AUTUMN-SOWN FORAGE LEGUMES FOR INTENSIVE ARABLE CROPPING SYSTEMS

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ABSTRACT

Initial studies in 1979 established that some legumes sown in the autumn could produce a large quantity of forage greenfeed by mid-winter and confer a substantial yield benefit on a succeeding cereal grain crop relative to the cereal yield obtained following conventional non-leguminous greenfeeds.

Subsequent studies, which form the subject of this paper, have established the following seven points on the management of these legumes.

1. The legumes must be sown early (beginning of February) for good winter forage yields.
2. The legumes should be used in the May-July period in Canterbury to avoid foliage deterioration later in the winter.
3. Tick beans (*Vicia faba*) and field peas (*Pisum sativum*) reach their peak winter forage yield earlier than lupins and should be used earlier.
4. Utilisation of these legume greenfeeds should be by grazing rather than by ploughing-in for maximum yield of the succeeding cereal. A winter fallow produced the lowest cereal yield.
5. The length of interval between legume grazing and cereal sowing had no effect on cereal grain yield.
6. The blue flowered lupins Borre and Fest produce substantially more winter forage than the white flowered lupin Uniharvest from an autumn sowing.

INTRODUCTION

In 1979, studies began in Mid-Canterbury to investigate the possible role of autumn-sown forage legumes as break crops in intensive cropping systems. The motivation for this work centred on the fact that all the currently used autumn-sown forage crops were non-legumes and consequently contributed nothing directly to soil nitrogen levels. As crop rotations become tighter, with fewer and shorter nitrogen-supplying phases in the rotations, the requirement for additional nitrogen inputs from other sources increases. Clearly, if a legume could be used instead of the conventional non-legume as the autumn-sown forage break crop, then this may become a nitrogen contributing, rather than a balanced or even nitrogen depleting, phase of the rotation.

The initial studies (Janson and Knight, 1980) confirmed these hopes. They showed that some legumes, when sown in the autumn, could produce a large quantity of forage greenfeed by winter and confer a substantial yield benefit on a succeeding cereal grain crop relative to the cereal yield obtained following conventional non-leguminous greenfeeds.

Four legumes were examined in the initial studies - sub-clover (*Trifolium subterraneum*), tick beans (*Vicia faba*), peas (*Pisum sativum*) and lupins (*Lupinus sp.*). All except sub-clover were considered worthy of further study. It was also apparent that a number of management questions associated with the use of these legumes as autumn-sown forage break crops needed investigation.

This paper reports the findings of these subsequent studies and provides specific guidelines for farmers on the use of forage legumes in arable cropping systems.

MATERIALS AND METHODS

The four studies reported in this paper were conducted during the 1981/2 and 1982/3 seasons at Winchmore Research Station. The soil and climatic features of this area are supplied in an earlier paper (Janson and Knight, 1973). In each of the studies, the forage break crops were sown in the autumn and their growth and development monitored. Where appropriate they were then grazed (or ploughed-in) and a cereal cash crop established on the area, grown to maturity and harvested.

TABLE 1: Crop cultivars and sowing rates.

	Crop	Cultivar	Sowing rate (kg/ha)
Forage	*legume*		
	tick beans	Maris Bead	250
	peas	Partridge	300
	lupins	Borre *	200
	non-legume		
	ryegrass/oats	Tama/Amuri	20/110
Cereal	wheat	Oroua	150

* plus Fest and Uniharvest in lupin cultivar study only
- all crops sown with 250 kg/ha of 0:9:0:11 superphosphate

Table 1 summarises some of the basic details common to the studies reported in this paper.

Specific details of the four studies follow.

Study 1: Forage sowing date and yield accumulation/deterioration

Three forage sowing dates were compared in this study: February 10, March 4 and April 6 1981. A split plot randomised block design was used with sowing date as main plots and forage species as subplots. There were four replicates.

The three legumes — beans, peas and lupins were allowed to grow uninterrupted through the winter and into the spring to monitor yield accumulation and deterioration. The ryegrass oats mixture was grazed quickly by sheep 2-3 times over the winter/spring period. Herbage samples (two 80 × 80cm quadrats per plot) were taken periodically from the legumes during the winter/spring period and from the ryegrass/oats mixture prior to each grazing.

