A survey of Canterbury lentil growers in the 1989-90 growing season

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Abstract

Nineteen mid-Canterbury lentil growers were surveyed. Information was collected on variety of lentil sown, soil type, climate and agronomic management of the crop. By world standards the farm yields obtained were high. The mean yield was 2.56 t/ha and only one crop yielded less than 1 t/ha. The area sown to lentils on individual farms ranged from 6 to 30 ha, an average of 10% of the total area per farm. The total area sown to grain legumes on the farms was considerably higher at 30%.

The cultivar Titore yielded 2.4 t/ha, Olympic 2.7 t/ha and a single paddock of Olympic 4.0 t/ha. There appeared to be no relationship between crop yield and sowing date which ranged from 28 May to 20 October 1989. None of the surveyed farms irrigated their lentil crop during the 1989-90 growing season.

Additional key words: *Plant population, fertilisers, herbicides, weeds, pathogens, crop rotation*

Introduction

Lentils are grown successfully in Canterbury, New Zealand. After a decade of commercial production with ups and downs, lentils are now well established in Canterbury farming systems. The evaluation of lentils as a crop in New Zealand began in 1972 in response to a demand from commodity importers for information on lentil production (Jermyn, 1981).

At Lincoln University (formerly Lincoln College) quantitative research on sowing date, optimum plant population, cultivar selection, irrigation response and the effect of growth regulators was carried out (Kausar, 1985; McKenzie, 1987; Husnan, 1989).

The Crop Research Division of DSIR selected the cultivar Titore, a small seeded variety with red cotyledons (PI 298922) and released it as a commercial variety. The yellow seeded cultivars Invincible and Olympic were introduced by C. Lill.

Over the decade average lentil yield varied between 1.1 t/ha in 1988 (a very dry season) and 1984 (a very wet season), and 2.5 t/ha (in 1982). In 1989-90 a crop of approximately 1500 ha of lentils was contracted by three seed companies to growers. The average yield was 2 t/ha. As the average yield of lentils in Canada and in the USA is 1.3 and 1.4 t/ha respectively (FAO, 1987), New Zealand is undoubtedly one of the top yielding lentil producers in the world.

The study reported here was conducted to:

1. Examine the effect of environment and crop husbandry on the yield of lentils.
2. Investigate farmer experience and problems with growing lentils.
3. Determine the role of lentils in Canterbury cropping farm systems.

Materials and Methods

The agronomic and management data are from a survey which was conducted during the 1989-90 growing season. The survey was divided into two parts. Part one concentrated on the soil type and crop husbandry of lentils. Part two solicited farmer experience and opinions concerning grain legumes in general and lentils in particular.

The main interviews and field observations were done in December 1989. Further visits were made during the following months to complete the survey.

All of the farms were located in mid-Canterbury. Farmers' addresses were obtained either from a seed company which contracts farmers to grow lentils or by personal communication.

Detailed soil physical data were not kept on most farms and where this was the case, data from SWAMP were used. Climate data were obtained from meteorological stations at Ashburton, Lincoln and Winchmore. For each farm, data from the nearest (0.2 - 20 km) climate station were used.

Climate data were grouped in terms of the physiological stage of crop growth. Priestly & Taylor evapotranspiration was calculated for each phase of crop development. Thus, the potential water deficit was determined during the vegetative, flowering and podding stages, and was analysed in terms of total mm and days of deficit at each growth stage. The effective (active) evapotranspiration was computed for a limiting deficit of 75% of field capacity. The number of ground frosts during crop growth were recorded.

After harvest, the total yield from each farm was analysed in relation to the climate data and to the 22 factors which had been collected in the first part of the survey using both simple correlations and multivariate analysis.

Information from the second part of the survey was descriptive.

Results

Environment

Rainfall is shown in Table 1 and Figure 1. Mean monthly temperatures over the growing season were close to the long-term averages. Rainfall in September, November and January was considerably below average, while in October and December it was higher. Although January was very dry, the seasonal total of

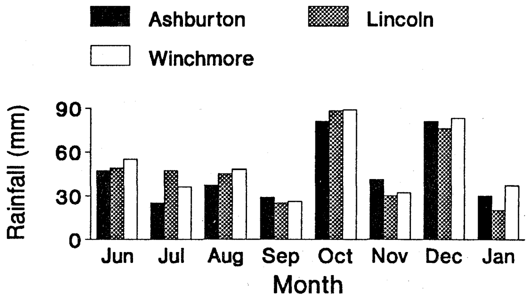

Figure 1: Rainfall recorded at the Ashburton, Lincoln and Winchmore meteorological stations during the 1989-90 growing season.

