

Laser land levelling technology

for enhancing the productivity

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Water conservation is one of the biggest benefits-as a level field demands the same level throughout; if it is undulated, water would not reach everywhere and would accumulate at one particular spot giving too much water thereby damaging the crop; also prevents soil erosion. Laser land leveller is praised for its optimum utilization of water, high speed working, and reduction in weeding cost. It was estimated that around 25 to 30% of irrigation water could be saved through this technique without having any adverse effect on the crop yield. The land levelling have resulted smoother soil surface, reduction in time and water required to irrigate the field, more uniform distribution of water in the field, more uniform moisture environment for crops, more uniform germination and growth of crops, reduction in seed weight, fertilizers, chemicals and fuel used in cultivation, and improved field traffic ability.

Key words: Laser land levelling technology, Productivity



Fig.1. Laser land levelling in the field



Fig. 2. Part of laser land leveller

INDIAN agriculture is diverse and complex with land area, capable of producing most of the food and horticultural crops of the world. India has an estimated 142 Mha cultivated area of which about 57 Mha is irrigated and remained 85 Mha is rainfed. Research efforts have been made to investigate proper agronomic practices and to develop suitable machine to face the challenge of level the land to increase the agriculture field important of levelling and Indian system. The aim of levelling is to determine the

relative heights of different objects on or below the surface of the earth and to determine the undulation of the ground surface.

The advanced method to level or grade the field is to use laser-guided levelling equipment. Laser land levelling is the field levelling within certain degree of desired slope using a guided laser beam throughout the field.

What is laser land levelling?

Laser levelling requires soil to be shifted from the high points of the

field to the low points in the most cost-effective way. In most situations fields will need to be ploughed and a topographic survey undertaken before levelling commences. (Fig. 1).

Working principle of laser guided levelling

The laser-controlled system requires a laser transmitter, a laser receiver, an electrical control panel and a twin solenoid hydraulic control valve. The laser transmitter transmits a laser beam, which is intercepted by the laser receiver mounted on the levelling bucket. The control panel

Table 1. Time required and suitability of different land levelling techniques

Land levelling technique	Capacity* (ha/day)	Levelling accuracy	Suitable for plot area (ha)
Animal	0.08	+/- 4-5 cm	< 0.25
Power tiller	0.12	+/- 4-5 cm	< 0.25
Blade	0.5-1.0	+/- 4-5 cm	< 0.50
Bucket	0.5-1.0	+/- 4-5 cm	> 0.10
Laser	up to 2 ha	+/- 1 cm	> 0.10

*Capacity depends on farm size and shape, crop residue, soil, type and, moisture conditions and the operator's skill.

Source: Rice-wheat consortium technical bulletin.

Table 2. Selection of tractor and scraper size

Tractor size Min/Ma × (hp)	Scraper width Min/Max (m)
30-40	1.8
40-50	2.0
50-100	2.0-3.0
100-125	3.0-3.5
125-150	3.5-4.0

mounted on the tractor interprets the signal from the receiver and opens or closes amount of soil that must be cut it may also be necessary to plosed during the levelling operation. Disc, moldboard or tine plows can be used.

Land levelling techniques

It includes different types of levelling. Some of them are discussed here.

Conventional levelling

Conventionally, farmers use plankers drawn by draft animals or by small tractors. However, farmers in Punjab, Haryana and Uttar Pradesh use iron scrappers or levelling boards connected to 4-wheel tractors. Traditional land levelling includes field survey, staking and designing the field, calculation of cuts and fills and then using a scraper and a land plan to even the land. Despite all these labour-intensive efforts, desired accuracy is not achieved. These levelling practices are crude and do not achieve a precise land levelling. Different land levelling techniques require different tools and conditions varying in operating times and accuracy. (Table 1).



Fig. 3. Laser Transmitter

Laser land levelling

Laser levelling is a process of smoothing the land surface (± 2 cm) from its average elevation using laser equipped drag buckets to achieve precision in land levelling. Precision land levelling involves altering the fields in such a way as to create a constant slope of 0 to 0.2%. This practice makes use of 40 to 50 horsepower (hp) tractors and soil scraper that are equipped with laser-guided instrumentation so that the soil can be moved either by cutting or filling to create the desired slope/level. (Fig.2)

Component of laser leveller

Drag bucket: The levelling bucket is designed to attach 3-point linkage semi mounted pulled by the tractors drawbar. Pull type systems are preferred as it is easier to connect the tractors hydraulic system to an external hydraulic ram than connect to the internal control system used by the 3-piont-linkage system. Bucket dimensions and capacity will vary according to the available power source and field conditions. A 40 hp tractor will pull a 2 m wide $\times$ 1 m deep bucket in most soil types. The design specifications for the bucket should match the available power from the tractor. Typical specifications as per hp of tractor are given in (Table 2).

