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EFFECT OF SOIL CRUSTING ON SEEDLING EMERGENCE IN SORGHUM GENOTYPES*

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ABSTRACT

The effect of soil crust on seedling emergence in sorghum genotypes was studied in Aridosols at Hisar and Alfisols at Patancheru. Although both soils were susceptible to surface crusting, the latter was also prone to soil hardening on drying. The increase in crust strength was accompanied by a decrease in soil moisture and an increase in soil temperature in the seed zone. Significant genetic variability was found in the ability of sorghum lines to emerge through the crust in the two soil types. Some promising genotypes with higher emergence through crust have been identified.

Soil crusting and hardening are major problems in the semi-arid tropics particularly when light showers are followed by rapid drying after sowing. The sequence of events leading to crusting (Richards, 1953; Parker and Taylor, 1965) and the influence of crust in reducing seedling emergence in different crops are well documented (Hanks and Thorpe, 1957; Taylor, 1962; Ellis, 1967).

The genetic improvement in emergence ability of seedlings through soil crust alongwith improved agronomic practices to reduce crust strength should improve crop establishment in soils prone to crusting. In this paper, the emergence of sorghum genotypes under crust conditions in the Aridosols at Hisar has been compared with that in the Alfisols at Patancheru. The main objective was to establish whether genetic variability exists and to identify genotypes which emerge well through soil crusts in both the soil types.

MATERIAL AND METHODS

The three experiments conducted at HAU research farm, Hisar and ICRISAT centre, Patancheru are described below. The soil characteristics of the two sites are given in Table 1.

Experiment 1 (Aridosols, Hisar)

The field was irrigated, disc harrowed and levelled. The sorghum lines were sown on 7th March, 1981 in a split-plot design with three replications. One seed per hill was sown with the help of a wooden dibbler. Thirty seeds of each

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TABLE 1
Physical and chemical characteristics of soil at HAU, Hisar (Aridosols) and ICRISAT, Patancheru (Alfisols)

Characters	Hisar	Patancheru
Colour	Yellowish brown on surface to brown in lower layers	Yellowish red on surface and dark red in lower layers
Texture	Sandy loam on surface to loam in lower layers, calcareous in nature	Sandy clay on surface to clay in lower layers
Bulk density*	1.52 to 1.62 g/cm^3	1.5–1.7 g/cm^3
Hydraulic conductivity*	0.17 to 1.20 cm/h	Not measured
Organic matter	Low	High
Taxonomy (USDA system)	Fine loamy, calcareous, mixed hyperthermic Camborthids	Fine, clayey mixed hyperthermic family of Udic Rhodustalf

*0–100 cm soil depth.

genotype were sown 100 mm apart in a row in single 200 mm spaced row plots. The main treatment comprised crusted and uncrusted plots. The crust was simulated by uniform application of 6 mm water by a garden sprinkler, held one metre above the ground, four hours after sowing. The uncrusted treatment did not receive sprinkler irrigation.

Experiment 2 (Alfisols, Patancheru)

The Alfisol was ploughed to a fine tilth with a rotovator and levelled. The sorghum lines were sown in a randomized block design, with three replications, on 8th April, 1981. Thirty seeds of each genotype were sown in a row in 3-row plots. Seeds were spaced 70 mm and rows 300 mm. Irrigation (40 mm) was applied after sowing using a fine spray. Due to a gradient in irrigation along the length of the irrigation pipes, the replications were laid at right angles to the pipes.

Experiment 3 (Alfisols, Patancheru)

Beds of 700 × 1600 mm were constructed by building low brick containers with 200 mm edges. The soil was separated from the bricks by PVC film to minimize edge-moisture effects but was in contact with the soil surface for allowing free and even drainage after watering. The soil was brought to field capacity (18 % soil moisture) by applying the equivalent of 40 mm of water to each container. The sorghum lines were sown on 13th April 1981 in an augmented randomized block design with three replications. Eighteen test lines together with two checks were sown in each brick container. Forty seeds were sown in single-row plots. Four hours after sowing, 6 mm of water was sprinkled from one metre above the ground to simulate crust formation.

In all the experiments, the same 100 genotypes alongwith two checks were used. The germination percentages of the lines tested were above 90. Seeds were sown at 40 mm depth. Soil temperature was recorded daily at 1400 h (when near maximum) with thermocouples inserted at 5, 50 and 100 mm depths. Crust strength was measured with a pocket penetrometer (Soil Test Inc, USA) upto 50 mm depth. Soil samples were collected with a sampling tube for gravimetric determination of soil moisture. Emergence counts were recorded daily at 1000 h and continued till constant emergence was attained.