TABLE 1: The mean, standard deviation and range of agronomic and climate data obtained from a survey of 19 mid-Canterbury lentil growers during the 1989-90 season.

	Mean	Standard deviation	Range
Yield (t/ha)	2.56	0.76	0.88 - 4.00
Area (ha)	12.44	5.72	6 - 30
Density (plants/m^2)	215	57	86 - 303
Sowing date	14 August	4.7 weeks	28 May - 20 Sept
N (kg/ha)	4.5	7.7	0 - 19
P (kg/ha)	13.2	6.7	4 - 22.5
Lentils (% of farm)	9.7	4.0	3 - 18
Grain legumes (% of farm)	30	16	7 - 65
Soil water availability (mm)	93	17.5	75 - 135
Rain (mm)	299	41	255 - 396
Frost (days)	18.2	18.5	2 - 66
Water deficit (mm)			
Vegetative	3.7	6.5	0 - 17
Flowering	62.1	19.8	4.5 - 87.6
Podding	83.4	21.3	34.0 - 116.3
Water deficit (days)			
Vegetative	0.8	1.4	0 - 4
Flowering	15.5	4.9	1 - 22
Podding	17.2	4.0	7 - 22
Effective ET (mm)			
Vegetative	206.2	14.6	176 - 224
Flowering	102.7	21.2	76 - 169
Podding	49.7	30.9	5 - 102

46 deficit days to the end of January was below the average of 51.1 days.

Lentil yield

Tables 1 and 2 show the various husbandry systems used by the lentil growers. The total area of lentils covered by the survey was 240 ha. The average yield of Titore was 2.424 t/ha. The yield from the two paddocks of Olympic was 2.647 and 2.772 t/ha respectively. The one paddock of Invincible in the survey yielded 4.00 t/ha which was the highest yield obtained of the farms surveyed. Figure 2 shows that 75% of the farms obtained yields of between 2.1 and 3.1 t/ha. Only two farmers had yields below 2 t/ha and three obtained more than 3.1 t/ha. From these results it appears that the surveyed farmers obtained higher lentil seed yields than the Canterbury average.

TABLE 2: Non-quantifiable characteristics obtained from a survey of 19 lentil growers in mid-Canterbury during the 1989-90 season.

Variety sown:
Titore, 16; Olympic, 2; Invincible, 1.

Preceding crop:
cereals, 7; pasture, 6; small seeds, 3; others, 3.

Crop rotation:
lentils and pasture, 6; lentils and non-grain legume crops, 9; lentils and crops of other grain legumes, 4.

Rolling:
heavy roller after drilling, 7; Cambridge roller after drilling, 4; heavy roller when plants 5 - 10 cm, 8.

Herbicide:
pre-emergent, 12; post-emergent, 3; both, 4.

Fungicide:
preventitive, 8; nil, 11.

Weed cover (November/December):
0%, 13; 10%, 2; 20%, 3; 30%, 1.

Weed cover (at final harvest):
0%, 7; 10%, 2; 20%, 6; 30%, 3; 40%, 1.

Lodging at final harvest:
none, 13; moderate, 1; severe, 5.

Simple correlations

Analysis of data collected from the 19 farms produced many statistically significant simple correlations among the 22 measured variables.

Only correlations of $r = 0.450$ ($P < 0.05$) or greater are presented in Table 3 or discussed in the text.

Agronomic factors: Of the eight agronomic factors analysed only weed cover had a significant effect on yield. The presence of weeds during early crop growth decreased yield ($r = -0.676$). Lentils do not compete well with other plants during their initial growth. However, weeds at the time of final harvest may be less important.

Not surprisingly sowing date was highly correlated with crop duration ($r = -0.976$). Late sown crops were sown at lower densities ($r = -0.513$). A partial explanation for this was that the two yellow varieties which are large seeded were sown later and at lower densities. Farmers with long experience of lentil growing tended to sow late ($r = 0.477$) at a lower seeding rate ($r = -0.505$) and used more phosphorus fertiliser ($r = 0.595$). Sowing rate was also correlated with the use of nitrogen fertilizer on the crops ($r = -0.556$). However only four farmers used any nitrogen.

