GENERAL ARTICLES

Conservation tillage using Roundup in Queensland and northern New South Wales

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Introduction

Conservation tillage is a general term in Australia for crop production systems in which traditional cultivation is reduced and mechanical weed control is replaced or supplemented by the use of herbicides. The principle of conservation tillage is that crop stubble is retained undisturbed for maximum protection against soil erosion and the fallow is maintained weed-free to conserve moisture. Weed control is achieved either entirely by the use of herbicides ('zero tillage') or by the use of herbicides and limited cultivation ('minimum tillage'), and crops are planted with a minimum of soil disturbance. The ultimate objective is no cultivation from harvest to harvest.

About 200 000 ha of winter cereals were sown by direct drilling or reduced cultivation methods in 1979 in the southern wheat belt areas of Australia, and this area is increasing rapidly as more farmers experience the benefits of conservation tillage.

In recent years many farmers in northern New South Wales and southern Queensland have adopted stubble retention farming methods (R. J. Bateman personal communication, 1981; Felton *et al.*, 1980), and since 1977 interest has extended to the use of herbicides in minimum and zero tillage systems. Many trials over the northern wheat belt have shown that both winter and summer crops can be successfully grown under these systems (Heron *et al.*, 1981).

The increased interest in and adoption of conservation tillage in the northern wheat belt over the past two years has been due to the recognition of the benefits of the concept, which can be summarized briefly as follows:

Reduced soil erosion Retained stubble reduces the impact of high intensity rainfall and undisturbed standing stubble gives maximum protection against soil erosion (Marston, 1980; Freebairn and Wockner, 1980).

Conserved soil structure Repeated passage of large tractors and implements breaks down the natural soil structure, causes wheel track compaction, and may lead to development of a 'plough pan'. Conservation tillage reduces or eliminates cultivation and allows the soil to regain its natural structure (Marston, 1980).

Conserved soil moisture Cultivation allows loss of moisture from the soil surface. A reduced tillage, stubble-retained system conserves soil moisture and reduces rainfall runoff losses (Loch and Donnollan, 1980).

Saving of time and fuel Spray application is much faster than cultivation and uses substantially less fuel (Fawcett, 1980; D. A. Hayes personal communication, 1981).

Timeliness of sowing Because less time is required for cultivation, more flexibility is available for sowing during the optimum period. With improved trafficability on undisturbed soil weed control and sowing can be achieved under a wider range of conditions.

Yields Trial results indicate that yields can at least be maintained under reduced tillage systems and there is promise of improved yields as experience and expertise grows. Recent trials indicate strong prospects for improving yields of summer crops in response to improved soil moisture storage and utilization and reduced soil compaction (W. L. Felton personal communication, 1981).

Reduced crop production costs Conservation tillage systems are less capital intensive than traditional cultivation, and as fuel, labour and machinery costs continue to rise the economic benefits of reduced tillage will become more evident. Experience gained now will be an investment for the future.

Roundup in conservation tillage

The use of glyphosate (Roundup herbicide by Monsanto) has helped in the adoption of conservation tillage throughout Australia. Glyphosate is a foliar applied translocated herbicide which controls many annual and perennial weeds and has no soil residual activity (Sprankle *et al.*, 1975), which makes it suitable for use within a few days before sowing wheat, barley and other crops.

Glyphosate has been under development for minimum tillage systems since 1972, but it was not until 1978 that it was first reported as suitable for the control of various grasses and broadleaved weeds before direct drilling cereals into stubble (Seeney and Eady, 1978). Numerous trials and commercial applications since then have demonstrated its ability to control a wide range of grasses and broadleaved weeds under a wide range of conditions (Herron *et al.*, 1981).

Typical programmes of conservation tillage are given below:

Minimum tillage Harvest the crop, cultivate or spray as required, plant the new crop, and control in-crop weeds.

Zero tillage Harvest the crop, spray as required to maintain a weed-free fallow, plant the new crop with a minimum of soil disturbance, and control in-crop weeds.