RESULTS AND DISCUSSION

In Expt. 1, the penetration resistance was 1.4 and less than 0.2 kg/cm^2 on the day of seedling emergence in crusted and uncrusted plots, respectively. The soil moisture at 0-100 mm depth was 13 and 12.8 per cent in crusted and uncrusted treatments, respectively. Although there was slightly higher soil moisture under crusted conditions, the seedling emergence percentage was lower than uncrusted soil (Table 2). Significant treatment X genotype interaction was found to exist ($p<0.01$) indicating genotypes behaved differently in the two treatments. Some of the lines which showed better emergence in Expt. 1, were also superior in other crust situations (Expts. 2 and 3) (e. g. IS-1072, IS-2705, IS-5642, IS-5977, IS-10022 and Nagawhite).

The crust strength in the Alfisols (Expt. 2) varied from 4 to 6 kg/cm^2 during the period of seedling emergence, whereas in the brick containers (Expt. 3) it was only 2 kg/cm^2. The higher crust strength in Alfisol could be associated with subsoil hardening in the field situation, whereas in brick container the crust was thin (2-3 mm). As expected, there was a gradual depletion of soil moisture with time, accompanied by a small increase in soil temperature. This brought about a marked increase in crust strength in the field (Fig. 1) and in the brick containers (Fig. 2). The mean percentage emergence was higher in the field than in the bricks containers at Patancheru, though the crust strength was higher in the field (Figs. 1 and 2). This might be due to the emergence of seedling through several cracks present in the field plots. Such cracks did not occur in the bricks containers.

Although the soils at the two test sites have a more or less same bulk density, other physical characteristics are quite different (Table 1). Antecedent soil moisture content (Carnes, 1934; Sharma and Agrawal, 1978), structure and texture are known to greatly influence the strength of the crust formed. Consequently, the nature of the crust was

