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A PRELIMINARY REPORT ON NEW SEPARATION TECHNIQUES FOR LIVE-DEAD ABOVEGROUND GRASS HERBAGE AND ROOTS FROM DRY SOIL CORES

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ABSTRACT

Separation of live from dead herbage and roots from soil can be expensive and time consuming operations. Equipment has been designed to greatly assist in each of these operations. The live-dead herbage separation operates on the principle of aerodynamic differences between live and dead herbage in an airstream. The root-soil device is a dry crusher-separator which is particularly well suited for obtaining non-washed roots for chemical analyses.

INTRODUCTION

The need for new and improved methods and techniques for IBP Grassland studies has been emphasized in various reports and publications such as Milner and Hughes (1968) and various technical reports.

This report will briefly deal with two new techniques that have been developed at the IBP Pawnee Site during the 1971 growing season. Both methods seem to be much better than the ones previously employed in terms of efficiency and man hours.

This applicability to other grassland sites (where growth form and soils are different from those of Pawnee) remain to be investigated. The instruments are currently in a prototype stage and various smaller changes and alterations are envisaged to facilitate operation.

THE LIVE-DEAD HERBAGE SEPARATOR (VAN WYK TOWER)

Hand separation of the live-dead aboveground grass herbage from clip plots is not only slow and tedious, but also a very costly undertaking. Dr. J. K. Lewis estimated that separation of a sample from the Cottonwood Site can take as long as 15 hours (personal communication), and hand separation of a sample at the Pawnee Site takes, on the average, about 3 hours.

The new wind tower (Fig. 1) technique employs the principle that the lighter material (mostly dead) can be blown off from the heavier material (mostly live) in a specially constructed tower with traps by means of an air stream. Automatic separation of a large proportion of the light and heavy components of the sample is therefore automatically achieved. An average separation