Environmental factors: Available soil water was the only environmental factor out of the 14 recorded which was correlated with final yield ($r = 0.523$). This suggests that lentils do not reach their full yield potential on shallow stony soils.

Early sown plants received more rain ($r = -0.954$), experienced more ground frosts ($r = -0.977$) and

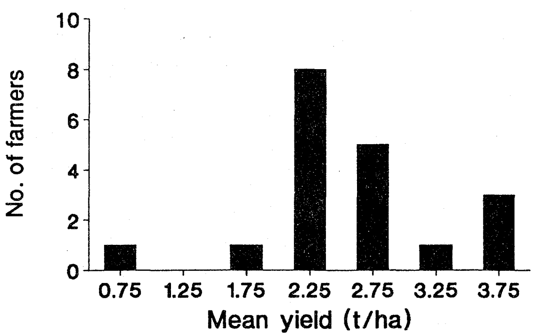

Figure 2: The distribution of lentil crop yield among the 19 farmers surveyed during the 1989-90 growing season.

TABLE 3: Simple correlations between agronomic and climate factors obtained from a survey 19 mid-Canterbury lentil growers during the 1989-90 season.

	Crop duration	Sowing density	Weed cover	Rain	Effective ET[1] Veg.	Effective ET[1] Flower.	Effective ET[1] Pod.	Available soil water
Yield			-0.676					0.523
Crop duration		-0.513	0.465	0.950	-0.783	0.894	0.897	
Sowing density				0.468	-0.645	0.490		-0.528
Farmer experience	0.477	-0.505						

[1] Effective evapotranspiration at the vegetative, flowering and podding stages of plant development.

endured higher total effective evapotranspiration (r = -0.658). Late sown plants had higher soil water deficits during flowering (r = 0.689).

More rain during crop growth was correlated with higher weed infestation (r = 0.520). Rain which fell after plants reached physiological maturity increased lodging (r = 0.461).

Interestingly, farmers tended to sow at a higher sowing rate on soils with low water availability (r = -0.528).

Stepdown regression

All 22 factors recorded were analysed in respect to yield using a stepdown multiple regression. The regression equation accounted for 93% of the variance. However, because of the small number of observations (19) and the many variables which remained in the final equation, it was not a good predictor of final lentil yield.

Farmer experience and problems with lentils

Generally farmers planted lentils in early spring following either a crop harvested during the previous summer or after pasture. The seed was planted using a grain drill, at a sowing rate of between 60 and 100 kg/ha. Three varieties of lentils were sown in Canterbury; the most common was the small seeded red cultivar Titore, and the yellow seeded cultivars Invincible and Olympic were also sown.

The most common fertilizer applied to lentils was superphosphate (containing phosphorus and sulphur).

Prior to sowing lentil seed was treated with Thiabendazole at 3 g a.i./kg to prevent Ascochyta, a major seed borne disease of lentils.

After emergence the lentils were heavy rolled to push stones into the ground and produce a level soil surface to aid mechanical harvesting.

Pre-emerge and post-emergence herbicides were commonly used for weed control.

In wet seasons the fungal diseases *Ascochyta lentis*, *Sclerotinia sclerotiorum* and *Botrytis* spp. were common. Aphids frequently caused crop damage.

At maturity the crops were mostly direct headed.

Previous crops: The crop grown prior to lentils were seen to have a number of effects on the lentil crop.

The incidence of soil borne fungal diseases such as *Aphanomyces euteiches* and *Fusarium solani* can increase rapidly if grain legumes were grown continuously. Significant reductions in the incidence of Aphanomyces root rot in peas has been reported by Chan & Close (1987) when Cruciferous crops such as rape, mustard, fodder radish, and kale preceded peas.

However, the survey indicates there were few agronomic problems associated with incorporating lentils into crop rotations in Canterbury. The relatively small area of lentils grown on each farm and the fact that lentils are a new crop in Canterbury may be part of the reason.

Cereals were often grown prior to lentils, even though it was hard to clean paddocks of their seed. Volunteer cereals were difficult and expensive to control, and were unacceptable in lentil crops grown for seed.

On one farm lentil yield was depressed when the crop was preceded by potatoes. Soil structure had been destroyed by potato harvesting and this may have accounted for the poor lentil yield.

Infestation of lentils by yarrow (*Achillea millifolium*) was hard to control and made direct heading of lentils impossible. As a result the lentils had to be cut, windrowed and dried in the field to reduce the intense smell of the yarrow prior to threshing.

