EFFECTS OF TILLAGE PRACTICE AND LEY PASTURE ON SOYBEAN PRODUCTIVITY ON A DEGRADED FERROSOL

M.J. Bell[1], B.J. Bridge[2], G.R. Harch[1] , D.N. Orange[3], R.C. Dalal[3], and R.M. Mason[1]

[1] Queensland Department of Primary Industries, PO Box 23, Kingaroy, Qld 4610
[2] CSIRO Division Soils, Queensland Wheat Research Institute,
PO Box 2282, Toowoomba, Qld 4350
[3] Queensland Department of Primary Industries, Queensland Wheat Research
Institute, PO Box 2282, Toowoomba, Qld 4350

Summary. The effect of four year kikuyu leys under various managements on improving the structural and hydraulic properties of a degraded, continuously cropped Ferrosol were examined at a site in the south Burnett area of Queensland. The effects of deep ripping, both during the ley phase and on continuously cropped soil, and choice of tillage system (no-till and conventional) were also examined during a return to cropping. Kikuyu leys significantly increased infiltration into the soil, particularly two years after establishment. Deep ripping the ley significantly reduced the bulk density of previously compacted layers and maintained high infiltration rates up to the cropping phase. Under cropping however, the prevailing seasonal conditions did not allow any improved water storage, plant extraction or crop yield. Deep ripping on continuously cropped soil resulted in yield increases under direct drill systems only.

INTRODUCTION

There is mounting concern about the sustainability of conventional cropping practices used for rainfed agriculture on the Ferrosol soils of the inland Burnett area of southern Queensland. Conclusive evidence of declining soil physical, chemical and biological fertility under conventional cropping systems is now available (1, 2). Of particular concern in these dryland cropping areas are soil structural changes which reduce rainfall infiltration and plant access to stored soil moisture. Such changes have led to examination of alternate farming practices which include ley pastures, reduced tillage/controlled traffic and the regular use of deep ripping. This paper reports the effects of four years of ungrazed kikuyu pasture with varying management inputs on soil physical fertility and on growth of a soybean crop on a degraded Ferrosol. In addition, the impact of deep ripping on soybean growth under both conventional and reduced tillage systems was examined.

MATERIALS AND METHODS

Ley pasture

Kikuyu (*Pennisetum clandestinum*) pasture was established on a degraded cropping site at Goodger (described in detail in 1) in the spring of 1990. The pasture was not cut or grazed during the next four years, while four management regimes were imposed - (a) low input (LI) pasture, where no fertiliser or other inputs were supplied; (b) fertilised pasture (FI), where annual applications of N,P and K fertiliser were made; (c) fertilised, ripped pasture (FR), where the sward was ripped to a depth of 35-40 cm during year 2 of the ley; and (d) fertilised pasture with earthworms (FW), where locally adapted earthworms (*Fletcherodrilus unicus, Aporrectodea trapezoides* and *Potoscolex corethrurus*) were introduced during pasture establishment. Above-ground dry matter (DM) production was assessed annually, while estimates of below ground DM to 70 cm were made at the end of the ley phase.

Cropping phase

At the end of the ley phase, the kikuyu was sprayed out with Roundup CT (1800 g/ha glyphosate) and plots were returned to cropping using either direct-drill, controlled traffic (DDL) or conventional cultivation, random traffic (CCL) practices. An additional area of continuously cropped, degraded soil in an adjoining contour bay was prepared as an unregenerated reference. Treatments in this bay represented factorial combinations of with (+DR) and without (-DR) deep ripping and direct drill, controlled traffic (DD) or conventional cultivation, random traffic (CC) treatments. All plots were sown to soybeans (cv. Dragon) in January 1995. Crop performance was monitored by DM sampling and final yields, while canopy temperatures (infra-red thermometry) and crop water extraction (neutron probe) were measured during the season.

Soil measurements

Soil parameters measured throughout the ley phase and at the beginning and end of the first crop year included water infiltration parameters (using portable field rainfall simulators and disc permeameters), soil bulk density to 70 cm, microbial biomass N and soil organic carbon.

RESULTS AND DISCUSSION

Ley pasture

The above-ground DM production by the kikuyu pasture responded to NPK fertiliser application but not to other treatments (Table 1), whilst total DM production did not differ greatly among treatments. Below-ground DM represented 66-76% of the total DM produced, with 72 (FR) - 79% (LI,FI) of that DM in the top 20 cm of the soil profile.

Table 1. Effects of management on kikuyu DM production after 4 years at Goodger.