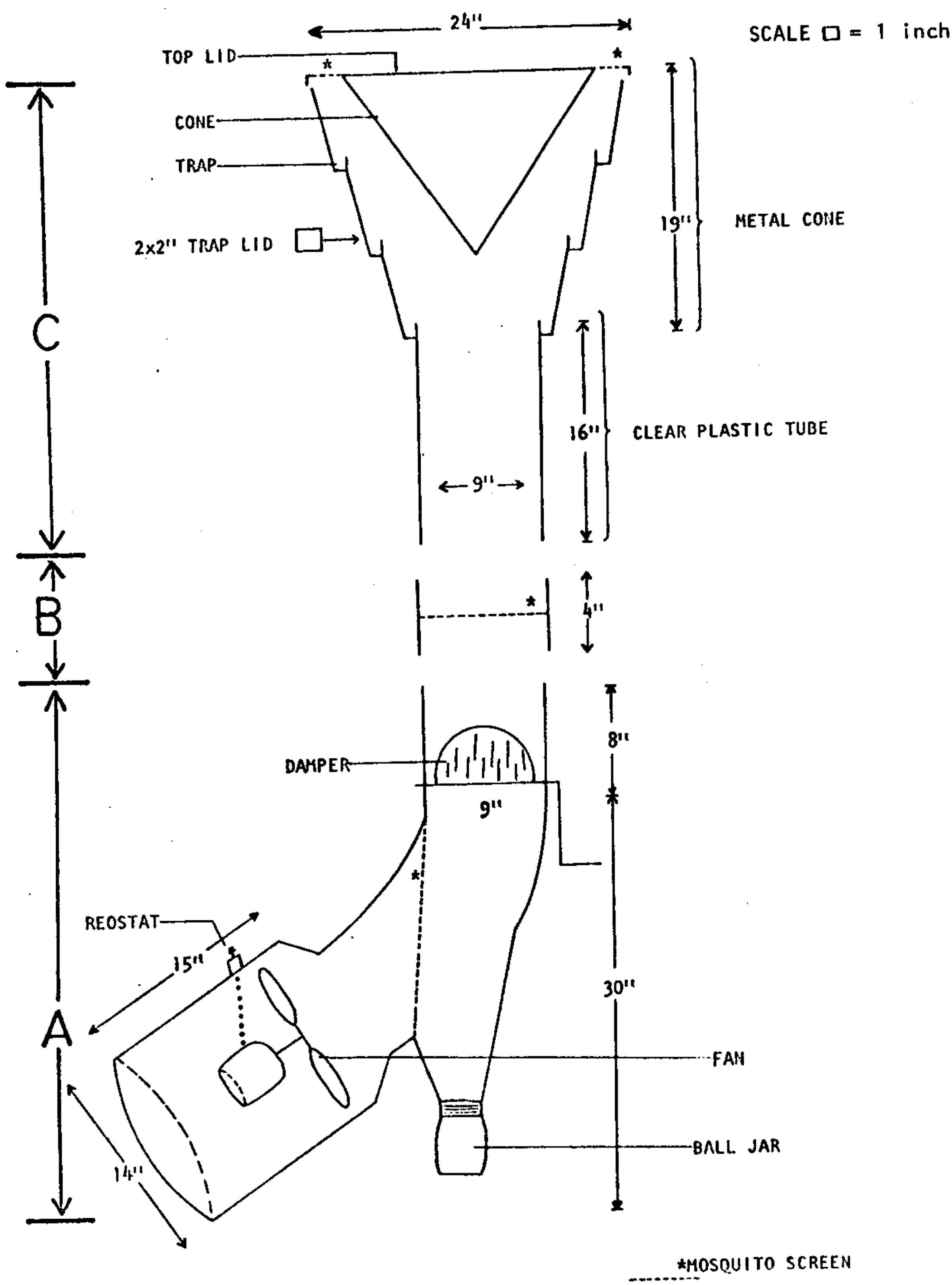

Fig. 1. Van Wyk Tower for live-dead herbage separation.

time of about 15 minutes per sample seemed sufficient to give a separation of about 80%, depending on the condition of the sample and the skill of the operator. The remaining 20% (±10% of the dead still mixed with the live and ±10% live mixed with the dead) should still, therefore, be hand separated. Final separation, following the tower separation, took an average time of 15 to 30 minutes for a Pawnee $\frac{1}{2}$ m^2 sample. The time reduction and man hour saving of this technique is therefore evident.

It should, however, be pointed out that there are at least two critical factors which influence the results directly, namely the skill of the operator and the condition of the sample.

Since separation is achieved by means of a very well regulated air stream that would only be strong enough to carry lighter portions (dead) to the higher parts of the tower and not the heavier live ones, the operator should be fairly well familiar with the tower to select the exact wind speed to achieve separation with the lowest degree of mixing.

The condition of the sample is also important, since separation is achieved on a specific gravity basis. Samples with distinct live-dead components, that were collected during the active growing season, will naturally separate much better than ones collected during the later part of the growing season when live-dead difference is less clear cut.

It has been experienced at Pawnee that tower separation was satisfactory until the end of August, and that the efficiency declined rapidly through September and reached a point of virtually no separation by the end of September. This is probably due to the season of growing and rapid change from standing live to standing dead at this time of the year.

Failure of separation at this point probably indicates the rapid deterioration (chemical breakdown or decomposition) of standing dead and perhaps not, as one would assume, a drastic water loss weight change at this stage. (It has been shown that tower separation of oven-dried samples collected early during the growing season is fairly successful.) Weight differences between live and dead, due to the high moisture content of the live seem, therefore, not the only major reason for successful tower separation. Chemical composition is perhaps just as important as moisture content with regard to specific gravity differences between the live and dead components of the sample.

The highest separation efficiency was achieved with fresh samples, which were separated directly after field collections when moisture and weight differences between live and dead portions are probably the greatest. Samples can, however, be stored in a deep freeze to prevent any weight changes until they can be separated.

Collection of samples immediately after rain showers or during early mornings before dew moisture disappears should be prevented if tower separation is to be performed in these samples.

Description of the Tower Separator

The separator (Fig. 1) consists of three basic parts; (A) bottom section; (B) middle section; and (C) top section.

