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Development of an animal-drawn, inclined-roller crust breaker

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ABSTRACT

An animal-drawn, inclined-roller crust breaker was designed, developed and evaluated in the Alfisol field. It completely breaks the soil crust, causes negligible injury to seedlings, and promotes emergence of pearlmillet [*Pennisetum typhoides* (Burm.f.) Stapf & C. E. Hubb., syn. *P. americanum* (Linn.) Leeke] and sorghum [*Sorghum bicolor* (Linn.) Moench] to the level expected in the absence of crusting. It covers a 1 m wide strip, and its average field capacity is 0.35 ha/hr. The design is simple and it can be made locally.

Poor emergence of seedlings because of soil crusting reduces plant density and prevents the establishment of a uniform plant stand under a wide range of soil and climatic conditions. Awadhwal and Thierstein (1985) reviewed the problem of crusting and its impact on crop establishment. To ensure proper emergence, even when crusts have formed, the soil surface should either be frequently wetted or mechanically broken. Breaking the crust with hand-tools such as sickle is excessively tedious and requires as much as 200 man-hr/ha. In the past, rotary hoes, finger-type weeders and tooth harrows have been tried as crust breakers. These implements tend to remove soil and may seriously damage the seedlings. A cultipacker crushes the surface and breaks the soil crust, but it also injures seedlings (Kemper and Miller, 1974). A wooden roller, with spikes projecting 60 mm above its surface, that punches holes in the crust to facilitate seedling emergence, could be useful but there is lack of quantitative information about its effectiveness and injury caused to the seedlings (UAS, Bangalore, 1984).

Awadhwal and Thierstein (1983) developed an implement that broke soil crusts over rows of germinated seeds to improve seedling emergence. It consisted of 2 spiked rollers placed in a tandem arrangement in a frame, with their axles perpendicular to the direction of travel. This tandem-roller crust breaker covered a 15 cm wide strip and effectively broke crusts without injuring the emerging seedlings. It is easy to use as a manually operated single-row implement. However to use it as a multi-row implement it is necessary to attach the required number of crust-breaker units to a wheeled tool carrier or a tractor. Moreover, the working width of a tandem-roller crust breaker is equal to only 1 roller width, though each unit employs 2 rollers. To overcome these limitations, and to achieve a wider coverage in a single pass, an animal-drawn implement was designed, developed and evaluated in field at the ICRISAT centre, Hyderabad. In this paper the design and performance of the inclined-roller crust breaker are described.

MATERIALS AND METHODS

Design criteria

The tip of a nail fixed on a roller follows a cycloidal path and staves a cavity into the soil surface when the roller moves freely on a flat soil surface with its axis perpendicular to the direction of

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travel. The inter-row spacing that provides continuity between the cavities produced by spikes in successive rows is a function of the roller radius and spike length. It can be calculated by an equation reported by Awadhwal and Thierstein (1983). The design of the tandem-roller crust breaker (Awadhwal and Thierstein, 1983) was based on this principle. However, it required 2 rollers in tandem because a single roller could not effectively break crusts.

If the angle between the axes of the spiked roller and the direction of travel deviates from 90°, the plane of spike rotation no longer coincides with the direction of travel and the spikes exert an additional shear force on the soil, that results in a better break-up of the soil crust. This concept was studied with spiked rollers. The roller axes were inclined at angles 0–15° from the perpendicular to the direction of travel. At 0° the spikes merely punched holes, whereas at and beyond 15° the roller stopped rolling. A complete break-up of the soil crust without any apparent injury to the seedlings was achieved with a single roller when its axis was inclined to 5–10°. It provided the basis for the design of the inclined-roller crust breaker.