	DM production (kg/ha)		
Treatment	Tops	Roots + Rhizomes	Total DM
Low input (LI)	11 060	34 930	45 990
Fertiliser (FI)	16 660	33 440	50 100
Fertiliser + deep ripping (FR)	14 650	33 220	47 860
Fertiliser + earthworms (FW)	16 630	32 710	49 340

Soil properties

During the four year kikuyu pasture phase we recorded marked improvement in soil hydraulic conductivity and in the capacity to allow high intensity rain to infiltrate (Fig. 1). Some of these benefits were lost when the area was maintained in pasture longer than two years, unless a form of pasture renovation (e.g. deep ripping) was undertaken. However, as the sprayed-out pasture has broken down in the DDL plots returned to cropping, there has been a return to higher infiltration rates despite a drastic reduction in hydraulic conductivity in wheeltracks.

Deep ripping effectively disrupted compacted layers down to 35 cm in both the FR treatment in the ley area and in the continuously cropped soil in either (DD+DR) or (CC+DR) treatments, with bulk densities of 1.3 Mg/m^3 in the 10-25 cm layer reduced by 15-20%. However, deep ripping had no effect on rainfall infiltration measured after soybean harvest in the (DD+DR) treatment (Fig. 2) due to the dominance of surface limitations in conditions of little surface roughness and only 40% cover. The (CC-DR) treatment produced 40% greater infiltration than the DD treatments in the continuously cropped area due to greater surface roughness, with a further 25% increase in the (CC+DR) due to reduction in subsurface limitations.

Whilst pasture ley treatments resulted in increased Walkley-Black organic C content (%) in the top 30 cm of the soil profile, the total amount of organic carbon (t/ha) present shortly after soybean planting was not different to the continuously cropped area. There were effects of tillage system within the ley treatments, however, with organic carbon better distributed throughout the top 30 cm in the conventionally prepared treatments.

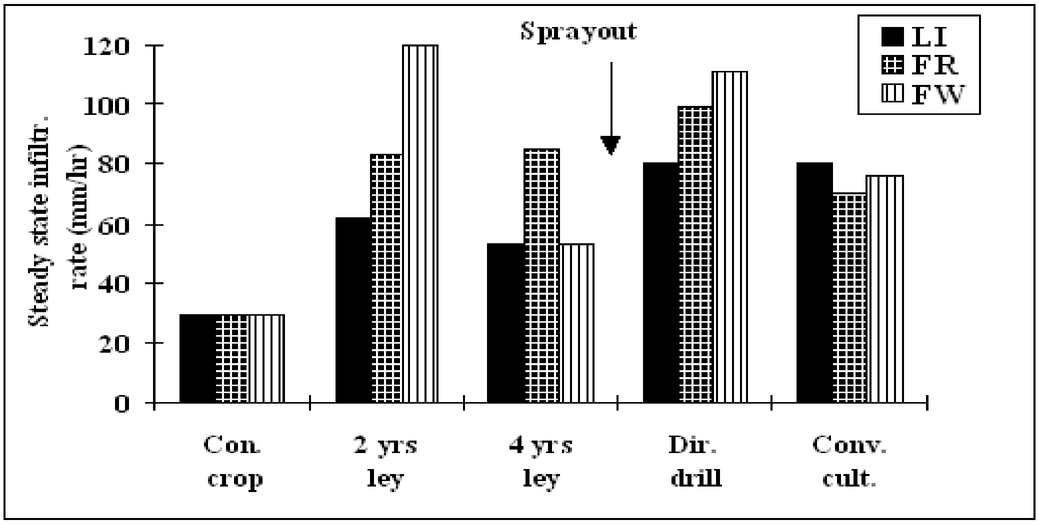

Figure 1. Effects of ley management, ley duration and tillage on rainfall infiltration at Goodger.