Cultivation: Most of the farmers used conventional tillage methods. Only one farmer practised zero tillage and drilled lentils directly. Many farmers were convinced that lentils require a reasonably fine seedbed and therefore at least two cultivations were used prior to sowing.

Sowing: The lentil crops were sown between late May and the middle of September. Invincible and Olympic were used for spring sowning. The seeding rate used for Titore was 200 to 333 seed/m^2. The seeding rate for the two yellow varieties was lower at about 100 seed/m^2.

Four of the farmers preferred autumn sowing. However, none of the experienced farmers considered that autumn sown crops outyielded spring sowings. Seven farmers favoured spring sowing. Contrary to experimental results there was no benefit of sowing early to increase yield. In fact, the highest yield of 4 t/ha was obtained from a crop sown in the third week of September which was the latest sowing.

Farmers mentioned the following factors in support of their choice of sowing date:

1. Early sown crops withstood drought better than late sown crops because of their deeper root system.
2. There was a lower risk of plant disease in spring sown crops.
3. The earlier the sowing, the higher the seeding rate required.
4. Sowing at lower seeding rates promoted outbreaks of *Ascochyta lentis*.
5. Direct drilling required a higher seeding rate.
6. Sowing at high seeding rates decreased seed loss caused by wind.
7. Direct heading was easier because plants were taller when sown at high seeding densities.

Rolling: Every farmer was convinced that it was necessary to roll lentil crops after sowing. The main reasons given were to provide a level, stone free surface for direct heading and to protect the soil surface from wind erosion.

Some farmers used a heavy roller directly after drilling the crop while others preferred to roll it one or two months after drilling when the crop was 5 to 10 cm high. If the soil was too wet for a heavy roller a Cambridge roller was used. The Cambridge roller was also considered to be a very effective method of mechanical weed control.

Weed control: Weeds were an important factor which limited crop yield, made harvesting difficult and reduced the quality of the lentil crop. As initial growth rate of lentils is slow the crop competes poorly with weeds. The weed flora present depends on crop rotation, time of sowing and the tillage system used (Ramig, 1987).

Weed species present included twitch (*Eltrigia repens*), yarrow (*Achillea millefolium*), wireweed (*Polygonum aviculare*), fathen (*Chenopodium album*), field pansy (*Viola arvensis*) and volunteer cereals.

The most common method of weed control was spraying with a herbicide combined with cultivation. Efficient ploughing reduced weed contamination. Cultivation to prepare the seed bed also eliminated established and newly emerged weeds.

After winter cultivation, weed populations were reduced by sheep which grazed on emerging weeds and rhizomes (e.g., yarrow).

The most commonly used herbicides were Cyanazine at pre-emergence (2 to 5 l/ha), and metribuzin at post-emergence (0.18 to 0.20 kg/ha). Farmers reported that the herbicides, when applied at recommended rates, sometimes damaged the lentils. They considered that this was because lentils were sensitive to the chemicals. They also considered that herbicide efficiency varied with both climate and soil conditions.

Pests and diseases: Because of favourable weather during the 1989-90 season, there was little damage to the lentil crops from fungal diseases.

In wet seasons fungal diseases such as *Ascochyta lentis* (although seed was usually treated with TBZ), *Sclerotina sclerotiorum* and *Botrytis* spp. were widespread.

On approximately every third farm Ascochyta regularly damaged lentil crops. Further, common root rot of peas (*Aphanomyces euteiches*) was also found in lentils.

Some farmers sprayed lentils with the fungicide Chlorothalonil every year as a preventive measure or at the first sign of disease.

The farmers reported that insect pests were not very common on lentils. The pea aphid (*Acyrothosiphon pisum*) and grass grub (*Costelytra zealandica*) had to be controlled in a few paddocks.

Irrigation: In the 1989-90 season none of the surveyed lentil crops was irrigated. In previous years (1988) a few farmers had irrigated the crop during flowering to help increase the numbers of pods per plant. Many farmers thought that irrigation had no positive effect on crop yield. McKenzie (1987) showed that irrigation of lentils in Canterbury was not likely to increase seed yield, even in a dry seasons, unless the soil was extremely shallow, sandy or stony.

Harvesting: All but one of the the lentil paddocks in the survey were direct headed in the 1989-90 season.