Study 2: Legume utilisation method

Two forage legume utilisation methods were compared in this study; grazing (immediately prior to sowing the succeeding cereal) and ploughing-in (six weeks prior to cereal sowing). The third treatment in this study was a winter fallow. Experimental design was randomised block with three replicates. The forage legume used in this study was tick beans, sown March 10, 1981.

Winter growing weeds on the fallow treatment were controlled with two grubbings between March and August.

On June 7, the tick beans on the appropriate plots were heavy rolled and ploughed-in, completely burying all green forage.

On July 28, adult sheep were put onto the grazing plots and remained there for seven days until all but a residue (400 kg/ha DM), of bean stalks had been consumed.

On August 10, the grazed and fallow areas were ploughed and then the whole trial area was topworked and sown to wheat.

One month after the wheat was sown, soil samples were collected from all the plots for determination of inorganic nitrogen release during laboratory incubation. Details of this technique are described in Quin and Drewitt (1979) and Janson and Knight (1980).

The wheat was flood irrigated twice at 25% available soil moisture (a.s.m.) and harvested on February 5, 1982.

Study 3: Forage grazing to cereal sowing interval

This study compared two forage grazing times, mid May and mid July, in terms of the effect on the grain yield of the succeeding cereal crop. A split plot randomised block design was used in which forage grazing times were main plots and forage crops subplots. There were four replicates.

The forage crops (beans, lupins, peas and ryegrass/oats) were sown on March 17, 1982 and grew uninterrupted to their respective grazing time of either mid May or mid July. They were then grazed with adult sheep as described for Study 2. After completion of grazing, the whole trial area was topworked and sown to wheat at the beginning of August. The wheat was irrigated twice at 25% a.s.m. and harvested February 1, 1983.

Study 4: Lupin cultivars

Three lupin cultivars were sown on March 15, 1983, in a randomised block layout with three replicates. Four months later in mid July, total accumulated herbage yield was measured by cutting to ground level all the crop within two 80 × 80cm quadrats on each plot.

The three lupin cultivars were:

Borre: blue flowered 'sweet' lupin (van Steveninck, 1956)
Fest: blue flowered non-shattering lupin (S.H. Manning pers. comm.)
Uniharvest: white flowered 'sweet' lupin (Withers, 1973)

RESULTS

Study 1: Forage sowing date and yield accumulation/deterioration.

For each of the three legumes, the yield from the February sowing substantially exceeded that from the March sowing; the increment ranged from 44% with peas to 165% with lupins (Table 2). Yield from the April sowing date for all three legumes was minimal. The ryegrass/oats mixture was not affected by a delay in sowing date from February to March but a further delay to April had just as severe an effect as with the three legumes.

TABLE 2: Effect of sowing date on herbage yield (kg/ha DM) at end of May.

Crop	Sowing date Feb 10	March 4	April 6
tick beans	4330 a*	2160 b	270 a
lupins	4030 ab	1570 c	210 a
peas	3630 b	2520 b	340 a
rye/oats	3730 b	4010 a	500 a
	C.V. 13.3%		

*Duncan lettering relevant to vertical comparisons.

Tick beans and peas first reached their peak yield at the end of May (from both February and March sowings) (Table 3). Over the next two months, i.e. to the end of July, no further increase in yield occurred. At the next sampling in October, there had been a substantial reduction in yield.

TABLE 3: Herbage yield (kg/ha DM) changes through the winter/spring period.

	Sampling date End May	End July	Mid Oct	C.V.
Sown February				
tick beans	**4330 a***	4130 a	3510 b	
lupins	4030 b	**5100 a**	2320 c	11.7%
peas	**3630 a**	2830 b	1310 c	
rye/oats	3730 c	5540 b	7160 a	
Sown March				
tick beans	**2160 a**	2240 a	1020 b	
lupins	1570 b	**3210 a**	1490 b	13.6%
peas	**2520 a**	2500 a	1090 b	
Rye/oats	4010 c	5360 b	6120 a	

(bold figures indicate time of first reaching peak yield).
* Duncan lettering relevent to horizontal comparisons.

