 b	85.7 b
	Nov 26	Turnip roots	11.1 cd	24.0 a	25.4 ab	82.8 b
1994	Oct 6	Radish tops	12.7 a	18.5 a	24.9 ab	80.0 d
		Turnip tops	11.5 a	17.1 ab	23.0 ab	81.2 cd
		Turnip roots	7.2 b	12.7 c	17.8 c	88.0 a
	Nov 15	Radish tops	8.3 b	18.0 ab	25.7 a	83.4 bcd
		Turnip tops	7.0 b	16.6 b	22.7 b	84.2 bc
		Turnip roots	7.1 b	13.1 c	18.1 c	86.5 ab
1995	Oct 18	Radish tops	11.0 ab	18.8 a	26.3 a	85.8 a
		Turnip tops	12.1 a	15.5 b	22.3 b	85.9 a
		Turnip roots	9.6 b	12.4 c	18.3 c	89.1 a

CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; IVDMD = in vitro dry matter disappearance.

Means within a column and year followed by the same letter are not significantly different.

Table 5. Estimated utilization of available forages[1].

Year	Seeded species	Seeded species: Tops	Seeded species: Roots[2]	Regrowth	Straw	Total
		Availability, kg/ha				
1994	Turnip	2082	1981	747	1217	6027
	Radish	2972	1167	702	1145	5986
		Utilization, kg/ha				
1994	Turnip	1838	1052	681	684	4255
	Radish	2585	50	646	670	3951
		Utilization, %				
1994	Turnip	88.3	53.1	91.2	56.2	70.6
	Radish	87.0	4.3	92.0	58.5	66.0

There were no significant differences (P>0.05) between turnip and radish means.

[1]Weeds (<390 kg/ha) were not included.

[2] Fleshy roots only.

Table 6. Carcass characteristics of turnip-grazed lambs in comparison to radish-grazed and drylot-fed lambs.

Year	Species/feed	Dressing percentage	Carcass weight	Yield grade	Fat depth
			kg		cm
1994	Radish, 10 weeks	48.1 b	22.7 b	1.8 ab	0.13 ab
	Turnip, 10 weeks	46.5 b	21.8 b	1.5 b	0.10 b
	Drylot, 10 weeks	50.0 a	26.7 a	2.2 a	0.18 a
1995	Radish, 12 weeks	48.8 b	24.2 a	1.5 a	0.10 a
	Turnip, 12 weeks	48.8 b	24.6 a	1.7 a	0.13 a
	Drylot, 12 weeks	50.1 a	25.3 a	1.6 a	0.13 a

Means within years and studies with the same letter are not significantly different (P>0.05).