A. The bottom section (see dimensions in Fig. 1) is a 45° curved galvanized metal tube which houses the fan and the deflector, and to which the throughfall catchment container is attached. A mosquito screen partition is placed vertically between the fan and the deflector to prevent plant material from drifting to the fan. The fan is a 12 inch ring exhaust fan. It has a capacity of 1535 ft^3/minute; 1500 rpm; 1/20 hp; 1.5 amp. The speed is regulated with a solid state speed control for AC motors Mod. KBSC 14.

The throughfall catchment container is a 6 inch Ball jar with a 3 inch screw cap. The screw cap ring is soldered to the tower, and the bottle can be removed by unscrewing. Both the bottle and the cap ring must fit tight to prevent leakage.

The deflector is housed in the top vertical portion of section A and is manually operated by means of a handle. Its purpose is to deflect and/or direct windflow if needed.

B. The middle section is a fine mesh, stainless steel screen (18 holes to an inch), housed in a 4 inch long metal cylinder which fits relatively tight <u>over the top</u> of section A.

The plant sample is deposited on top of the screen, preferably after the top section C has been put in place.

C. The top section, in which separation occurs, is a combination of a 9 inch diameter clear plastic pipe, a widening metal cylinder with traps, and a lid to which a metal cone, extending downwards into the tower, is attached (Fig. 1 and 2).

The shape and size of section C need not necessarily be fixed to definite dimensions, since two different size cones have been tested at Pawnee. One of the cones is slightly smaller than the one in Fig. 1, and the other (Fig. 2) is much larger. It was felt, however, that the smaller cone with only two traps was somewhat small for optimum functioning and

