Reliable and cost-effective legume establishment in black speargrass grazing lands

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Summary. A band-seeder capable of consistently placing seed and fertiliser accurately under rough operating conditions and spraying a band of herbicide to control plant competition has been developed for establishing legumes in grazing lands in southern Queensland. This system significantly increased emergence and subsequent seedling survival, compared to surface sowing. A wide row spacing (1.5 m) minimised input costs and allowed the machine to operate in rough, partially cleared country. A benefit-cost analysis comparing band-seeding with surface sowing and cultivated seedbeds reveals significant potential. net benefits to livestock producers.

Introduction

During the 1960s and 1970s much of the pasture improvement in Australia was based on fully cultivated and appropriately fertilised seedbeds. Such practices often resulted in highly productive pastures within 12-18 months of sowing. Surface sowing, or aerial seeding, often in conjunction with a chemical seedbed, although less effective than the cultivated seedbed in terms of reliability and the speed of pasture development, has been widely used in non-arable hill country areas where rainfall is favourable (1). Surface sowing with legumes has been successful in the tropical areas of north Queensland where summer rainfall is reliable, although it may take up to 8 years for the pasture to reach full production (5). However, as the amount and reliability of rainfall decrease, the risk of establishment failure from surface sowing increases. In the black speargrass, *Heteropogon contortus,* region of central and southern Queensland, surface sowing has proved relatively unreliable (80% failure rate). Competition from the existing vegetation, frequently aggravated by lack of soil moisture, was shown to be a major cause of establishment failure (3).

Incomes of livestock producers are being eroded by a chronic cost-price squeeze and lost productivity through land degradation. While these losses may be offset via pasture improvement, it is important to recognise that development options must be both agronomically and economically feasible. Investment of scarce capital in pasture development options that have a high risk of failure, low returns and long pay-back periods is questionable. If pasture improvement is to remain a viable option in the speargrass region, there is an urgent need for a cost-effective and reliable method of pasture establishment for grazing lands. While the use of chemical seedbeds could overcome many of the unreliability problems of surface sowing, it is an expensive option that removes all herbage and is not compatible with augmentation of grass pastures with legumes; Any augmentation strategy would therefore have to be incorporated in a ground-based machine in order to address the problem of controlling plant competition.

A competition control system using the systemic herbicide glyphosate was the preferred approach as glyphosate provides more consistent control of competition than mechanical disturbance in a single pass over a range of seasonal conditions.

The objective was to improve the success rate for establishing legumes into existing pasture and to minimise inputs of machinery, labour and fuel costs, herbicide, seed and fertiliser.

Development of band-seeding technology

Herbicide

The use of bands of herbicide to control competition adjacent to emerging seedlings provided encouraging results in early trials (2). This approach is a means of minimising herbicide inputs with row spacing adjusted to reduce the proportion of pasture being sprayed. Testing showed that the wider the herbicide band, the better the growth and survival of the sown legumes. Band widths of less than 30 cm provided inadequate control of plant competition under most conditions, while widths of 30 and 40 cm, though effective in wetter seasons, failed to provide adequate control of root competition during dry years. On the other hand, a 50 cm wide band provided reasonable seedling survival under dry conditions and, when combined with a row spacing of 1.5 m, was acceptable from an economic viewpoint (4).

Seed

Compared with a conventional seed drill, the 1.5 m row spacing effectively reduced seed and fertiliser inputs by a factor of almost 10. In addition, drilling the seed to a depth of 5-10 mm increased seedling emergence of shrubby, *Stylosanthes scabra* cv. Seca, and fine-stem, *S. guianensis* var. *intermedia,* stylos (2 fold) and round leaf cassia, *Cassia rotundifolia,* (8 fold), relative to that of seed broadcast on the soil surface. However, both stylos were extremely sensitive to planting depth with emergence declining sharply as planting depth was increased beyond 10-15 mm (Cook, unpublished data).

Fertiliser

The wide row spacing selected for the machine design means that if fertiliser rates are considered on a per unit area basis, the fertiliser in the rows becomes highly concentrated. For example, 2.5 kg phosphorus (P)/ha is equivalent to 20 kg P (or 225 kg superphosphate)/ha in the band. When applied at this or higher rates in contact with the seed superphosphate reduced the number of Siratro, *Macroptilium atropurpureum,* seedlings that emerged by 30%. Superphosphate placed 2 cm below the seed did not affect emergence of Siratro seedlings at rates up to 10 kg P/ha. Similar results were recorded for other legumes, with shrubby stylo emergence being reduced by 48% when superphosphate was applied at 5 kg P/ha with the seed (Kerridge and Cook, unpublished data).

Implications for machine design

Much of the speargrass country amenable to pasture improvement has had the trees thinned or removed at various times since the early 1900s, either by ringbarking or poisoning. Some of the dead timber has been burned leaving the country with some logs, stumps and rocks. Conventional machinery, including direct drills, could not operate in these areas unless they were cleaned up, the cost of which could exceed that of the planting operation itself. The soils throughout the region range from loose gritty sands to hard setting sandy loams, and are highly susceptible to erosion. Any machine for these areas would therefore have to be very robust, have good trash clearance, and the ability to penetrate hard soils, while creating only minimal disturbance.