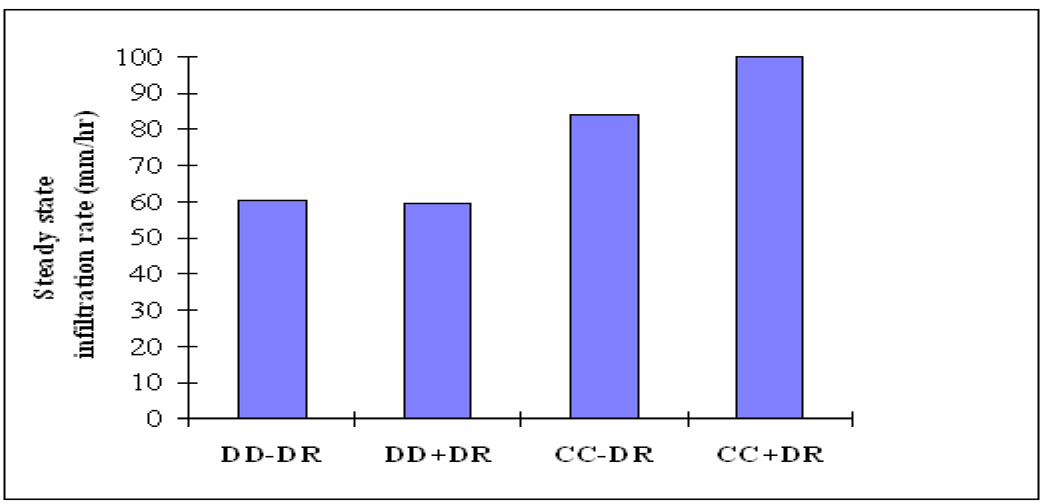

Figure 2. Effects of tillage system and deep ripping on rainfall infiltration.

Soybean growth and crop water use

Planting was unusually late due to lack of sufficient planting rain, and unfortunately it was necessary to replant both the DD and CC ley areas some 14 d after the initial planting operation due to poor emergence. This was due to a combination of low vigour seed and poor seed bed condition, the latter due to the dry conditions and the large amount of kikuyu DM incorporated. This meant that direct comparisons of the ley and continuous crop areas could not be made.

Dry matter samples taken during early podding showed significant effects of ley pasture management and tillage in the ley area, but no effects of tillage system or deep ripping in the continuous crop area. Crops grown after low input grass (2590 kg/ha) had less well developed canopies than other ley managements

(2970-3200 kg/ha), whilst conventionally tilled ley plots had significantly better growth than under direct drilling (3210 vs 2670 kg/ha). The tillage effects were due to higher levels of available N in the conventional plots during early growth, with early flowering (due to the late plant) and later water stresses resulting in a lack of opportunity for the direct drill plots to compensate. Starter N fertiliser would have overcome this problem.

There were no detectable differences in ability of grass ley or continuously cropped plots to better extract soil water during the season, with all plots suffering extreme stress resulting in premature senescence and death late in the season. However, IR canopy temperature measurements indicated that stress onset was almost 14d earlier in the conventionally tilled ley plots, compared to the direct drill (Table 2).

There were no significant differences in seed yields due to ley pasture management or tillage system, with an overall mean yield of 1370 kg/ha. However there was a trend to higher yields in the DR treatments, especially under direct drill. Yields in the continuously cropped area were slightly higher (overall mean 1560 kg/ha), with this likely due to the earlier plant establishment in an already very late season. Deep ripping produced a significant increase in yield under direct drill (1590 vs 1370 kg/ha) but not in conventional tillage. This was probably due to the fact that the conventional tillage operation caused a partial disruption of the existing plough layer which had developed under less intense, reduced tillage practices.

Table 2. Canopy - air temperature differentials at mid-day in the ley area.

	Differential (^{0}C)	
Date	Conv. cultivation	Direct drill
22/3/95	-0.5	-3.1
23/3/95	+0.9	-2.4
6/4/95	+2.1	-0.2

CONCLUSIONS

Pasture leys have produced major changes in soil hydraulic properties, and particularly in combination with deep ripping, provided significant amelioration of compacted layers. However, under the prevailing seasonal conditions this did not result in improved soil water storage, plant extraction or crop yield. Direct drilling into sprayed pasture was undertaken successfully, with significant potential benefits in maintaining surface cover and high rainfall infiltration. However, N nutrition of crops grown in this system will need to be closely monitored and the impact of direct drill systems on peanut productivity, and the effect of peanut digging on soil properties under direct drill, will be of interest in future seasons. Continuously cropped soils were difficult to manage under direct drill systems without adequate levels of surface cover. Roughness generated by conventional tillage systems, combined with disruption to subsurface compaction layers, increased rainfall infiltration but deep ripping alone did not aid infiltration as surface seals were the major limitation. Effects of deep ripping on moisture extraction from deeper soil layers, and the duration of effects of deep ripping under different tillage systems, will be examined further.

ACKNOWLEDGMENTS

This work has been partly funded by GRDC through support to project DAQ 278NR.

REFERENCES

1. Bell, M.J., Harch, G.R. and Bridge, B.J. 1995. Aust. J. Agric. Res. 46, 237-253.

2. Bridge, B.J. and Bell, M.J. 1994. Aust. J. Soil Res. 32, 1253-1273.