Laser levelling land for flood irrigation

M D. Green

J. P. Middlemas

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Since the introduction of laser levelling to Western Australia's South-West irrigation area five years ago, many farmers have benefited from this new and precise method of land-forming.

The use of laser controlled earthmoving equipment to redevelop irrigated paddocks has led to improved irrigation efficiency and drainage. Less water is used for each irrigation, water is applied more evenly and less labour is needed. Many older, grass-dominant paddocks have been reseeded to improved pasture species.

Irrigation practices

There are about 11,000 hectares of flood irrigated land in the Government controlled South-West irrigation area, of which about 1800 ha have been laser levelled so far (Figure 1). Most of this land is sown to perennial pastures and is flood irrigated using the border check method. This is a system of using small parallel borders or check banks of earth to prevent water moving laterally across the paddock. Checks may be a few metres or up to 20 metres apart depending on topography. Check banks are normally 200 to 300 millimetres high and 800 to 1000 mm across.

Up to 4,000 ha of annual pasture is irrigated in March and early April to provide additional grazing during late autumn and early winter.
How the laser system works

The use of the laser beam for irrigation land-forming was developed in the United States of America in the late 1960s. Laser levelling was first introduced to Australia's irrigation areas in northern Victoria in 1977. Previously manually controlled road graders and scrapers were used and it was extremely difficult to achieve consistent grades. With laser levelling accurate, even grades are easily achieved.

The components of a laser levelling system are a laser beam transmitter, a receiver, and a 'carry-drag scoop' fitted to a large 200 to 300 kilowatt tractor. The scoops have horizontal floors which allow them to carry most of the soil. However, the vertical sides of the scoop protrude forward past the floor, allowing the scoop to drag soil as well.

The laser beam transmitter, which is powered by a 12 volt battery, is set on top of a three-metre high tripod which is placed within the area to be graded. The transmitter sends out a pencil-thin beam of light which continually rotates over the paddock on a pre-determined grade. A receiver mounted on a mast directly above the scoop's cutting blade locks on to the beam of light, converting it to an electrical impulse which registers as a series of lights on a control panel mounted in the tractor cab. The impulse activates a series of solenoids and hydraulic rams fitted to the tractor and scoop which automatically keep the cutting blade parallel with the beam of light, no matter how undulating the terrain over which the tractor and scoop are travelling.

The operator can manually over-ride the automatic cutting action at any time. This is essential when large amounts of earth have to be shifted as it is not always possible to achieve the correct grade in one pass. The scoops are usually three to four metres wide and carry between six and nine cubic metres of soil.

The tractor and scoop constantly cross the area being land-formed. Where there are ridges, the cutting blade remains on grade and soil builds up and fills the scoop. When low spots are encountered, soil falls out of the scoop, filling the holes and building up the level of the paddock to the required grade.

Laser controlled earthmoving equipment removes the need for constant checks with conventional survey equipment while earth is being moved. When used properly, the equipment has an accuracy of plus or minus 20 mm at 300 m from the transmitter, well within the accepted tolerance for irrigation systems in Western Australia.

Redevelopment plans

Irrigation layouts must provide for the efficient use of water, land and labour. Aerial photographs and contour plans are used as aids in planning new layouts. To maximise returns from newly designed layouts, farmers should undertake a complete redevelopment plan of the area before starting any earthworks. The plan should include the location of supply channels, tail drains, access ways, water supplies, tree shelter belts and paddock areas to suit cow herd sizes (Figure 2).

Redevelopment plans are usually carried out as finance, time and pasture productivity levels permit. A plan ensures that redevelopment is co-ordinated, even though it may take about 10 years.

Department of Agriculture staff have already helped many irrigation farmers to draw up redevelopment plans and many more are making use of this free service.

Figure 2. In this irrigation system there were originally 5 different-sized paddocks, about 120 bays and 2 km of supply channels and runoff drains. After development there were 5 equal-sized paddocks, about 20 bays and less than 1 km of supply channels and runoff drains.
Survey and design

Areas to be land-formed are generally surveyed on a 30 m grid and a computer is used to help design the optimum grade, width and direction of irrigation bays. The computer print-out also shows the amount of earth to be shifted per unit area and the depth of cut or fill at each grid point. A range of different options for each area can be quickly examined. Soil movement is kept to a minimum.

Ground preparation

Good ground preparation is essential before any land-forming starts. Earth cannot be shifted quickly and efficiently when it is extremely grassy. Paddocks to be land-formed should be grazed heavily and where a thatch has built up, the paddock should be rotary-hoed to break it down. This should be followed by at least one more cultivation using either a disc or mouldboard plough or large rippers.

In very heavily thatched paddocks it may be necessary to bury the thatch by ploughing the area in late autumn. The land can then be used to grow a forage crop such as rye grass or oats over the winter-spring period, then land-formed the following summer.

Land-forming can only take place when the soil is dry between November and April each year.

Soil fertility

When excessively large amounts of soil have to be moved, infertile clay subsoil is sometimes exposed. Two methods are used to overcome this problem.