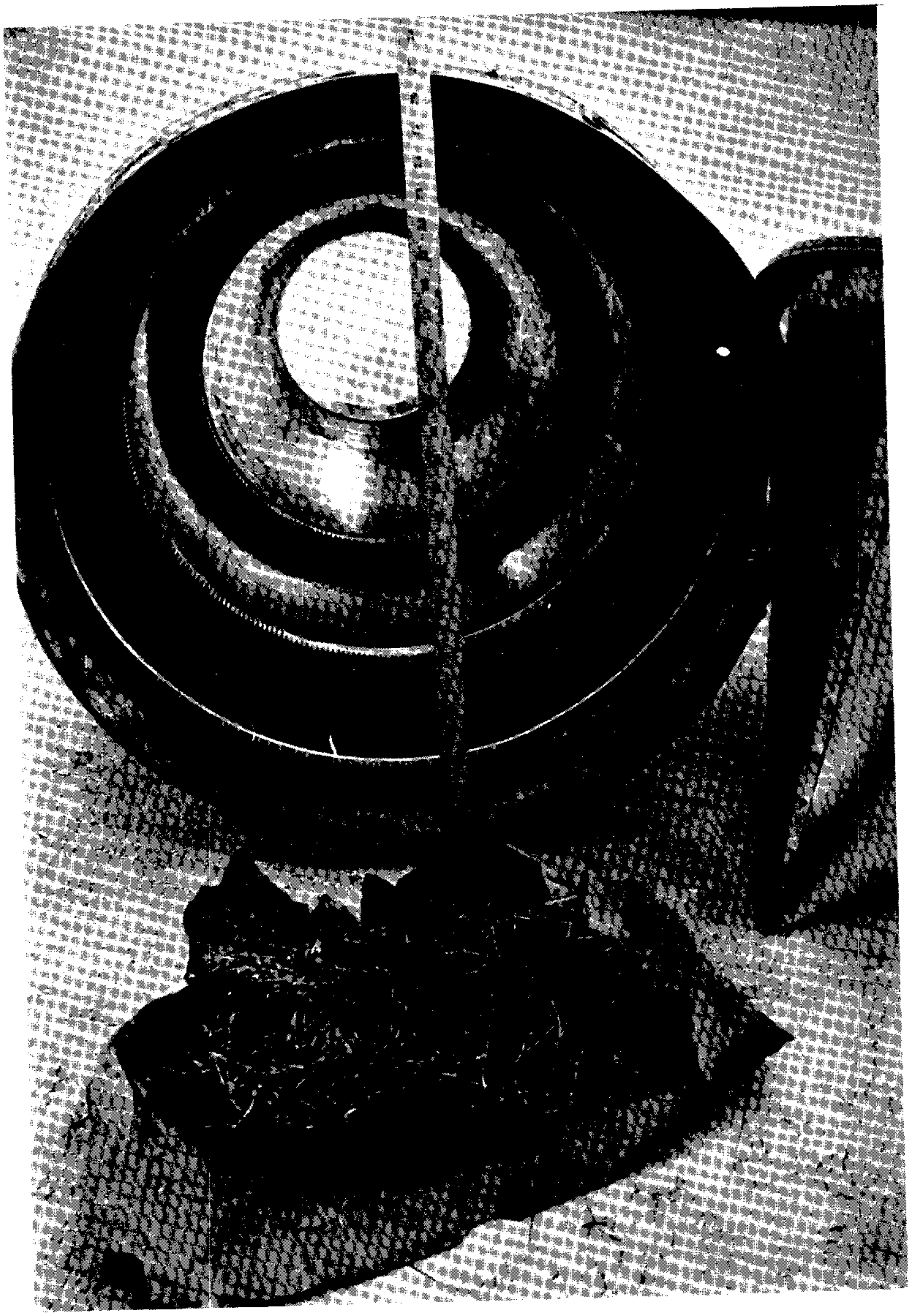

Fig. 2. Larger cone used in van Wyk's wind tower.

that the bigger cone (Fig. 2) was somewhat large, since practically no material could be blown to the top trap without simultaneously blowing green material to the lower trap.

A medium sized cone (dimensions in Fig. 1) ought to give better results than the ones tested (this applies only to Pawnee).

The length of the clear plastic pipe is also optional, although it was found that a 16 inch pipe functioned satisfactorily during the first half of the growing season, while a shorter pipe (8 inches) in combination with the bigger cone was somewhat superior during the latter part. Two interchangeable pipes are therefore recommended. These should be of exactly the same diameter to ensure tight sealing with (inside) the screen section below and the trap section above.

The metal trap section should be constructed as is indicated in Fig. 1, with the traps 6 inches above one another going all the way around the inside perimeter. They should be at least 1 to 1¼ inches deep and wide with the inside walls vertical. These dimensions will ensure proper trapping and easy removal of trapped material.

A small 2 x 2 inch opening with a sliding cover should be provided for each trap for removal of the material. Material can easily be removed with a 1 inch paint brush.

The top lid consists of an outer ring which fits tightly over the end of the trap section by means of a rubber seal, a 2 inch wide mosquito screen section which serves as an exhaust, and a central solid section with a cone extending downwards to a point between the first and second traps from the bottom. This cone is constructed in such a way that it reduces the open space at the higher traps and therefore increases the wind velocity to carry the light material to the top trap. It also serves to deflect the air stream to the perimeter to bring the plant material closer to the traps.

It should be noted that the top of the lid cone should be at least as wide as the inside measurements of the top trap and preferably a little wider. The outer rim of the lid is attached to the central portion by means of 4 x 1¼ inch metal bands. The screen should be soldered all the way around both to the outer rim and to the central section to prevent any loss of plant material.

The exhaust opening can also be located in the top trap section (Fig. 3) instead of the lid. This does not have any particular advantages or disadvantages that were detectable.

The tower is mounted on a suitable wooden base to keep it in position. The thermostat can be secured in any convenient place for easy handling.

Operation

Operation is relatively simple and does not require skilled training of any kind. (Familiarity with the tower seems to be of some advantage.) Once sections A, B, and C have been properly placed on top of one another, the removal opening lids closed, and the bottle screwed in place, the top lid can be removed and the sample can be dumped on the screen. Care should be taken to prevent any material from getting into the traps at this stage. The lid should be put back in proper position to seal tightly. The fan can now be turned on with the neostat in slow position.