In dry seasons plants tended to be short. They were then harvested by mowing and swathing followed by combine harvesting to reduce seed loss. Seed losses were also caused by sequential ripening and pod shattering. Losses resulted from both pod drop and from pod dehiscence. The former was considered to be the more serious (Erskine, 1984).

To reduce shattering losses farmers sprayed their crops with Diquat one week before harvest to promote even ripening or used brushes on the header pick-up.

The farmers estimated their seed losses were 5 to 20% with direct heading. This was less than reported losses in Jordan and Iraq, where the seed losses from harvesting with a combine harvester were estimated at 24% and 27% respectively (Haddad, 1986).

Lodging: Lentils were prone to lodging, especially in wet seasons or when sown at high densities. Lodging made plants more susceptible to fungal diseases and tended to reduce final yield. Because of lodging and their short stature it took longer to harvest lentils than cereal crops. Damage to harvesters caused by stones increases the cost of harvesting.

The role of lentils in Canterbury farming systems

Mixed cropping farms predominate in Canterbury. On the farms surveyed the area cropped was between 34 and 100% of the total farm. In the 1989-90 season the proportion of each farms sown to grain legumes ranged from 7 - 42% of their total area.

Peas (garden, field and vining) (*Pisum sativum*) were grown on an average of 15.1% and lentils on 7.6% of the total area of each farm. On a smaller scale broad beans (*Vicia faba*) and green beans (*Phaseolus vulgaris*) were also cultivated.

Peas have played an important role for many years on most of the properties surveyed whereas lentils are a relatively new crop in New Zealand. Lentils were cultivated for the first time on a Canterbury farm in 1979 (C. Lill, pers. comm.).

On average, the proportion of grain legumes grown in the crop rotations of the farmers surveyed had varied little over the previous four years. On some farms however, there had been large increases (up to 47%) in the area sown to grain legumes.

The main object of the farmers in growing lentils was to obtain a high net return from the crop. However, agronomic benefits such as addition of nitrogen to the soil, increased soil organic matter and their role as a break crop were also given as advantages of growing lentils.

Some farmers grew lentils because they fitted into their crop rotation. As lentils are drought resistant, they can be grown on paddocks that do not have irrigation.

Lentils in crop rotations: Many arable crops were grown on the surveyed farms and therefore the crop rotations differed greatly. Two aspects mainly determined the crop rotation used. The first was the availability of irrigation water for all or part of the farm. The second controlling aspect was soil type.

On farms which had irrigation covering the whole farm, conventional crops like cereals and peas were grown along with alternative crops such as squash, chicory and evening primrose.

As there was no typical crop rotation among the surveyed farms, increases or decreases in the area sown to lentils on these farms depended on their market price.

On farms which could only irrigate part of their area, lentils were grown on fields which could not be irrigated. On these farms lentils were either sown after pasture or grown in a rotation with grass seed and cereals.

On irrigated farms peas were grown in rotation with cereals and other crops. Lentils tended to be grown on the shallow, stony soils of the farm. Peas were sown on deeper, and better, soils.

Cereals and pasture were the main crops which preceded lentils on the surveyed farms. On three farms lentils were sown after grass, on two they followed peas and on one mustard. On four farms a green feed crop of rape, turnips or forage oats was grown before lentils.

The farmers differed in their opinions concerning the position of lentils in their crop rotation in conjunction with other grain legumes.

According to Jermyn (1986) lentils are host to several diseases which are common to peas and thus should not be grown any closer together in the rotation than every five years to prevent the build up of plant pathogens.

When planning their crop rotation five of the farmers did not regard peas and lentils as similar and used crop rotations where peas directly followed lentils, or peas were followed by lentils after a one year gap.

When asked, how many years the gap between successive grain legume crops should be, the farmers answers were: 2 years, 3 farmers; 3 years; 4 farmers; 4 years, 8 farmers; and 5 years, 2 farmers.

Use as a break crop: Grain legumes were used as a break crop, particularly prior to sowing cereals. The incidence of take-all of wheat (*Gaeumanomyces graminis*) can be greatly reduced by growing it after a legume crop (Roughely *et al.*, 1988).

Thirteen of the farmers appreciated the potential advantages of using lentils as a break crop in their crop rotation. On many of the farms cereals succeeded lentils. After using lentils in their crop rotation three farmers noticed that there was reduced twitch infestation in their wheat crops. One farmer observed a big reduction in take-all of wheat in a paddock with a previous history of the disease when wheat followed lentils.