The first is to stockpile the topsoil and land-form the clay subsoil. The clay is cut below grade, then the topsoil is placed over the clay and the land surface is brought up to grade. Stockpiling the topsoil for respreading later increases the cost of laser levelling by about half. The relative economics of using this method are not well known.

The second method is to laser level the land then carry out soil tests on both the cut areas (exposed clay areas) and the fill areas (areas of predominantly fertile topsoil). Separate superphosphate, potassium and lime requirements can then be determined for each individual area. Trace elements may also be required but the need for these cannot be ascertained until after the pasture has been re-established. Leaf tissue samples are then taken and analysed for trace element deficiencies.

Soil rhizobia (nitrogen-producing organisms) may also be removed from cut areas of the paddock during laser levelling. To ensure that the clover growing in these areas is well nodulated and capable of producing its own nitrogen, all seed should be inoculated before planting. Seed should be inoculated even if

Cultural practices

Paddocks that are land-formed early in summer are generally planted to a summer forage crop, usually millet or a sudan-sorghum cross, before being reseeded to perennial pasture the following autumn. Both forage crops produce a large amount of dry matter quickly. They can be grazed, green chopped, or made into silage or hay.

Paddocks that are land-formed in late summer or autumn are usually reseeded to perennial pasture.

When reseeding irrigation pastures, the seed mixture should contain at least 10 kilograms per hectare of perennial white clovers and 20 kg/ha of perennial ryegrasses.

During laser levelling farmers are encouraged to have the contractor deep rip all the cut areas just before final grading. Deep ripping allows the whole area to settle more uniformly over winter and helps to prepare a seed bed. After laser levelling the land does not need cultivation and crops or pastures can be seeded directly into the bare soil.

Paddocks that are land-formed early in summer and are used to grow a summer forage crop do not have to be cultivated before being reseeded to perennial pasture in autumn. Any cultivations at this time will only increase the bogginess of the paddock over winter. A knockdown herbicide can be used to control weeds and the pasture can then be seeded into the crop stubble by using a sod seeder.

John Jahn, of the Weather Bureau, with a class A pan evaporimeter.
When to water

There is a reasonably close correlation between the amount of water that a plant uses each day and the amount of water lost from a Class A evaporation pan. Evaporation is measured from its surface daily.

Agronomists throughout southern Australia generally recommend that perennial pastures should be irrigated each time the cumulative daily total evaporation from the pan reaches 70 mm. This is often varied slightly according to soil type. For example, pastures on heavy clay soils should be watered more often while on loamy soils the interval between irrigations may be increased slightly.

By watering according to evaporation measurements, the total number of irrigations each season has increased from the traditional 12 to about 15. Although irrigations are not as frequent during spring and autumn, they can be closer together during summer heat waves. Total water usage each season has not increased significantly and the clover-rye grass content of irrigated pastures appears to be improving.

Evaporation readings provided by the Weather Bureau for the South-West irrigation area are broadcast each night as part of the weather segment on the Golden West Television network and each morning over ABC radio during the irrigation season.

Costs

Land-forming for flood irrigation is expensive. The cost of earthworks during laser levelling varies and depends on the total amount of earth to be shifted, the distance it has to be shifted and how well the ground has been prepared. Much of the laser levelling in the South-West irrigation areas in the past three years has cost between $300 and $450 per hectare.

Advantages of laser levelling

Less labour needed

The bays in old irrigation pastures are generally about 5 m wide and 200 m long, and few of them have even grades. Bays formed with laser controlled earthmoving equipment are generally about 30 m wide and 300 to 400 m long, with an even surface on a constant grade. Fewer bays and bay outlets mean less labour is needed to operate a flood irrigation system.

Less water used

On laser levelled paddocks water is applied more evenly. Water requirements per irrigation have been reduced from about one megalitre per hectare to between 0.5 and 0.7 megalitres per hectare.

Improved pastures

Before the introduction of laser levelling, many farmers extended the interval between waterings for longer than was desirable for optimum pasture growth, because flood irrigation was labour intensive and water usage high. Unfortunately long intervals between watering encourage the growth of paspalum and kikuyu which are the less preferred grasses within the sward, as they quickly become dominant at the expense of the more nutritious clovers and rye grasses.

The economic potential of clover-based pastures was emphasised in a two-year trial at Wokalup Research Station. Cows grazing on clover-rye grass pastures produced between three to four litres of milk a day more than cows on kikuyu pastures. This extra milk production represented a gross return of $350/ha a year at surplus milk prices.

Reduction in salinity

Parts of the South-West irrigation area are underlain by a rising saline groundwater table. Many of the old irrigation layouts have flat spots or reverse grades which trap surplus irrigation water on the soil surface. This surplus water can cause surface waterlogging which inhibits plant growth. Much of it also moves down through the soil profile, adding to the already rising saline watertable.

On paddocks that have been laser levelled surplus water quickly drains to the ends of the bays for safe disposal. The amount of water moving through the soil profile and entering the watertable is significantly reduced, thus lessening the salt problem.

Improved plant growth

The improvements in irrigation layout, coupled with watering according to evaporation readings, mean water can be applied according to plant needs during summer, thus leading to improved production. Plant growth in winter has also improved because of better surface drainage.