Very slow adjustment of the neostat to increase the fan speed gradually to a point where the dead material just begins to float in the air stream is

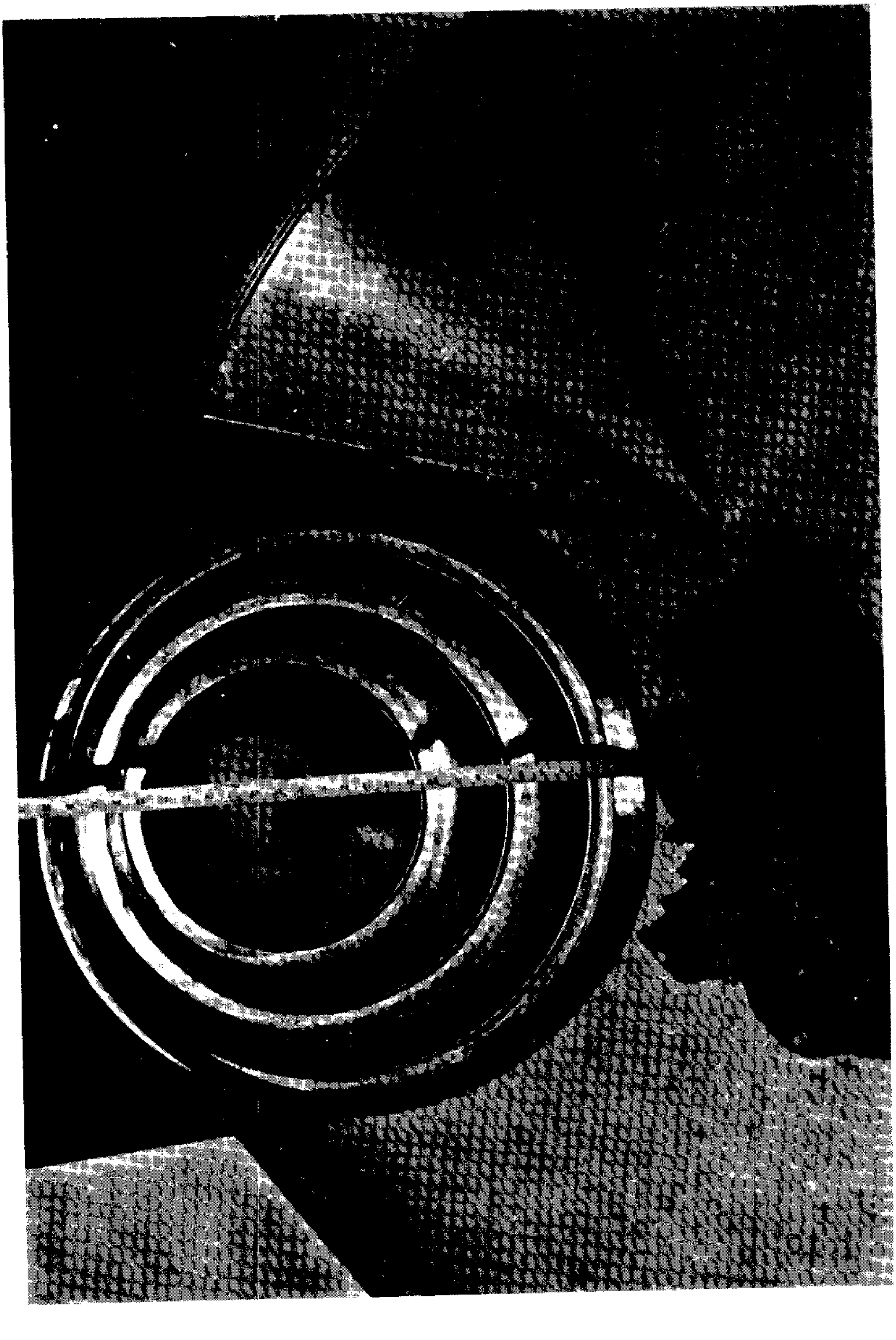

Fig. 3. Top trap section of van Wyk's wind tower.

absolutely essential. This point can be referred to as the minimum fan speed since very little or no material will be driven into the traps.

Too much air will drive both the dead and live material to the traps and result in no separation at all. This can conveniently be referred to as maximum fan speed.

The optimum fan speed lies naturally somewhere between these two points and experience has shown that it is in close range just above the minimum. The exact point will have to be determined for each situation. It can, however, be described as the fan speed which causes enough thrust to carry the light dead to the top trap, medium weight dead to the middle trap, and heavy dead with a small percentage of light live to the bottom trap (a small degree of mixing in the bottom trap is inevitable). The bulk of the live (green) material must, however, remain on the screen or only partially be lifted in the plastic pipe.

