Jour. Agric. Physics, Vol. 1, No. 1, pp. 76-79 (2001)

Clod Formation - A Serious Problem for Wheat Cultivation in Rice Wheat Cropping Sequence

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ABSTRACT

Rice soils when dry are difficult to till. When tilled, they break into hard different-sized clods, having high breaking strength. The cloddy soil tilth is unfavourable for wheat crop. It affects wheat emergence due to poor seed-soil contact. A simple apparatus, using proctore penetrometer, was developed and tested to determine the clod breaking strength (CBS). The CBS of 9 typically rice-growing areas in mid-hills, sub-humid zone of HimachalPradesh was determined. It varied between 168 and 691 kPa. The CBS increased linearly with clay content, and decreased exponentially with water content of soil clods. Results from a long-term field experiment revealed that addition of lantana (*Lantana camara*) @ 10, 20 and 30 t/ha (fresh wt. basis) annually for 6 years significantly affected cracking pattern and clod formation in soil under rice-wheat cropping. Cracking pattern changed from wide, deep cracks in hexagonal pattern to close-spaced net-work of fine cracks. Total volume of cracks per unit area was 44, 36 and 31% of control with 10, 20 and 30 t lantana/ha, respectively. The lantana additions increased the proportion of smaller clods with lower bulk density. The CBS decresed from 419.9 kPa in control to 215.6 kPa with 30 t lantana/ha. There was significant reduction in the energy requirement to plough the land from 5.4 GJ/ha in control to 3.4 GJ/ha in 30 t lantana/ha treated plot. The farmers may take up treatment of rice soils with different locally available waste organic residues to alleviate problems of clod formation. Different strategies to tackle the problem of clod formation in rice soils are also discussed.

Introduction

Poor soil tilth has largely been recognized as a major soil physical constraint to wheat cultivation after wetland rice. Soil tilth, however, is a broad term. The Soil Science Society of America defines soil tilth as "the physical condition of soil as related to its ease of tillage, fitness as a seedbed, and its impedance to seedling emergence and root penetration." According to this definition, soil tilth includes mechanical and structural properties of both, plough and subsoil, which serve as seed and rootbed, respectively. Karlen *et al.* (1990) reviewed in detail various perceptions about "soil tilth". They concluded that "soil tilth" was a multifaceted concept that was difficult to quantify. It is essential, therefore, to become specialized by studying individual components that ultimately determine soil tilth. Cloddiness of seedbed is an important soil-tilth parameter.

Soil clod refers to a natural lump of soil that exists as an isolated entity in the field. Some workers define soil clod as a natural lump of soil carefully dugout so that its shape is not altered in the process. Clods are formed possibly by two mechanisms; one, by coating of soil lumps with deflocculated clay paste, and two, due to soil compaction. The number, size-distribution and breaking strength of soil clods are closely related to clay content, bulk density and cracking pattern of soil, soil-water content at the time of tillage, and tillage implements (Kutsuma *et al.* 1974; Sinmura *et al.* 1974; Campbell, 1979).

Clod formation is a serious problem in rice soils. Tillage of a compacted soil results in greater cloddiness than of an uncompacted soil (Johnson *et al.*, 1979). Puddling causes compaction in rice soils. Thus, clod formation is directly related to the puddling intensity (Takashi *et al.*, 1986). Rice soils have massive structure, with as high as 100% elimination of macro-pores (Sharma and De Datta, 1986). Upon drying, puddled soils usually shrink in volume, develop surface fissures, become compact and hard, and are difficult to till. Their draft-power requirement is high. Sometimes the draft requirement is so high that it becomes impossible to till these soils with the countryside, animal-drawn ploughs or even with small tractors. When tilled, these soils break into hard and massive clods of varying sizes and shapes, having high breaking strength. To crush these clods into fine tilth is a labour, time and energy intensive process. The cloddy soil is unfavourable for wheat crop. It affects wheat emergence due to poor seed soil contact. In one study in Thailand, emergence of wheat and maize was positively correlated with soil clods of size < 2 cm (Takashi *et al.*, 1986).