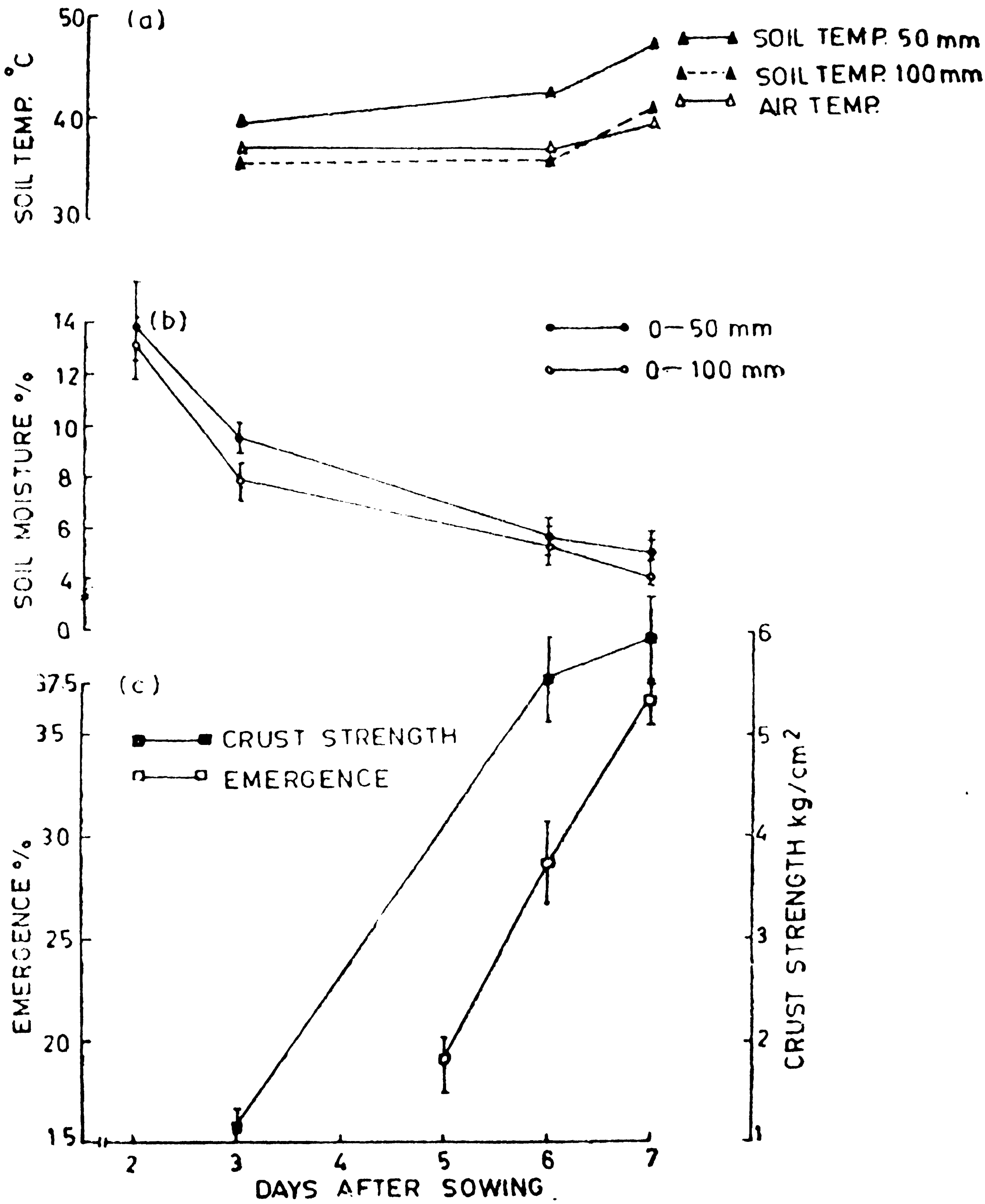

Fig. 1. (a) Soil and air temperatures
(b) Per cent soil moisture
(c) Crust strength and emergence percentage at different days after sowing in Expt. 2

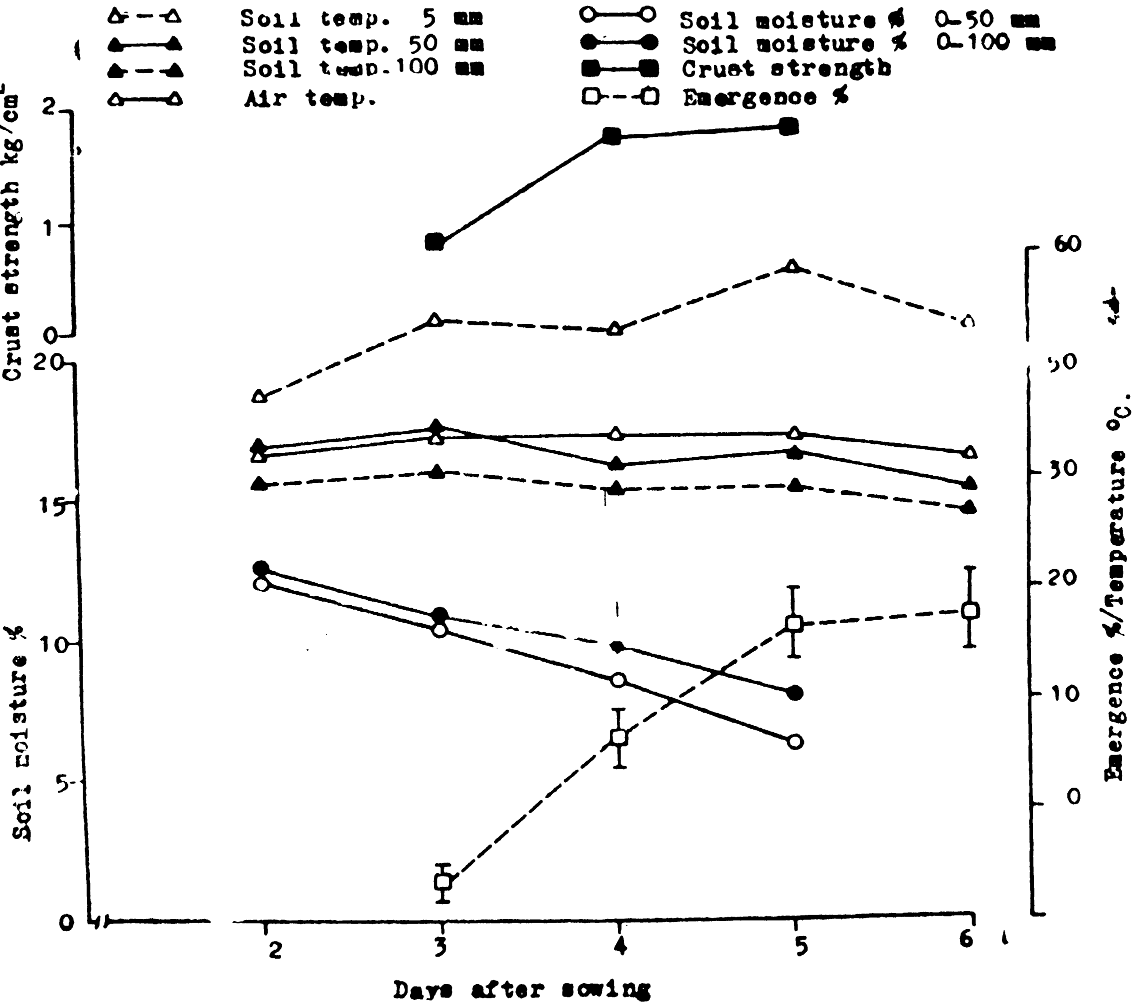

Fig. 2. Soil and air temperatures, per cent soil moisture, crust strength and emergence percentage at different days after sowing in Expt. 3.