According to the species of weeds present in the fallow, weed control may be achieved with a range of herbicides including glyphosate, dicamba and 2,4-D. The appropriate herbicide treatment should be selected for the range of weeds present. For example, where a mixed infestation of grasses and small broadleaved weeds occur, 1.0 to 1.5 L ha^{-1} of Roundup can be used effectively, but where no grass weeds are present economic control of certain broadleaved weeds is possible using label rates of 2,4-D. On the other hand, a mixed infestation of grasses and mature broadleaved weeds or hard to kill broadleaved weeds such as bladder ketmia (*Hibiscus trionum*), fleabanes (*Conyza* spp.) and common sowthistle (*Sonchus oleraceus*) can be controlled with a tank mix of 1.0 to 1.5 L ha^{-1} of Roundup plus 0.5 L ha^{-1} of dicamba. Note that dicamba is the only herbicide which can be tank mixed with Roundup.

In a wheat-to-wheat rotation under zero tillage it has generally been found that

two to five herbicide applications are necessary during the fallow period, depending very much on the type of season and the pressure of the weeds. Trials have indicated that a wheat-to-sorghum rotation is a good starting point for new users of conservation tillage systems. Sorghum appears to lend itself well to the new concept and in several trials has shown potential to respond to improved soil moisture utilization (W. L. Felton personal communication, 1981). For initial ease of management, conservation tillage should be introduced onto fields that do not have a serious weed problem. A farmer should become familiar with the new system before tackling difficult weed problems or difficult soil types. The latter are a problem only at planting time, and while conservation tillage has been practised successfully on a range of soil types beginners should avoid certain soils. These include crusting saline soils, such as some around Moree in New South Wales, and very heavy textured self mulching black clays, such as those of Anchorfield near Brookstead in Queensland.

Management of conservation tillage

Conservation tillage is a management-intensive practice and for this reason it is suggested, as stated above, that new users learn on a relatively easy paddock. Planning for fallow weed management should begin with the previous crop. Good in-crop weed control ensures that maturing weeds are not carried over into the stubble immediately after harvest.

There are three main aspects of management under a conservation tillage system. These are stubble management, spraying and seeding.

Stubble retention is essential to provide protection against erosive rainfall and to reduce soil loss and rainfall runoff. For ease of subsequent sowing, the stubble should be left as short as may be practicable (preferably 25 to 30 cm long) and the straw well spread from the header, covering its full width if possible. Avoid heavy header trails which may cause blockages when sowing the next crop.

Straw management during the fallow should be related to the type of seeder available to sow the next crop. Where suitable trash clearance equipment is not available, it is possible to remove the straw by burning prior to seeding. Retained stubble does not interfere with weed control, and Roundup provides excellent weed control in stubble situations.

The spraying operation must be carried out at the early stage of weed growth to keep the chemical rate and hence the cost to a minimum. To ensure that this happens conservation tillage farmers must check weed population frequently, say every 10 to 14 days.

Good weed control with herbicides is dependent on proper herbicide use and critical timing of application. Users should be familiar with the weed spectrum of the field and familiar with the herbicides they may use. Do not spray weeds that are under stress, which can be caused by lack of water, high temperatures, hot dry winds, frost, waterlogging or insect attack. The stress condition of weeds should always be considered, since glyphosate works best on healthy actively-growing plants.

A full understanding of boom spraying techniques is essential. Boom sprayers should be thoroughly checked and calibrated and the boom set at the correct height above the tallest weeds present, for example, for 80° flat fan nozzles at 50 cm spacing the correct height is 65 cm above the tallest weeds present to ensure double overlap.

The effectiveness of glyphosate may be reduced by mixing with water containing clay or organic matter or with hard water. Use only clean water and low water volumes. For rates of Roundup in the range of 0.5 to 1.5 L ha^{-1} a water volume of 60 to 100 L ha^{-1} is recommended, but significantly lower volumes have been used successfully.

To avoid wheel tracking of the sprayed area the boom should be mounted behind all vehicle wheels. Under some conditions excessive dust thrown up behind the wheels may partly inactivate glyphosate and cause stripping, and this can be avoided by using nozzles of 50% greater capacity over the wheel tracks.