Strategies to tackle problem of clod Formation

*a. **Tilling soil at optimum moisture content*** : If a soil is tilled when too wet or too dry clods are formed. So tillage operations are to be performed at a moisture content when the soil is in friable range. The relationship between soil friability and moisture content depends largely on the soil mechanical properties, i.e. the plastic index (Kutsuma *et al.*, 1974; Campbell, 1979). In some soils, a gravimetric moisture content around 0.9 times the plastic limit provides the maximum friability (Utomo and Dexter, 1981). Puddled soils, in general, have narrow friability range. It may be difficult for the farmers to know this moisture range. Even if they know it, they may be busy elsewhere in other farm operations, and not bale to till the land at appropriate time.

*b. **Enhancing soil friability*** : Soil friability is directly related to the organic matter content of soil. Organic matter makes soil porous with low bulk density, and helps in the fast regeneration of structure of puddled soils (Sharma and De Datta, 1986). Regular additions of large quantities of organic residues are needed to increase and maintain organic matter content of soils. The real challenge, however, is to generate organic residues for soil amendment.

Addition of calcium compounds to soil has also been reported to decrease clod breaking strength (Grant *et al.*, 1992).

*c. **Adopting less intensive tillage system in rice*** : Decreasing the intensity and/or frequency of puddling in rice wherever possible is advocated. In many situations, rice can be grown successfully even without pudling or intensive tillage (Sharma and De Datta, 1986). Such soil conditions need to be identified.

d. Developing suitable tillage tools : The design of tillage implements strongly influences clod formation. Rotary and disc harrows produce relatively fine seedbed. Reduction in the ground pressure of machines minimizes clod formation. Reduction in traffic over the land through elimination or combination of certain tillage operations, and by the use of power rather than draft implements minimize clod problem.

Once the clods are formed, they need to be efficiently broken into fine tilth. Energy efficient implements need to be developed for this purpose. Some work was initiated at HPKV, Palampur, along these lines. Animal drawn, V-shaped, wooden plank with nails at regular intervals was developed to break soil clods, and was tested at few sites in farmers fields. It was quite efficient in breaking soil clods (Er. R.K. Dohru, personal communication).

*e. **Use of conservation tillage for wheat following rice*** : Post-rice tillage and establishment of wheat have been studied by various workers. Many findings are necessarily soil and site specific, but some generalizations seem possible. Direct drilling of wheat without post-rice tillage has been found feasible in some areas in north-western India, Bangladesh, Nepal, Japan and Pakistan. The use of conservation tillage, if successful, would eliminate the problem of clod formation.

In this paper, the discussion is centred on the second strategy.

Evaluation of clod breaking strength

Clod breaking strength may be defined as the energy required to break the clods into fine tilth. In simple words, it refers to the friability of soil/clods. Some idea about soil/clod friability may be obtained by crumbling soil in hand, but it is a qualitative approach. Quantitative measurements are needed to compute energy requirements to prepare seed-beds.

Different methods have been used from time to time to measure the breaking strength of soil clod; viz. Drop-shatter technique, small torsional shear box technique, pushing mechanically a dome shaped plunger into clods while the clod rested on a spring balance to register the load etc. (Sharma and Bhagat, 1993). However, most of these methods entail use of rather expensive loading frames, load rings and balances or are laborious, time consuming and less precise. A need is felt to develop a simple and reliable apparatus for measuring clod breaking strength.

Extent of problem in Himachal Pradesh and findings of experimental results

About 80 thousand ha area in Himachal Pradesh is planted to rice-wheat cropping. About 95% of the rice area is wet tilled. Nearly 85% of the rice area is put to wheat cultivation. The productivity of wheat for over last two decades has been fluctuating between 7.0 and 11.8 g/ha (Thakur *et al.*, 1994). Poor soil tilth, low soil fertility and inadequate use of chemical fertilizers have been identified as the major constraints in realizing optimum wheat yields after rice.

Very few studies have been made with respect to tilth of rice soils in HP (Chenkual and Acharya, 1990). Some experimental data are presented here.

Experimental

Studies were undertaken at Himachal Pradesh Krishi Vishvavidyalaya, Palampur, on some aspects of clod formation in rice soils in mid-hills, sub-humid zone of HP (1500-3000 mm rainfall; 651-1800 m elevation). A simple apparatus was developed and tested to measure the clod breaking strength (CBS). Soil clods were collected after rice harvest at nine typical rice-growing locations to determine CBS. The relationships among CBS, clay and water content of clods were computed.