Laser transmitter: The laser transmitter mounts on a tripod which allows the laser beam to sweep above the tractor unobstructed about 100 m circle. With the plane of light above the field, several tractors can work from one transmitter. (Fig.3)

Laser receiver: The laser receiver is an omni-directional receiver that detects the position of the laser reference plane and transmits these

signals to the control box. The receiver mounts on a manual or electric mast attached to the drag bucket. (Fig.4)

Control panel: The control box accepts and processes signals from the laser receiver on scraper mounted. It displays these signals to indicate the drag bucket's position relative to the finished grade. When the control box is set to automatic, it provides electrical output for driving the hydraulic valve. The control box mounts on the tractor within easy reach of the operator. The three control box switches are On/Off, Auto/Manual, and Manual Raise/Lower, which allows the operator to manually raise or lower the drag bucket (Fig. 5).

Hydraulic control system: The hydraulic system of the tractor is used to supply oil to raise and lower the levelling bucket. The oil supplied by the tractor's hydraulic pump is normally delivered at 2,000-3,000psi pressure. As the hydraulic pump is a positive displacement pump and always pumping more oil than required, a pressure relief valve is needed in the system to return the excess oil to the tractor reservoir. If this relief valve is not large enough or



Fig. 4.Laser Receiver



Fig. 5. Control Panel

malfunctions, damage can be caused to the tractors hydraulic pump.

Benefits of laser land levelling

Laser levelling systems are commonly used in agricultural applications in developed countries like Australia, Japan and the United States since long time. Increasingly, laser-guided systems are being used in developing countries like India, Pakistan, Bangladesh etc. The benefits over other land levelling methods include: conserves water by up to 40%; increase in field areas about 3.5%; enhances water retention and storage; increases productivity by up to 35 %; save fuel, electricity used in irrigation; reduces fertilizer run-off; uniform water distribution and helps in weed control; more level and smooth soil surface; reduction in time and water required to irrigate the field; more uniform distribution of water in the field; more uniform moisture environment for crops; more uniform germination and growth of crops; reduction in seeds, fertilizer, chemicals and fuel used in cultural operations; protect top-soil erosion by rainfall and water runoff due to maintaining uniform slope; and improved field traffic ability (for subsequent operations).

Weed control: Land levelling increases yield. A large part of this



Fig. 6. Weed control after laser land levelling

increase is due to improved weed control. Improved water coverage from better land levelling reduces weeds by up to 40%. This reduction in weeds results in less time for crop weeding. A reduction from 21 to 5 labor days/ ha is achieved. This represents a reduction of up to 16 person-days/ha a 75% decrease in the labour required for weeding (Fig. 6).

Farm operation: Land levelling makes possible the use of larger fields that increase the farming area and improve operational efficiency. It increases the farm area about 2 to 5% due to reduction of bund and channels etc. This increase in farming area gives the farmer the option to reshape the farming area that can reduce operating times by 10% to 15% (Fig. 7).

Seeding practices: Levelling reduces the time taken for planting, for transplanting. Land levelling provides greater opportunity to use direct seeding. The possible reduction in labour by changing from transplanting to direct seeding is approximately 30 person-days / ha. (Fig.8)

Efficiency of water use: Rice farmers using animal or 2-wheel tractors rely on water to accumulate in the field before starting land preparation. The average difference in height between the highest and lowest portions of rice fields in Asia is 160 mm. This means that in an unlevelled field an extra 80 to 100 mm of water must be stored in the field to give complete water coverage. This is nearly an extra 10% of the total water requirement to grow the crop. Land levelling effectively terraces fields allowing water in the higher fields to be used in the lower fields for land preparation, plant establishment and irrigation. (Fig. 9)



Fig. 7. Uniform water standing in levelled field Operation

Procedure of laser levelling

1. Survey the field and determine the average cut depth of soil.
2. Set the average elevation value of the field in the control box.
3. The laser-controlled bucket should be positioned at a point that represents the mean height of the field.
4. The cutting blade should be set slightly above ground level (1.0 to 2.0 cm).
5. The tractor should then be driven in a circular direction from the high areas to the lower areas in the field.
6. To maximize working efficiency, as soon as the bucket is near filled with soil the operator should turn and drive towards the lower area. Similarly as soon as the bucket is near empty the tractor should be turned and driven back to the higher areas.
7. When the whole field has been covered in the circular manner, the tractor and bucket should then do a final levelling pass in long runs from the high end of the field to the lower end.
8. The field should then be re-surveyed to make sure that the desired level of precision was attained.