The two most important aspects band-seeding, control of plant competition and the placement of seed at a consistent shallow depth under tussock grassland, set the design constraints for the development of the machine. The fact that glyphosate is de-activated on contact with soil meant that soil disturbance and the creation of dust had to be minimised during the planting operation. Depth control also had to be maintained, even under rough operating conditions. The machine also needed to be extremely robust in order to operate in partially cleared grazing lands.

A wide range of components, based on both disc and tine furrow openers, were tested to assess their suitability and performance for seeding directly into undisturbed speargrass pastures. Double disc openers performed well where the soil was soft but they failed to penetrate hard soils. On the other hand, a narrow spear point tine penetrated both soft and hard soils consistently well. However, variation in depth of seed placement was still unacceptably high because of an inability to maintain a constant tine depth where micro-terrain varied significantly relative to the shallow depth required. Mounting the tine on a parallelogram, with depth regulated from either depth wheels located to the side and front of the tine, or from a press wheel following the tine, resulted in only a marginal improvement in performance; grass tussocks and variable micro-terrain reduced the effectiveness of the depth wheels. The most consistent shallow seed placement was obtained from a system where the seed was dropped into the disturbed furrow 15 cm behind the tine, and the seed covered with a double ribbed press wheel

Sowing depth was therefore virtually independent of tine operating depth. This system allowed for frame-based depth control, thus avoiding the complexity and cost associated with parallelogram units. It also allowed a design incorporating separate seed and fertiliser delivery tubes, thus enabling fertiliser to be drilled below, and out of contact with the seed. This design not only performed well under a range of conditions, but was also attractive in that it was relatively cheap to manufacture and maintain. A leading flat coulter was also incorporated into the design because it reduced soil disturbance by the tine-based furrow openers.

Field evaluation

A prototype three-row band-seeder (6) was built in 1987. Since then it has been tested under a wide range of environmental conditions on the gritty sandy loam soils of the South Burnett district of southern Queensland. The performance of band-seeding has been compared with surface sowing and a disc strip technique for legume establishment in 8 sowings over 4 years. A mixture of 5 tropical pasture legumes (Siratro, round leaf cassia, fine-stem stylo, shrubby stylo and lotononis, *Lotononis bainesii),* were used as test species. These species provided a range of seed sizes, seedling characteristics and growth habits. In the surface sown plots the seed mixture was broadcast into undisturbed black speargrass pasture. The disc strip treatment involved broadcasting the seed mixture onto the disturbed area following one pass of a set of offset discs, the disced area covering one-third of the plot area. The experiment was sown in both early (November-December) and mid to late (January-February) summer each year.

Legume establishment in the band-sown treatments was variable, depending on soil moisture conditions at and following planting, and on the effectiveness of the herbicide band. Since both planting depth and the separation of the seed and fertiliser relies on soil flowing into the groove behind the tine, band-seeding performed best where the surface 20 mm of soil was dry at sowing. Under these conditions, and where more than 90% of the potential competition was removed by the herbicide, legume establishment in band-sown treatments was equal to or better than legume establishment in the disc strip. Establishment of surface sown seed was either very poor or a complete failure in all sowings. Sowing legumes in rows 1.5 m apart also resulted in better legume distribution throughout the pastures than in the more widely-spaced disc strip treatment.

In a grazing experiment which investigated the early management of band-sown legumes, pasture development was similar whether the pastures were grazed from sowing, or spelled for 3, 9 or 15 months (S.J. Cook, unpublished data). Legumes in these pastures contributed 18-25% of total pasture yield 15 months after sowing, despite the fact that the summer in which the pastures were sown, and the following spring, were the fifth and fourth driest in 104 years, respectively. Cassia, fine-stem stylo and lotononis had all spread from the sown rows to the middle of the inter-row areas by seed and/or runners, 27 months after sowing. The ability to graze the pastures during the establishment phase means that the pasture is not out of production.

Economics

Preliminary economic assessments of band-seeding have shown that the treatment compares favourably with alternative establishment techniques, including cultivated seedbeds and surface sowing (4, 7). Comparative treatment costs have been established for each treatment

These show that band-seeding ($68/ha) costs about the same per treated hectare as surface sowing ($72/ha), and considerably less than a cultivated seedbed ($170/ha). Discounted cash flow analyses based on 15 year development profiles for these three treatments yielded net present values of $565/ha, $407/ha and $223/ha for cultivated seedbed, band-seeding and surface sowing respectively (4). When considerations are given to terrain suitability, reduced risk of erosion and presence of standing timber/rock outcropping, band-seeding is an attractive low-cost alternative to cultivated seedbeds. Similarly, competitive treatment costs and risk considerations associated with establishment failure of surface sowing increasingly favours band-seeding as a low cost and reliable technology.

Future outlook

We believe that band-seeding has performed above expectations in relation to legume establishment on the gritty sandy loam soils of south east Queensland, in what have been very dry years. Band-seeding may also offer a cost-effective method of improving other grazing lands when the requirement is to bolster pasture productivity through the addition of new species, rather than complete replacement of the pasture.

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