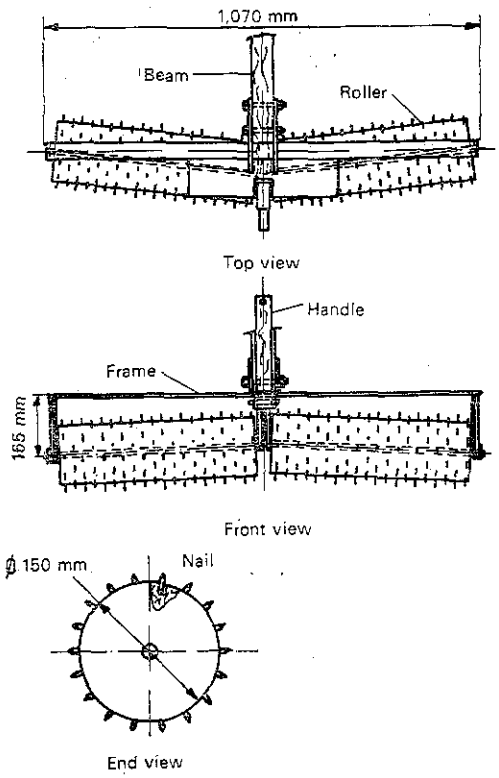

Fig. 1. Animal-drawn inclined-roller crust breaker

Construction

The inclined-roller crust breaker consists of 2 wooden rollers, each 500 mm long and 150 mm in diameter (Fig. 1). Nails are fixed on to the rollers, projecting 25 mm above the surface, in rows 25 mm apart running along the roller axis. The rollers are arranged side by side in a U-frame made of mild-steel flats, such that their axles make a 170° included angle at the centre of the frame. The axle of each roller is inclined at an angle of 5° from the perpendicular to the direction of travel. This arrangement permits a coverage almost equal to the combined length of the 2 rollers. It also counterbalances the side forces arising from the inclination of the rollers. The axle housings are 20 mm shorter at the centre of the frame than at the outer ends, so that the entire length of the rollers comes in contact with the soil surface when the implement is brought in operating position by raising its beam to an angle of about 30° with the horizontal. It can be pulled by a pair of oxen, either as an independent unit (Fig. 2, *top*) or as an attachment to an indigenous blade harrow (*bakhar*) or a plank (Fig. 2, *bottom*). It covers a 1 m wide strip, and its average actual field capacity is 0.35 ha/hr. It weighs about 50 kg (without beam) and costs about Rs 250.

Performance

The ability of the inclined-roller crust breaker to enhance the emergence of pearlmillet [*Pennisetum typhoides* (Burm. f.) Stapf & C.E. Hubb., syn. *P. americanum* (Linn.) Leeke] and sorghum [*Sorghum bicolor* (Linn.) Moench] was evaluated.

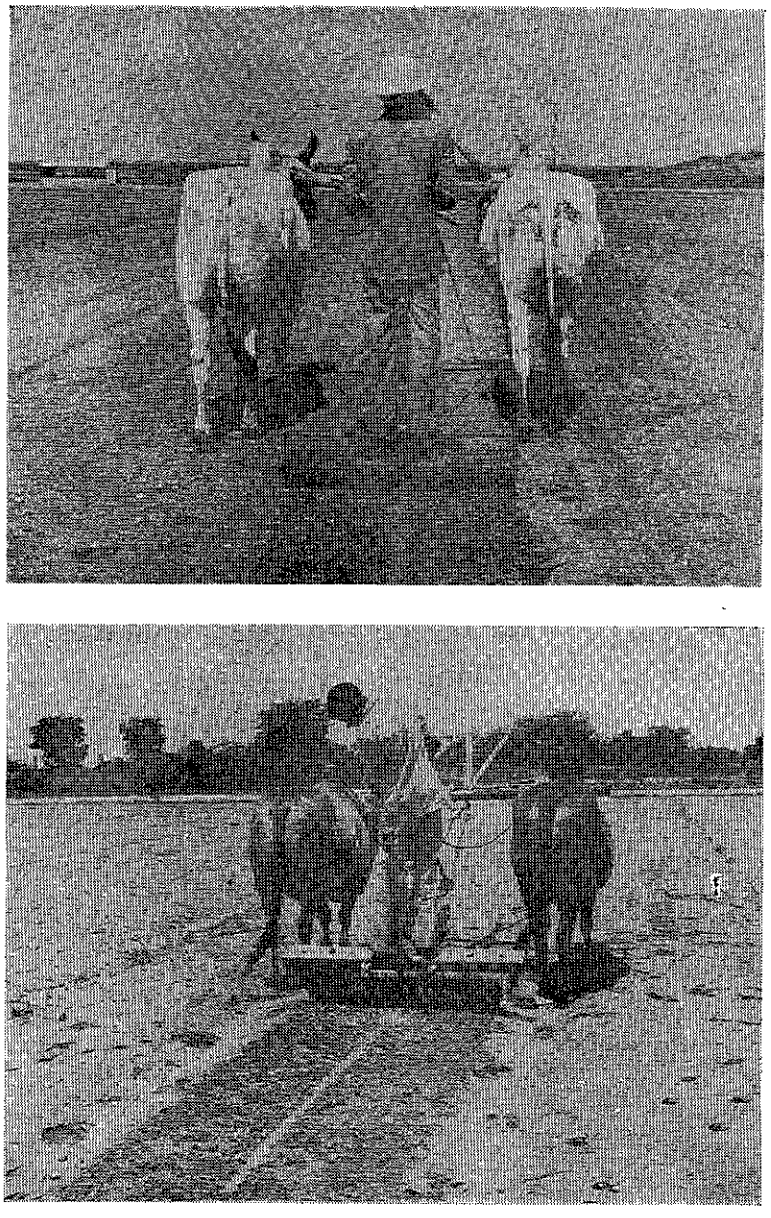

Fig. 2. Inclined-roller crust breaker, independent unit (*top*) and inclined-roller crust breaker, attached to a plank (*bottom*)

A trial was conducted in an Alfisol field with sandy-loam soil in the summer of 1986 and was repeated in the rainy season. Both the trials were conducted in randomized block design with 4 replications. The treatments were unbroken