GENERAL COMMENTS

From the studies of seedling establishment, we find that there is a wide ra of variability of seedling traits in sorghum and also that there is enough scop select different resistance traits. We need to investigate whether selection of for better performance at early seedling stages is related to their performanc a later stages. The vigor and productivity of the crop may be established as e as the seedling stage. Leaf growth was found to correlate with emergence index (Allan *et al.*, 1961).

In sorghum, large seeded cultivars produced vigorous seedlings (Kaufmann Guitard, 1967) with higher yield potentials (Kaufmann and McFadden, 19 Similarly, high seed protein has also been found to show increase in seedling v in wheat and increased vigor was found to be associated with higher grain yi (Ayers *et al.*, 1976; Ching *et al.* 1977; McFadden, 1963; Ries and Everson, 19 Welch, 1977). There was small but statistically significant correlation betw seedling and adult plant characteristics in Russian wild grass. This indicated the selection in the seedling stage could also have some benefit in breeding higher yields. It has been possible to release improved cultivars based on selec for improved seedling emergence and vigor from deep planting (Lawrence, 19 This present study indicates that seed size and seed quality depend on envi mental and cultural conditions in which the cultivars are grown. This needs to taken into consideration in seed production program.

Sorghum genotypes showed a wide range of variability to different seed resistance traits, emergence from depth of planting and through soil crust, to ance to high soil surface temperature, soil moisture, and expression of seed vigor, etc. The relationship between seedling resistance and adult resistance co be correlated. Genetic variability in biochemical traits (eg. chlorophyll, carbo drate, HCN and wax content) are found to be related to drought resistan Research in this directions needs to be strengthened for genetic improvemen sorghum for drought resistance.

With the help of some simple techniques mentioned, sorghum genotypes be identified for different resistance traits. For a long time, physiologists breeders have been working together looking for a simple resistance trait incorporation in the breeding material. Identification of a simple seedling tr glossy and its relation to various resistances have been reported. Incorporat of this trait into sorghum cultivar may contribute substantially to the crop impro ment program.

APPENDIX:

TECHNIQUES TO EVALUATE DIFFERENT CROP ESTABLISHMENT TRAITS

At ICRISAT, crop establishment research was intended to study different physical and biotic factors affecting the crop at different stages of development and to develop techniques for identifying resistance sources. Some techniques developed at ICRISAT for the identification of different crop establishment traits are enumerated below and attempts were made to find out genotypic variability for different resistant traits.

1. **Seed viability**: The objective is to screen the germplasm for seed viability following wetting and drying conditions. This is a potential characteristic in an area where dry sowing is recommended.

   Methodology: The seeds are kept in petridishes lined with moist paper for 4048 hours and allowed to germinate. The germinated seeds are dried at 35 - 40°C in an incubator for two days and then kept at room temperature up to 40 days. Seeds are counted and sown in wooden flats filled with soil or in the field. Final emergence count is taken and expressed as percentage of seeds sown. Genotypes showing good emergence are recommended for dry sowing adaptation.

2. **Preharvest sprouting (germinability)**: Sorghum grains attain germinability at an early stage of grain development. Preharvest sprouting is one of the major problems in early sorghums in rainy season. Lines showing no germinability during and after maturation could aid in reducing grain weathering and improving crop quality. This was done to screen lines showing no germinability during maturation.

   Methodology: Grain samples are collected at 5 day intervals from anthesis (50% flowering), pretreated with 0.2% mercuric chloride to prevent mold infestation and tested for germination.

3. **Grain mold and grain weathering**: Grain mold is a serious problem in sorghum during the rainy season and infestation starts at an early stage of grain development. This again is associated with the problem of preharvest sprouting, thus causing grain weathering and loss of seed viability. This technique is used to screen lines with insignificant mold infestation in the laboratory.

   Methodology: Grains are collected at intervals of 5 days from the days after anthesis. One set of grains are put for germination after pretreatment with mercuric chloride for 4 days. Counts of molded grain are made and scores given for mold severity on a 1 - 5 scale (1 = no mold, 5 = severe mold). Sorghum genotypes are shown to exhibit genotypic variability in seedling emergence and seedling vigor of affected with grain mold (Maiti and Banerjee, unpublished).

4. **Depth of sowing**: The objective is to screen lines showing ability to emerge from deeper depth of planting and with long mesocotyls.

   Methodology: screening is done in wooden boxes 160 x 110 x 30 cm. Lines are sown in each box in single row plots on a layer of soil and the boxes are irrigated. The percentage emergence of the genotypes is counted. The seedlings of each line are carefully excavated by slicing vertically parallel to the rows with a thin metal sheet. The mesocotyl of each seedling is measured and the m mesocotyl length computed for each line. Sorghum genotypes can als evaluated and selected for their ability to emerge from 10 - 15 cm dep planting in polyethylene bags filled with soil. Genetic variability is foun occur among sorghum in their capability to emerge from deep planting w is associated with mesocotyl elongation (Maiti and Carrillo, 1991). A la number of sorghum lines could be evaluated for their capacity to emerge f deeper depth of planting. Lines selected could be further tested for resista to other stress factors (Carrillo, 1986).