A swath marking system is recommended to ensure accurate application, but disc markers are not recommended as they throw up soil which inactivates the glyphosate and results in a strip of uncontrolled weeds. The most effective marking system is to establish tramlines in the fallow at the first spray after harvest. This entails measuring the distance between adjacent sprayer tracks according to the boom width and the use of flags to get the vehicle tracks perfectly straight on the first spray. These tracks are readily visible and are used on all subsequent sprays. No other wheeled vehicles should drive over the paddock, and any necessary traffic should also follow the tramlines. The tramlines are maintained at sowing by shutting off the sowing tines in the wheel tracks. Tramlining minimizes soil compaction and assists in reducing the plough pan effect, whilst improving soil structure and water infiltration. Wheel tracks other than the tramlines make sowing under conservation tillage more difficult due to the unevenness of the ground. Apart from the normal requirements for correct seed placement and coverage, a seeder suitable for reduced tillage situations requires good stubble clearance and minimum soil disturbance. In trials over the last few years crops have been sown successfully with a variety of modified or specially constructed seeders. Features of successful equipment include narrow tines for minimum soil disturbance, press wheels to improve seed–soil contact, and good under-frame clearance and wide spacing between tines for straw clearance. Independent depth control on each tine is also desirable to allow them to follow the contours of untilled ground. At present, the ideal seeder is not commercially available and some improvisation will be necessary in the early stages of conservation tillage development.

In some cases, with light stubbles and more easily managed soils, crops have been successfully established with conventional equipment by removing the cultivating tines and increasing row spacing.

The seeding rate and fertilizer requirements under reduced tillage systems are being monitored on existing Monsanto–D.P.I. trials. At this stage it is suggested that seeding rates for cereals be increased by 10 to 20%. Sowing depths and crop varieties need not be changed from normal practice.

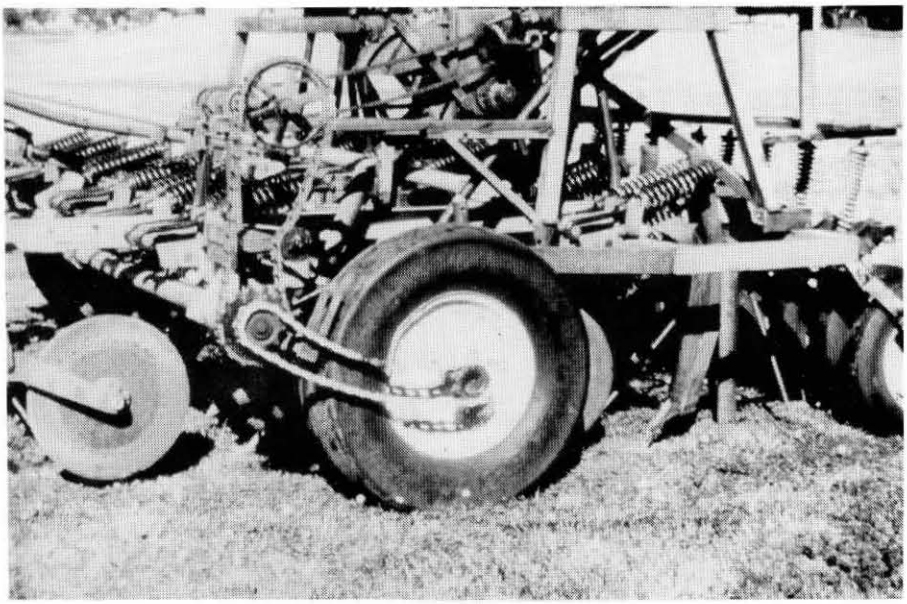
Roundup as an aid to cultivation

There are two situations in conventional farming systems in which glyphosate is a valuable aid to crop establishment — seedbed moisture conservation and seedbed salvage.

Where light rains produce marginal seeding moisture, it is recommended that weed growth be sprayed instead of cultivated to conserve seedbed moisture. Cultivation will cause much of the seedbed moisture to be lost and delay sowing until further rain occurs, whereas spraying with glyphosate provides rapid weed control, saves time and retains seedbed moisture.

During conventional seedbed preparation weeds frequently emerge between cultivations, and under wet conditions these weeds can be difficult to kill by cultivation, many being merely transplanted. The use of herbicides for weed control in this situation is called seedbed salvage. Glyphosate provides a cost-efficient, rapid and reliable alternative to cultivation. Rates of Roundup as low as 0.5 L ha^{-1} may be used (Fellowes *et al.*, 1979), but where wet conditions prevent ground operations Roundup is recommended for aerial application at

Tramlines in wheat



Department of Primary Industries Prototype no-till planter

up to 1.5 L ha^{-1}. Depending on soil condition and weed density crops may be sown within three days of spraying unless further cultivation is needed to achieve a suitable seedbed.

Much has been learnt over the past two years regarding conservation tillage, but still more has to be learnt. Not all the answers are known, but with continued trial work and farmer adoption, problems will be surmounted as they arise. The recommendations for the use of Roundup in conservation tillage are currently being expanded to allow its use before planting most other crops.

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