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EVALUATION OF GENOTYPIC DIFFERENCE IN SEEDLING EMERGENCE THROUGH SOIL CRUSTS UNDER FIELD CONDITIONS

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ABSTRACT

A field technique in which soil crusts are formed by sprinkler irrigating a powdered and smoothened soil surface was used to evaluate genetic variation among sorghum and pearl millet lines for emergence. The strength of the crust formed varied from 1.1 to 1.6 kg/cm2. The c/u ratio, the relative emergence of seedlings through crusted surface compared to that through non crusted surface, varied from one to zero showing availablity of significant genetic variation for emergence through a soil crust. Differences among entries were found to be repeatable over different trials and over different seed lots.

INTRODUCTION

Sorghum and pearl millet are widely grown in soils of poor physical structure, such as alfisols, which are prone to crusting. The reasons for crust formation in West African savanna soils where sorghum and pearl millet are major crops have been reviewed by Jones and Wild (1975). The effects of soil crust on crop establishment have been reviewed in general by Goyal (1982) and for sorghum and millet in particular by Soman et al (1984). For these two crops it is their small seed size (5 to 40 mg/seed) and the consequent low penetration strength or poor lifting capacity of the emerging seedlings which are responsible for the poor emergence when soil is crusted (see Taylor 1962).

It is our long term interest to select or breed genotypes of these two crops with improved ability to emerge through crusted soils. In order to do this it is necessary to have (i) variation in crop response and (ii) a reliable screening technique for identifying this variation. In this presentation we describe the use of such a screening technique (Soman et al 1984) to identify variability for ability to emerge through a crusted soil surface.

MATERIALS AND METHODS

Experimental technique

The screening technique for emergence through a soil crust was described in detail by Soman et al. (1984). It was developed at ICRISAT research center in an Alfisol field (Udic Rhodustalf, Patancheru series). The soil surface layer (0 to 100 mm) is composed mainly of coarse sand (54%) and fine sand (23%), with only 8% clay. It forms a crust naturally when rainfall is followed by drying conditions for 2 to 3 days. The trials were conducted in the dry season (February to April) because of the unpredictability of the rainfall and drying conditions during the rainy season.

The procedure consists of preparing a finely powdered seedbed, sowing, smoothing the soil surface, and then irrigating by overhead sprinkler. The crust is broken in the control plots on the day before emergence is expected; emergence from the crusted plots is then expressed as a fraction of the emergence from the control plot.

The following measurements were made routinely from the day following irrigation to the day emergence began: (1) crust strength (Soil Test model L-700 penetrometer), (2) gravimetric soil moisture content from 0-100 mm in 25 mm increments (Uhland soil sampler) and (3) soil temperature at 20 mm at 1400hrs (thermocouple probe). Ten to fifteen individual measurements of each parameter were made per replicate and mean values calculated. In addition, soil surface bulk density and soil crust thickness were also measured.

Seed material

In 1984 a selection of 139 sorghum germplasm lines from areas with a mean annual rainfall ranging from 250 to 2500 mm (Trial I) and a selection of 171 sorghum germplasm lines from areas with altitudes ranging from 75 to 2500 m (Trial II) were evaluated for emergence. In 1985 a set of 287 pearl millet germplasm lines from West Africa and North and West India (Trial III) were evaluated. In addition 27 entries selected from trial I to represent the whole range of c/u ratios (% of plants emerged in the crusted treatment as a fraction of the % emerged in the control) were retested using the same seed lot used in 1984 and a fresh seed lot produced in that year (Trial IV).

Fifty seeds were sown per 2 m row (individual plots), and replic ed three times in randomized block design. The crusted and control plots were sown on adjacent beds and c/u ratios were calculated from these adjacent plots for each replicate. Seeds of all entries in each test were produced in the same seed multiplication (except as stated for trial IV) and stored at 4 oC until used.

RESULTS AND DISCUSSION

The environment

Seedbed conditions varied between trials, because of differences in the environmental conditions and in the amounts of irrigation water applied at sowing. Data for Trials I and IV (which contained some common entries) illustrate these differences (Table 1). Air temperatures and evaporation rates were greater in Trial IV than Trial I and a lesser amount of water (20 vs 35 mm) was applied at sowing in this trial. The combination of factors resulted in lower soil moisture content in the surface and somewhat stronger crust in Trial IV. Moisture in the seed zone (25-75 mm) was 8-10% in both trials which was adequate for germination and emergence. Mean emergence for common entries in both trials (Trial IV entries), however, was similar (see below), indicating that differences in crust strength on the day of emergence were not sufficiently large to affect genoty response. The bulk density of the surface layer (0-25 mm) ranged from 1.24-1.36 g/ml. and did not differ between trials. The mean thickness of the crust was 8.3 mm.

Table 1. The crust strength, % moisture of the top soil layer, and soil temperature at 2cm, air temperature, pan E and solar radiation measured in subsequent days after sowing (DAS) till emergence

	Crust strength (kg/cm^2)				% moisture				Temperature (°C)			
DAS	Trial I		Trial IV		Trial I		Trial IV		Trial I		Trial IV	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
2	0.49	0.02	0.69	0.03	8.8	1.6	3.9	0.6	31.7	0.3	40.8	0.2
3	0.51	0.04	1.46	0.04	4.8	0.3	4.4	0.6	39.2	0.2	39.3	0.2
4	1.10	0.05	1.62	0.05	3.5	0.2	2.7	0.2	39.5	0.2	40.8	0.3

	Max. Air Temp. (°C)		Pan E (mm/day)		Solar radiation $(X\ 10^4 J\ m^{-2} day^{-1})$	
DAS	Trial I	Trial IV	Trial I	Trial IV	Trial I	Trial IV
1	26.5	34.2	5.6	7.5	1600	1932
2	27.5	34.5	5.8	7.9	1915	1898
3	30.0	35.2	7.1	8.2	1869	1777
4	31.0	34.2	6.8	8.9	1785	1873

Genotype differences in emergence

The percentage of emergence in the crusted treatments (0 to 73%) for the four trials was always less than that in the control treatment where the crust was broken (48 to 96%), the c/u ratio for individual genotypes ranged from 0.0 to 1.0. A small percentage of lines in each trial had a high c/u ratio (>0.8) but for the majority of the lines the ratio was less than 0.5 (Figs. 1a, b and c).