5. **Effect of soil temperature on sorghum emergence**: This technique is use study seedling emergence in a wide range of soil temperatures. High soil surf temperature is one of the reasons for poor seedling emergence.
   Methodology: brick containers 70 x 160 cm, some 22 cm high are construc on level ground. They are filled with equal volumes of alfisol. The soi separated from the brick by PVC film to minimize edge moisture effects lies directly on the ground below, thus allowing ready and even drainage to f capacity after watering. Water (40 mm) is applied with a garden sprink When the soil reaches field capacity, the lines to be tested are sown. Tw lines can be fitted into each container across the length in one row plots. F seeds are sown at a depth of 50 mm. Metal sheets with sharp edges are u as sowing implements to slice through the soil to the correct depth. The surface is then levelled and pressed lightly with a sheet of plexiglass to prov a suitable base for the surface treatments. Thermocouples are inserted depths at which soil temperature is to be recorded. Four thermal regimes be obtained by the following surface treatments (i) fine charcoal dust (g/m²), (ii) bare soil, (iii) light kaolin (125 g/m²) and (iv) heavy kaolin (500 g/ The black charcoal absorbs light and increases soil temperature, whereas white kaolin reflects light from the soil surface and maintains a lower tempe ture compared with that of charcoal treatment. Soil temperature is recor daily by connecting the lead wire to a multichannelled electronic thermome Soil moisture is measured at 0 - 5 cm and 5 - 10 cm depths by the gravime method. Emergence counts are made daily until no further emergence occur As emergence is influenced by the initial germinability of the seeds, a laborat germination test is carried out. Emergence is expressed as a percentage of see sown and adjusted for germination percentage.

6. **Emergence through soil crust**: Soil crusting is an important problem caus poor seedling emergence in SAT areas. The objective is to screen sorghum li for emergence ability through crust. Techniques were developed both in t field and brick containers for screening genotypes for emergence ability throu simulated crust.
   Methodology: depending upon the nature of the soil, 2 techniques can experimented with in the field:
   a) For fine loamy, calcareous, mixed carbothids, typic, thermic (USDA s taxonomy) the field is irrigated to excess several days before sowing. It is th levelled by a tractormounted leveller. Seeds are sown, one seed per hill a cm depth with the help of a wooden seed dibbler. After sowing, the crust

induced by uniform application of 6 mm control (uncrusted) plots.
   b) For fine, clayey mixed hyperthermic udic Rodhustalf, the alfisol is ploughed to a fine tilth with a rotator and then levelled carefully. The seeds are sown at 4 cm depth and 40 mm perfospray irrigation applied. If a gradient in irrigation along the length of the perfos exists, the replications should be laid at right angles to the sprayers. The distance between the two perfos is maintained at 3.5 m by shifting the pipes for the second half of the irrigation time. A light roller is run over one set of plots and unrolled plots from the control. This technique gives opportunity for testing genotypes for emergence through soil crust and compaction.
   c) For brick flats= brick flats similar to those used in the soil temperature studies. They are filled with equal volumes of the fine alfisol. Water 40 mm is applied and the soil allowed to come to field capacity. Seeds are then sown at 40 mm depth using metal sheets with sharp edges to slice through the soil to the correct depth. About four hours after sowing, 60 mm water are sprinkled from 1 m above, which helpes in the lateral migration and accumulation of fine particles to form a crust.
   In all these techniques, crust strength, soil temperature and moisture are monitored daily. Emergence counts are made each day.

7. **Drought resistance at the seedling stage**: Techniques exist for field and semicontrolled conditions (in brick containers and PVC cylinders in a greenhouse). In both, limited water (40 mm) is applied after sowing, without further watering. As seedlings grow in the declining soil moisture, they slowly come under stress and began to wilt. Visual scores for wilting were given on a 5-point scale. Stress is released when most of the lines show wilting and some lines have no chance of recovery. Recovery scores on a 5point scale (1 = best recovered, 5 = least recovered) and percentage survivals are noted. Soil moisture is monitored at different depths periodically. Individual details in each technique are dealt with below.
   Methodology: sorghum lines are flat planted in an augmented random block design (RBD) with 2 checks entries repeated in each block. Controlled perfospray irrigation is given after planting. If a gradient in irrigation along the length of 'perfos' exists, the replications should be laid at right angles to the sprayers. Irrigation differences may result in high CVs. Brick containers similar to those used in the soil temperature studies can be employed and an augmented RBD used. Each flat has 20 plots, of which 16 are for test entries and 4 reserved for 2 checks which should be repeated twice in each container. There are 15 plants in each row. Portable rainout shelters can be used to protect the brick containers from rain. Container effects can be estimated as a difference between the mean of the checks within a container and their overall mean. The test entries are adjusted for the container effects. The adjusted values are then analyzed to assess for resistance or susceptibility of the test entries.
   Intervarietal competition exists in the brick containers, therefore, the genotypes can be sown separately in sealed PVC cylinders (30 cm length with an internal diameter of 10 cm) filled with equal weights (4.4 kg) of alfisol. Measured amount of water (approx. 40 mm) are applied equally to each cylinder. The

amount of water is determined from preliminary trails to get the requ wilting symptoms at the seedling stage. The plants are thinned to 6 per p day after emergence. Root growth is restricted. To prevent the sidewall o cylinder from getting heated, it could be coated with white paint.