Lupins, unlike the tick beans and peas, did not reach their peak yield until the end of July (from both February and March sowings) but, like the beans and peas, showed a substantial yield reduction by October.

The ryegrass/oats mixture with its vigorous regrowth responded to the 2-3 grazings over the winter/spring period and total yield continued to rise through to the last grazing in mid October.

Study 2. Legume utilisation method

Table 4 presents firstly the N mineralisation results from the soil samples collected from the different winter management plots (one month after sowing the cereal into these plots) and secondly, the grain yield of the cereal sown into these plots.

TABLE 4: Effect of legume utilisation method and winter management on the increase in inorganic N during soil incubation (ppm) and on cereal grain yield (kg/ha-12% moisture).

Management	Increase in inorganic N	Cereal grain yield
Grazed: immediately before cereal sowing	45.3	5970 aA
Ploughed in: 6 weeks before cereal sowing	41.6	4870 bB
Winter fallow	33.0	4140 cB
C.V.		23.0%

The greatest release of nitrogen during incubation occurred where the bean crop had been grazed. Slightly less nitrogen was released if the bean crop had been ploughed in and much less nitrogen was released if the area had been fallowed through the winter.

Cereal grain yield followed a similar pattern with highest yield occuring where the beans had been grazed and lowest yield followed a winter fallow.

TABLE 5: Effect of length of interval between forage grazing and cereal sowing on cereal grain yield. (kg/ha-12% moisture). Main effects only.

Interval length	Cereal Grain Yield
12 weeks: mid May - early Aug.	4280 a
3 weeks: mid July - early Aug.	4390 a
Forage crops	
tick beans	4940 a
lupins	4580 a
peas	4590 a
ryegrass/oats	3230 b
interval length x forage crops	NS
C.V.	17%

Study 3. Forage grazing to cereal sowing interval

The length of interval between forage grazing and cereal sowing (in the 3 to 12 week range) had no effect on the grain yield of the cereal, irrespective of the forage crop (Table 5).

This table also shows once again (see also Janson and Knight, 1980) the increased cereal grain yield possible following a leguminous (beans, lupins, peas) rather than a non-leguminous (ryegrass/oats) forage crop.

Study 4: Lupin cultivars

There was no significant difference between the herbage yield harvested from Borre and Fest lupins (despite a 25% yield advantage to Borre), but a significantly lower herbage yield from Uniharvest (Table 6).

TABLE 6: Herbage yield (kg/ha DM) in mid July from three lupin cultivars.

Cultivar	Yield
Borre	3550 a
Fest	2820 a
Uniharvest	1560 b
C.V.	36%

DISCUSSION

The importance of early sowing for the three legumes has been emphasised in these studies. The yield penalty for a delay in sowing date even into early March is very severe and contrasts with the much lower sensitivity to sowing date (over the early February to early March period) of the ryegrass/oats mixture.

Tick beans and peas are certainly forages to be used early in the winter, reaching their peak yield first at the end of May. The different growth pattern of lupins, where yield peaked two months later than beans or peas, irrespective of sowing date, indicates that the planned time of utilisation should be considered when choosing a forage legume.

The deterioration in foliar quality first and then total herbage yield that occurred on the tick beans and peas and then on the lupins from mid-winter was a consequence of both physical frosting damage and foliar disease. Both effects were very evident on the tick beans. On this forage both rust (*Uromyces viciae-fabae*) and *Botrytis cinerea* were found throughout the crop in June/July.

This study has shown that winter legumes should be sown, early, used early and grazed rather than ploughed-in. It has also shown that the benefit conferred on the succeeding cereal by the winter legume is not dissipated by intervals of up to 12 weeks between forage grazing and cereal sowing. This provides the sowing date flexibility needed in a large scale winter/spring seeding operation.

Finally, the improvement in the grain yield of the succeeding cereal crop following tick beans and peas found in our first studies (Janson and Knight, 1980) has been demonstrated again (Table 5). In addition, lupins have been shown to confer the same benefit on a succeeding cereal if the appropriate cultivar is used (in our studies Borre rather than Uniharvest.

These findings will assist the intensive arable farmer to determine the role of winter legumes in his particular system and the management to best exploit them.

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