There were considerable differences between the three groups of materials. Entries from the altitude gradient collection (Trial II) generally performed poorly; more than 90% of the entries had a c/u ratio <0.6 (Fig. 1b). The situation was similar in the case of the millets (Trial III Fig. 1c). Entries in the rainfall gradient trial (I) however generally did much better as 44% achieved a c/u ratio of 0.6 or greater (Fig 1a). The difference between Trials I and III were expected as the

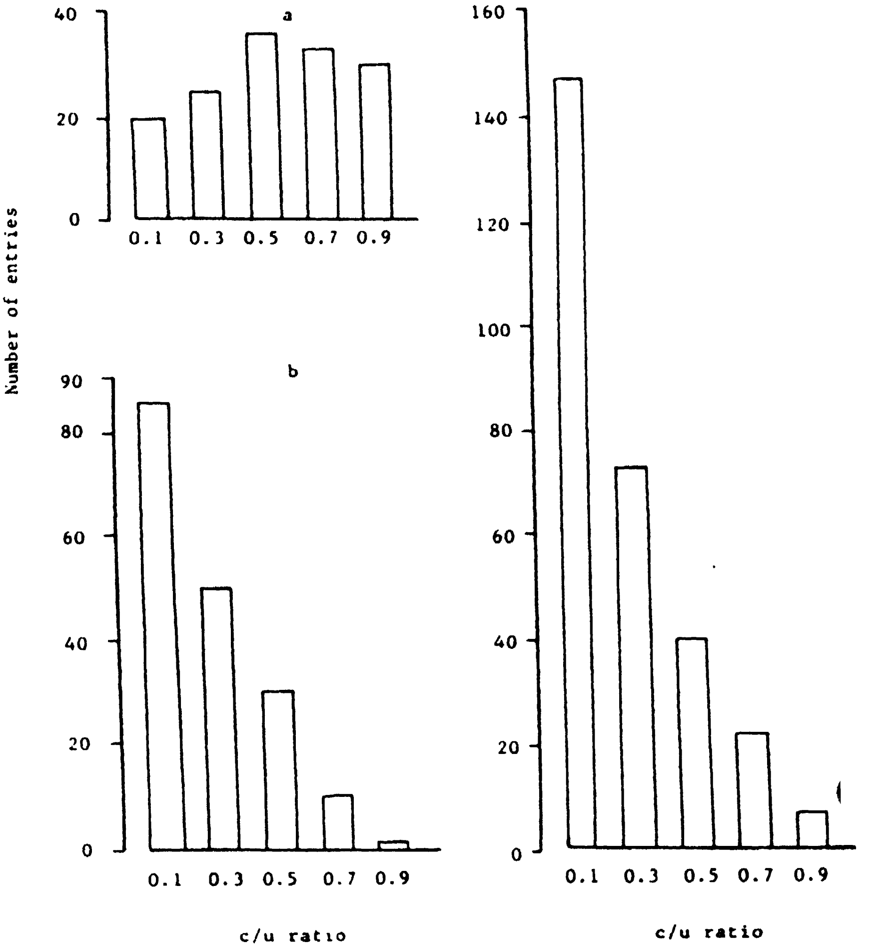

Fig. 1: Distribution of c/u ratio for entries in trials I (a)-139 entries; II (b)-171 entries and III (c)-287 entries. The c/u ratios of 0.1 to 0.9 represent classes of 0-0.20, 0.21-0.40, 0.41-0.60, 0.61-0.80 and 0.81-1.0 respectively

smaller seed of pearl millet (5-12 mg/seed) result in a smaller seedling which is more vulnerable to a soil crust than is sorghum (20-40mg/seed). Why the materials from the altitude gradient trials (II) performed poorer than that from Trial I is not known.

The finding of genetic variability for emergence through soil crust for both species is very encouraging and suggests that genotype selection for improvement in this trait may be possible. This conclusion was reinforced by the results from trial IV which tested for repeatability of difference in emergence, both over experiments and over seed lots. There were no differences on c/u ratios of the 27 selected entries either between years with the same seed lot or between different seed lots in the same year. The correlation coefficients for the entry means in two trials with the same seed lot was 0.87 compared to 0.73 for the two different seed lots in the same trial and to 0.82 for different trials with different seed lots (all coefficients significant at $P<0.001$). This repeatability of genotype performance over both years (despite the difference in conditions in the two years) and over seed lots strongly suggests that differences among lines are genetic in origin.

CONCLUSION

A technique to simulate natural soil crusting in the field was developed where seedlings were to emerge through crusted soil while soil moisture could be maintained adequate for germination and initial seedling growth. Differences for emergence through crusted soil were found among both sorghum and pearl millet entries. These differences could be repeated over trials and over seed lots for the same entries, suggesting that these differences are genetic and therefore of use in a crop improvement programme.

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