8. **Technique for seedling drought resistance in hydroponics**: The screening seedling drought resistance is generally done in soil of flats, pots or beds greenhouse or growth chamber. When the seedlings are established, wat simply withheld until they show severe wilting. At this stage, stress is relea with water and survival counts taken. The problem with this method is th is very difficult to control the level of stress to which the plants are expo particularly with repeatability of subsequent experiments, and water extrac may differ markedly in the vicinity of individual plant roots. The techni adopted by Sullivan and Ross (1979) overcomes these defects.
Methodology: seedlings are grown hydroponically in rows of plastic dish p The seeds are first germinated in wet paper towels and then transferred or 3 days to the dish pans. An acrylic plastic tray is cut to fit the pans. T rows of holes (about 2 mm diameter) are drilled and spaced about 2 cm, a with 4 cm between rows. A countersink is made above each hole. The rad is placed in the hole when the seedling is transplanted with the seed being in the countersink area. The solutions need to be aerated for growth of ghum seedlings. When the seedling are 7 to ten days old, Carbowax 60 added to the solutions in increments over a 3 day period until a stress of 15 bars is reached. The plants are then evaluated for drought resistance a exposure to the stress for several days. For a small number of entries, the p height, leaf number, leaf area, maximum root length and dry weight are m sured and compared to nonstressed controls. When many genotypes evaluated, they are visually ranked from 1 - 5. One is assigned to green, tu plants with few, or no symptoms of drought injury. A rating of 5 is give dead plants.

9. **Visual scoring of seedling vigor**: The objective of this technique is to estim rapidly and efficiently the seedling vigor of a large number of lines. The vis scoring system used is a relative one, based on the range of variability seedling size in the material being scored. The individual 15 ratings (1 = m vigorous, 5 = the least vigorous) are based on individual plots within experiment which serves as a reference for scoring all entries. The follow factors enter into the assessment of seedling size: height, pseudostem thickn spread of leaf canopy and/or the length of breadth of the individual leaves. T restriction to a limited number of classes may be a limitation to the use visual scoring for some types of studies (e.g. parentprogeny comparisons).

4

LEAF AND STEM

LEAF MORPHOLOGY

Each sorghum leaf consists of a thin flat lamina with a definite midrib and a thicker rigid leaf sheath clasping the pseudostem internode. The midrib may be strong or weak, white or green in color. Leaves may be erect, semi-erect to drooping; the leaf blade and sheath meet at a point called collar at different angles to the stem which may vary from almost vertical to near horizontal. At the base of the lamina ligules project from the leaf base. Leaf length becomes gradually shorter and smaller towards the tip. The terminal leaf is called flag leaf. The length of leaf may be as long as 1 m and the width 10 to 15 cm. The number of leaves in well adapted genotypes vary from 14 to 17, whereas in less adapted ones there may be as many as 30 leaves.The leaves are arranged in 2 ranks alternatively at an angle along the stem and each node. The sheath is attached to the node, and surrounds the internode, and often the node above it. In some cultivars the leaf sheath is covered with a waxy bloom. Leaves are glabrouos except on the inside, just above the membranous ligule and on the cuticle near the junction with the sheath. The leaf margins are smooth or scabrid (Fig. 4.1; House, 1980).

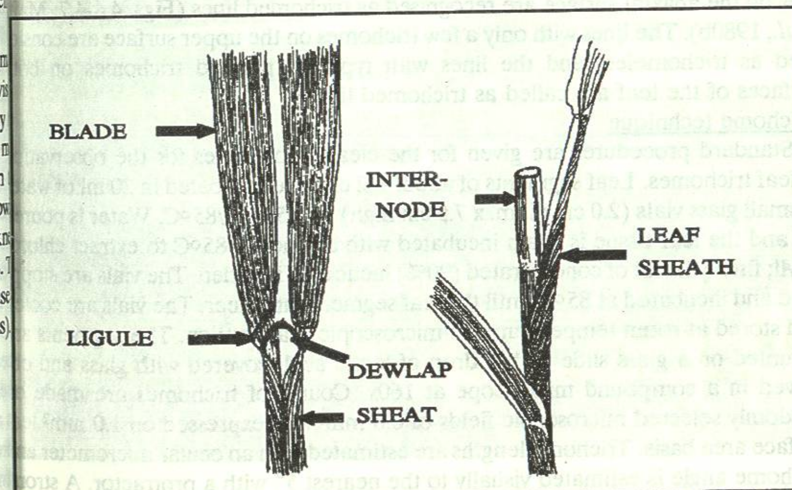

Figure 4.1 Morphology of a leaf showing its parts and its attachment with stem. a) A portion of a leaf; b) Attachment of leaf sheath with stem.