Grass, peas, clover and brassica crops were all grown successfully after lentils. Four farmers grew kale, turnip or rape after lentils as a winter green feed before drilling a cereal. This is a practice which potentially has many positive aspects. Quite apart from the forage produced, the Brassica crops act as N-catch crops (Jensen, 1988).

Nitrogen fixation by lentils: As with most other grain legumes, lentils fix significant amounts of atmospheric nitrogen. Estimates of the amount of nitrogen fixed by lentils varies from 75 kg/ha (Brener *et al.*, 1988) to 162 - 190 kg/ha (Rennie & Dubetz, 1986).

All of the farmers surveyed were convinced that lentils were able to fix sufficient nitrogen for their own growth. Only four farmers used any fertilizer N on their lentil crops. Three farmers thought that the nitrogen fixed by lentils was also a source of N for following crops. Many of the farmers considered that lentils left the soil highly fertile and that they promoted good soil structure.

Discussion

Climatic conditions in Canterbury during the 1989-90 growing season were highly favourable for lentils. This was indicated by the Canterbury average yield of 2.1 t/ha. The monthly rainfall was very similar to that in 1982-83, when the average lentil yield was 2.5 t/ha and dissimilar to 1985-86, a bad year for lentils, when the average yield was only 1.1 t/ha. These results suggest that optimal rainfall for lentil growing consists of lower than average rainfall early in the season (September to November), which might reduce the incidence of leaf disease, and low rainfall at harvest (January). However, a higher than average rainfall in October and December may have assisted pod-filling.

Neither simple correlation nor multiple regression analysis gave any strong indication of a significant relationship between rainfall, water deficit, or effective evapotranspiration and crop yield. Because climate data was not available for the individual farms a study of the correlation between climate and crop yield over a number of seasons might give a better indication of any significant relationships.

Because of the lack of a relationship between rainfall and yield these results strongly suggest that crop husbandry and soil factors were the major determinants of yield on the surveyed farms.

The good correlation between available soil water and crop yield (Fig. 3) has to be interpreted carefully since available soil water can differ markedly within quite short distances in the same paddock. The significantly lower average yield from stony, Lismore silt loams (left bar in Fig. 3) indicates that lentil crops were most likely to reach their full yield potential on soils with greater water availability. However, because of the crop's intolerance to water-logging it was also important that lentils were sown into free draining soils.

On the surveyed farms there was little relationship between sowing date and crop yield which is contrary

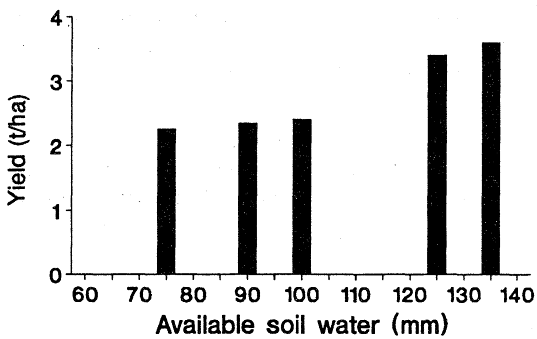

Figure 3: The relationship between lentil yield and available soil water for the 19 surveyed farms during the 1989-90 growing season.

to some firmly held beliefs that early sown crops yield more. There was, however, less yield variation of the later sown crops.

Good weed control is essential to obtain high yields of lentils (Butler & Jermyn, 1981). Spring sown lentils were usually less weed infested than autumn sowings both in surveyed fields and in the farmers' experience.

Weed competition during initial growth suppressed crop development and significantly reduced yield. Weeds growing later in crop development did not reduce the yield as much.

In this study it was not possible to quantify the effect of the previous crop or crop rotation on the yield of lentils.

Conclusion

Lentils are still a relatively new crop in Canterbury. As each growing season passes farmer experience of the husbandry and management of the crop improves.

Farmers have not experienced the yield of lentils as being as stable as the yield of crops such as wheat. Like many grain legumes, it is possible that as lentil cultivars which are better adapted to the New Zealand environment are developed, this high yield fluctuation may fall. It is obvious from this survey that, in a season where the weather is favourable to the crop, experienced farmers were able to obtain very high yields of lentils. Lentils thus have the potential to produce high financial returns and it is significant that the best yields obtained in this survey were higher than reported experimental yields in the Canterbury environment (McKenzie & Hill, 1990).

These high direct financial returns do not take into consideration the less quantifiable advantages from the use of the crop in crop rotations.

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