SPECIFIC DESIGN LIMITS FOR TATURA PERMANENT BEDS

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Tatura Permanent Beds (TPB) were constructed from soil which was modified so that the chemical, physical and biological properties met specific design limits. The specifications were used to develop a crop rotation and design farm equipment to create a soil which is soft, stable and permeable. Laser beams were used to create straight and graded furrows and traffic was controlled by confining compaction to the furrow. Soil tilth and porosity were improved by tillage at the Lower Plastic Limit and crop rotations. Plant roots, calcium and an organic mulch from crop residues decreased the strength and improved the stability of the soil.

Introduction

Many of our experienced farmers can produce a high yielding crops in the first year on land that has never been under crops before. But these yields are difficult to maintain year after year on the same land. After the second crop yields decline, weeds and diseases spread, forcing the grower to move to a new site (Adem *et al.*, 1984).

There is no standard spacing for wheels on tractors and equipment forcing the operator to run over the raised beds (Tisdall and Adem, 1989). Tractor traffic, inter-row cultivation and wetting of the furrow breaks down and compacts the soil. In a wet season, tillage causes pugging of the soil, which creates a cloddy seedbed when the soil dries. In a dry season, tillage produces large clods, which when broken down, create a high percentage of dust particles mixed with clods, making the soil set hard and become less porous which in turn restricts the growth of crop roots. In a soil where the structure has been degraded, the soil becomes difficult to manage and weeds become aggressive competitors with the crop.

Tillage makes the soil softer by loosening but the effect is temporary (Stirzaker and White, 1995). Wetting and drying of the soil will cause it to become harder with time. Traditional cultivation practices are thought to be a factor in declining yields but if we stop cultivation altogether the soil becomes too hard. Tillage can pulverise soil, oxidise organic matter, cut roots and fungal hyphae and destroy micro-organisms. In extreme cases, the soil is almost sterile i.e. low in useful flora and fauna which help to stabilise it.

Yields can be maximised and sustainable by integrated research on several factors which make up a management system or package (Collis-George and Lloyd, 1978; French, 1985; Hillel, 1980; Schafer *et al.*, 1985; Tisdall and Adem, 1989). The ideal levels of soil physical properties for each of the stages of seed germination, seedling emergence, movement of water and air and root growth must be defined (Adem, 1993; Hillel, 1980).

The TPB were developed with the aim of producing and maintaining the desired specification in specific zones in the soil (Tisdall and Adem, 1989). These zones were the seeding-zone, which was the soil around the seed and developing seedling, the root management-zone which was the soil containing the bulk of the crop roots, and the traffic-zone which supported the farm machinery.

The desired aggregate size in the seeding zone and root zone was produced by tillage at the Lower Plastic Limit with a rotary hoe and a spring-tined cultivator respectively.
Wheat roots and the straw mulch from the wheat stubble were used to create pores in the soil through the biological activity of roots and earth animals (Table 1).

Table 1 Pore dimensions of biological origin or significance (After Hamblin, 1985).

Mean pore diameter (μm)	Biological significance
2,000-50,000	Ant nests and channels
1,500-8,000	
500-3,500	Wormholes
2,000-11,000	
6,000	
300-10,000	Tap roots of dicotyledons
500-10,000	Nodal roots of cereals
1,000	Root plus root hair cylinder in clover
100-1,000	Seminal roots of cereals
50-100	Lateral roots of cereals
30	**Field capacity (-10 kPa)**
20-50	1st- and 2nd- order laterals
5-10	Root hairs
0.5-2	Fungal hyphae
0.2-2	Bacteria
0.2	**Permanent wilting point (-1500 kPa)**

The Tatura Permanent Beds system

The TPB were constructed to specifications, from the literature or from our own research, which described the optimum range for each property (Table 2). The aim was to modify soils so that the chemical, physical and biological properties meet these specific design limits. The specifications are not fixed nor are they a complete list but are refined and added to as more information becomes available. Where information is limited, the specified range may be broad or may only relate to a particular crop.

Table 2 Specifications for Tatura Permanent Beds

Purpose	Property	Specification
Controlled traffic	Wheel compaction	<25 %
	Directing index	<1 cm
Water management	Matric potential	-10 to -50 kPa
	Levelling index	<1 cm
	Aggregate size	>0.5 mm
Germination, emergence and root growth	Air-filled porosity	15-20 %
	Aggregate size (germination and emergence)	10-20% diameter of seed
	Aggregate size (root growth)	1-10 mm
	Bulk density (germination)	1.3 g cm^{-3} (wheat)
	Temperature	29^0 C (wheat)
Root growth	Penetrometer resistance	<1 MPa
	Bulk density	1.0-1.3 g cm^{-3}
Soil stability	Organic carbon	>2 %
	Water stable aggregation	>75 %
	Clay mechanical dispersion	<1 %

In the first autumn we used a hiller to set up the land into beds separated by a furrow. A laser receiver, mounted vertically on a mast at the centre of the toolbar, received a beam from a transmitter in the middle of the field. A second receiver mounted horizontally over the front axle of the tractor received a second beam from another transmitter at the edge of the field. In this way, laser beams controlled the depth of the hilling shovels and guided the tractor so that the levels and the direction of the furrows were accurate. The pre-irrigated beds were tilled with a spring-tined cultivator at the Lower Plastic Limit to create a high proportion of aggregates in the range of 0.5-10 mm in diameter. Cereal was drilled into the beds and furrows to stabilise and improve the porosity of the soil and to provide a grain crop. To control soil dispersion, gypsum (Ca SO_4) was spread at the rate of 5 t ha^{-1}. Immediately after the cereal was harvested, the stubble was shredded with a flail mower and the straw directed into the middle of the bed. On each bed and in the one pass, two 5 cm wide rotary hoes and two precision seeders were used to prepare a fine tilth (10-20 % the diameter of the seed) and sow a summer crop.

Benefits of Tatura Permanent Beds

* Improved trafficability.
* Crops can be grown repeatedly on the same land with a short crop rotation.
* A well-structured soil which is soft, stable and porous.
* Lower cost in land preparation.
* Less risk of poor soil conditions due to wet weather or drought.
* Less wastage and more uniform application of irrigation water.
* Decreased risk of root disease.
* Investments in land improvement and structures are optimised.
* Weeds can be managed better.
* Timeliness of sowing.
* Yields are optimised and sustained.
* Income stability through minimised fluctuations in production.

Conclusion

This paper describes a recipe based on specific design limits which combine to create a useful management system with the potential for high and sustained yields. Adoption of the specifications would give direction to and challenge many of the traditional activities which make up the preparation and maintenance of land for cropping. The approach differs from some traditional management systems which apply to a particular soil, climate, location and crop. The focus has been shifted away from the activity of farming to the end result, regardless of where the system is applied or what implements are used. This may eventually lead to a lower energy input, fewer operations, increased accuracy, more predicability and better returns from farming. More research is needed to extend and refine the list.

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