different at the two locations. The Aridosols at Hisar were low in organic matter and susceptible to a thin layer (about 2 mm) of surface crust formation. The Alfisols at Patancheru in addition to surface crusting appeared to be prone to soil hardening during drying. The crust strength recorded by the penetrometer on the day of emergence was much higher in the Alfisols. This explains the lower emergence in the crusted Alfisols than in the Aridosols (Table 2), although the difference is very small (4%).

The percentage emergence on the first day (5 days after sowing in Expts. 2 and 3 days after sowing in Expt. 3) showed a significant positive correlation with final percentage emergence in all the experiments ($r=0.59$, 0.75 and 0.51 in Expts. 1, 2 and 3, respectively; $p<0.01$). Similarly, the final percentage emergence index showed a significant positive correlation with the emergence ($r=0.56$, 0.56 and 0.66 in Expts. 1, 2 and 3, respectively; $p<0.01$). Also the rank correlation between emergence on the

TABLE 2

Means and ranges of final seedling emergence percentage and emergence index in the three experiments

Expt. No.	Seedling emergence (%)				Emergence index (Crusted soil)	
	Crusted soil		Uncrusted soil		Mean	Range
	Mean	Range	Mean	Range		
1	40	1-66	65	11-88	50	15-58
2	36	7-68			7	3-9
3	26	1-71			11	0-15

first and final day in all experiments was significant ($r=0.70$; $p<0.01$). Thus, the emergence on the first day may give an indication of the emergence on the final day. The genotypes that emerged earlier, in general, emerged better in the crusted soils and are suited for crusted soils. Therefore, rapid emergence could be used as a pre-selection criterion for genotypes in crust situations.

Crust strength increased with time (Figs. 1 and 2). The higher emergence in genotypes which emerged earlier may be ascribed to their emergence through a weaker crust. Thus, the better emergence may be attributed to 'crust avoidance'. It is also expected that the higher rate of coleoptile growth and seed vigour could help these genotypes to emerge through crusts. This needs to be confirmed.

Some genotypes emerged well (more than 60% emergence) in all the three crust situations (Table 3). When the data from all the three experiments were pooled and analysed, it was found that genotype, experiment and genotype X experiment interaction had significant effect on percentage emergence and emergence index (Table 3). Genotypes behaved differently in different crust situations. Even after removing the early emerging lines which avoided crust, the genotypes showed significant variability in emergence through soils prone to crusting.

Although good management practices like use of mulches, chemicals and tillage as suggested by some workers (Mehta and Prihar, 1973; Chaudhary and Prihar, 1974; Agrawal and Sharma, 1980, 1984) could improve emergence under an adverse soil environment, selection of suitable genotypes with greater ability to emerge under such situations would be further advantageous. It is also important to establish the morphological and physiological characteristics of genotypes which are responsible for the large variation in emergence ability through a crust.

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TABLE 3

Mean emergence (%) of some selected genotypes showing better emergence in different soil environments and analysis of variance

Genotype	Emergence % in Alfisol field, Patancheru	Emergence % in Aridosol Hisar	Emergence % in Alfisol in brick flats, Patancheru
IS-923	87.5	82.0	63.0
CSV-5	84.5	89.5	92.5
IS-5140	78.5	70.0	73.0
IS-4667	100.0	84.0	66.0
IS-8962	84.5	80.0	66.0
IS-2314	82.0	86.5	87.5
CSH-5	82.0	100.0	92.5
IS-2482	97.5	100.0	77.5
IS-5567	75.5	64.0	77.5
GPR-148	63.0	84.0	87.5
IS-5109	97.5	62.0	92.5
IS-4664	73.5	89.5	99.5
IS-5067	91.0	95.0	96.5
IS-4663	68.0	70.0	63.0
IS-15632	100.0	99.0	96.5
M35-1	89.0	97.5	100.0

Analysis of variance of emergence percentage and emergence index (102 genotypes and 3 experiments)

Source of variation	df	F-values: % emergence final	% emergence adjusted*	Emergence index
Experiment	2	9.13**	4.41 NS	2360.45***
Replication (within experiment)	6			
Genotype	101	4.49***	3.60***	2.76***
Genotype x Experiment	202	1.54***	1.61***	1.68**
Error	606			
Total	917			

*Based on number of seeds that did not emerge on first day.
**Significant, $p<0.05$
***Significant, $p<0.01$
NS—Not significant

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