A long-term field experiment was established in kharif, 1986, to investigate the effects of regular additions of organic residues on physical properties of soil under rice-wheat cropping. Soil texture was silty clay loam (30% clay, 54% silt and 16% sand). *Lantana camara* biomass @ 10, 20 and 30 t/ha (fresh wt. basis) was added annually to soil before puddling. Among various soil physical properties, cracking behaviour of surface soil, bulk density and CBS, and draft-power requirement were determined. The results obtained at the end of sixth rice crop are summarized below.

(i) CBS measuring apparatus : A simple low cost apparatus was developed for measuring the clod breaking strength (Sharma and Bhagat, 1993). The apparartus uses proctor penetrometer and a screw jack for the rapid empirical assessment of CBS. The penetrometer is fixed in a metal frame and the clod is raised slowly under the tip of the penetrometer with the help of screw jack until the clod breaks. The penetrometer records the value of CBS. Repeatability of results with this apparatus is very high, coefficient of variation is small.

(ii) CBS of rice soils : The CBS values for nine rice soils (loam to silty clay loam in texture) at air-dry moisture cotents varied between 168 and 691 kPa, with 7-16% CV (Table 1). The CBS was significantly correlated with clay and water content of clods. The CBS increased linearly with clay content, and decreased exponentially with the water content of clods. These data corroborate our day to day observations that clod formation is relatively high in fine-textured soils, and the clods are easy to break when in the moist state.

(iii) Effect of lantana on soil clods : Soil physical properties were modified with lantana addition due to significant increase in organic carbon status of soil. Organic carbon of 0-15 cm soil layer increased from 1.10% in control to 1.23, 1.30 and 1.37% with 10, 20 and 30 t lantana/ha. This increase in OC was about 11, 18 and 24% over the control, respectively.

Table 1. Clod breaking strength (CBS) at air-dry moisture content of some rice soils in mid-hills, sub-humid zone of Himachal Pradesh (Sharma and Bhagat, 1993)

S. No.	Location	CBS (kPa) Average*	CV (%)
1.	Chamota	168	16
2.	Gopalpur	202	14
3.	Samloti	261	16
4.	Banuri	265	14
5.	Chimbalhar	295	7
6.	Paraur	376	9
7.	Malan	410	7
8.	Bhadiarkhar	578	15
9.	Palampur	691	11

* average of 10 clods

(a) *Soil cracking* : Clod formation is closely related to the cracking behaviour of surface soil. The cracking pattern influences the bulk density, number, size-distribution and CBS of clods formed when the soil is tilled. Lantana additions modified the cracking pattern from wide, deep cracks in almost hexagonal pattern to a close-spaced network of fine cracks (Sharma *et al.*, 1995). Lantana additions increased < 5 mm wide cracks at the expense of 10-20 mm wide cracks; 5-10 mm wide cracks remained unchanged. Cracking depth was linearly and positively correlated with cracking width ($r = 0.987^{**}$).

Total voume of cracks per unit area declined to 44, 36 and 31% of control with 10, 20 and 30 t lantana/ha. Total surface area of cracks exposed to evaporation decreased to 59, 53 and 50% of the control.

(b) *Soil clods* : Cracking pattern significantly affected the extent and size-distribution of soil clods. As mentioned earlier, lantana additions decreased deep and wide cracks and increased the fine cracks. Consequently, larger clods decreased in favour of smaller clods. The bulk density and CBS of clods

Table 2. Effect of six annual additions of lantana biomass on bulk density and clod-breaking strength (CBS) of clods (4-6 cm size) in a silty clay loam soil (Sharma *et al.*, 1995)

Lantana (t/ha)	Bulk density (Mg/m^3)	CBS (kPa)
0	1.49	419.9
10	1.45	377.2
20	1.44	220.8
30	1.40	215.6
CD (5%)	0.03	87.0

formed in lantana-treated plots were significantly lower than in control plots (Table 2). The lantana-treated soil was more porous and friable. Measurements made at the end of third rice crop revealed that the average ploughing energy in lantana-treated plots was 3.4 GJ/ha as against 5.4 GJ/ha in control plots (Bhagat *et al.*, 1994).

Conclusions

Incorporation of waste organic residues in rice soils before transplanting was helpful in achieving soil tilth favourable for wheat. Soil became porous and friable, and clod formation decreased. Clods which were formed had relatively low breaking strength. The treatment of rice soil with lantana or any other locally available waste organic residues may be easily adopted by the rice farmers on farm scale. Organic residues having few alternative uses as fodder or fuel need to be identified.

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