Operating principle and characteristics of laser levelling

Laser land levelling system



Fig. 9. Efficiency of water use after levelling



Fig. 8. Seeding practice in levelled field

includes three parts: laser transmitter and receiver, control system, and scraper. The scraper is mounted on rear wheels, which could automatically up and down according to the height of ground. The scraper goes up and down through the telescopic oil- cylinder. The cylinder is installed between the rear axle and scraper. In the process of moving forward, when ground is higher, the oil cylinder will be shortened to make the scraper down then scraper blade cut soil there and goes forward with the soil. When the ground is lower, the oil cylinder will be extended to make scraper up, and then the soil in the scraper will be filled here. During the land levelling, soil in the higher places will be scraped to flatten the lower places to complete the land levelling. (Fig. 10)

Determine the theoretical time to level a field

The length of time taken to level the field can be calculated by knowing the average depth of cut from the cut/fill map, the dimensions of the field, the volume of soil that can be moved by the bucket and the tractor operating speed.

Example	
Field dimensions	= 100 m×50 m,
Average depth soil to be cut	= 25 cm,
Levelling bucket dimensions	= 2m × 1m × 1m
Bucket fill	= 50%
Tractor speed (average of when the bucket is full and empty)	= 8 km/hr.
Volume of soil to be moved [Field area/2 × average depth cut (m)]	= $100 \times 50 / 2 \times 0.25 = 625 \text{ m}^3$
Volume soil in bucket (m ³)	= $2 \times 1 \times 1 \times 0.5 = 1 \text{ m}^3$
Number of trips required (full and empty)	= $625 / 1 \times 2 = 1,250$ trips
Average trip length (50% of field)	= 100/2 m = 50 m
Total distance travelled (m)	= $1,250 \times 50 \text{ m} = 62,500 \text{ m}$
Time (hr)	= $62,500 / 8 = 7,777.78$
Distance (m)/speed (km/hr)/1000	= 1,000
	= 7.77 hr

Therefore approximately 8 hr is required to level this field. This is a theoretical time and will vary

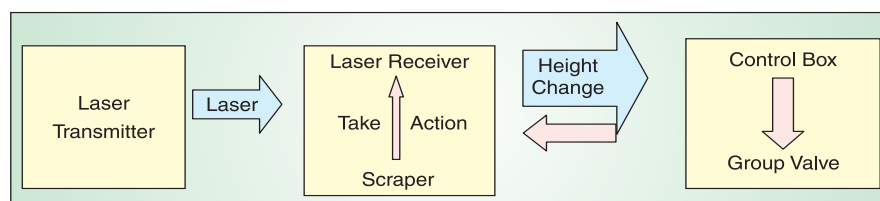


Fig. 10. System Configuration

according to the skill of the operator, the soil type and operating conditions.

Checking and calibrating

The laser transmitter should be periodically checked for accuracy. Most laser transmitters have two horizontal level adjustment screws that allow minor adjustments to be made along the two axes of the horizontal plane. The axes are usually labeled 'X' and 'Y'. All checking and calibration procedures are done at the zero slope reading. The following items are required to check the accuracy of the transmitter.

1. A suitable tripod that allows you to rotate the transmitter in 90° increments.
2. A minimum 65 m range that is unobstructed and as close to flat as possible.

Environmental benefits of laser land levelling

Laser land levelling can certainly minimize yield variability at farm level, optimize input output relation and save resources like soil, water and energy. If adopted on a large-scale, the laser levelling would help in improving the quantity and quality of ground water because of improved water productivity and less accumulation and deep percolation of water-soluble pesticides and chemicals, especially nitrate. It is estimated that adoption of precision land levelling system to just two million hectare of area under rice-wheat system could save 1.5 million hectare-meter of irrigation water and improve crop yields.

The limitations include the followings

- High cost of the equipment/laser instrument.
- Need for skilled operator to set/adjust laser settings and operate the tractor.

- More efficient for regularly sized and shaped field

SUMMARY

Laser levelling of agricultural land is a recent resource-conservation technology. It has the potential to change the way food is produced by enhancing resource-use efficiency of critical inputs without any disturbing and harmful effects on the productive resilience of the ecosystem. In spite of several direct and indirect benefits derived from laser land levelling technology, it is yet to become a popular farming practice in the developing and the underdeveloped countries. For accelerating its popularization and large-scale adoption, it requires a number of well-considered and synchronized research, extension, participatory, economic and policy initiatives keeping in view the long-term sustainability of our production systems. Popularization of this technology among farmers in a participatory mode on a comprehensive scale, therefore, needs appropriately focused attention on priority basis along with requisite support from researchers and planners. The change in our vision of future agriculture in relation to food and nutritional security, environmental safety and globalization of markets demands improving resource-use efficiency considerably to reach the desired growth levels in food production and agricultural productivity. Laser levelling is evidently one of the ways by which we can address these issues to a great extent.

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