Stirring of the sample on the screen is somewhat of a problem with the current model since the deflector does not cause sufficient stirring and untangling of the live and dead material, especially when the leaves are extremely curly and tangled. A large deflector causes desirable stirring, but cuts down too much of the spiraling effect of the air stream, which is essential for separation, that it has more disadvantages than advantages.

Stirring and untangling with the present model (see proposed alterations) can best be achieved from the outside by means of a Z shaped no. 10 (electrical copper) wire through a small ¼ inch hole in the side of the plastic tube 4 inches from the bottom. This can also be regarded as the maximum sample height in the tube.

This stirring mechanism allows the operator to stir the sample adequately and to untangle dead and live material due to the curly and spiral nature of the leaves. Continuous stirring is necessary since dead material is rapidly removed from the top of the sample and much less from within.

A small percentage of live material, especially needle-like leaves, will work their way downwards through the screen (due to mechanical stirring of the sample) and will end up in the bottle. This, unfortunately, cannot be prevented, as a finer mesh screen reduces the thrust of the air stream too much.

The fan can be shut off as soon as sufficient dead material has been driven off at the optimum speed. The traps can be emptied as indicated, and a rerun can be performed using a slightly higher air speed than the optimum on the previous run. The second run is usually not very successful (depending on the success of the first run) and usually yields quite a mixture of live and dead material, especially the lower traps.

Proposed Changes and/or Alterations

Since the tower was developed on "a spur of the moment decision" with no prior thorough testing of the principle or most suitable mechanism to achieve separation, several changes to facilitate operation are already decided on. Three of these will be briefly indicated.

1. Stirring mechanism. The current stirring mechanism is, although rather successful, somewhat amateurish. A better deflector should be developed, and a long golf club-like stirrer with a handle should be provided through the center of the top lid.

2. Removal of plant material. The removal of plant material, which now takes as long as separation time, should be much easier and faster. Various alternatives are currently investigated, i.e., a slanting screen in section B, vacuum, etc.
3. Mobility. Use of the tower is currently limited to the laboratory. Changes in construction and design will be investigated to change the tower to a mobile field apparatus so that it could be used in combination with the D-vac simultaneously with clipping.

ROOT SEPARATION FROM DRY SOIL CORES

Separation of roots from soil is best achieved by means of root washing techniques such as currently employed at the various IBP sites. Roots extracted through washing can, however, not be used for chemical analysis. The only alternative to wet extraction is dry extraction, which is suitable for chemical analysis, but not a very satisfactory method.

Crushing of the soil cores through a series of sieves usually results in a large degree of fragmentation of the roots, and hand picking of the fragments is time consuming, tedious, and not very successful.

It was therefore decided to develop a technique whereby soil cores can be crushed in such a way that fragmentation of root material is minimized and also to remove the roots from the soil by some other means as hand picking.

Crushing of Soil Cores

A special apparatus (Fig. 4) was constructed for crushing the soil cores. The principle employed was to apply differential pressure on the

Fig. 4. Apparatus constructed for crushing soil cores.

core as it was passed through a narrowing tube to break up the soil without changing the original shape of the core. This would prevent excessive root breakage, yet allow the soil to gradually break up as it passed through the tube. The tube consists of two halves of a 3 inch pipe section 18 inches long. They are full half-sections at the top and taper down to virtually a point at the bottom, like a bird's beak. One section is mounted stable, and the other hangs from two hinges near the top. A lever mechanism and spring is provided to achieve slight (2 to 5 mm, open and close) movement of the one section.

Soil cores, 3 inches in diameter, are inserted at the top and slowly worked down through the tube by flipping the lever up and down. This causes gradual breaking up of the soil without excessive root damage. The fine soil passes down the tube followed by the bulk of the root system. The tube functions in such a way that the bottom and side openings can be regulated to prevent coarse soil aggregates from running through.

A series of two standard soil sieves, 2 mm and 1 mm, and a bottom pan are placed below the crusher to collect both the soil and the roots.

Removal of Roots from the Soil

The roots are removed from the soil by means of vacuum instead of hand picking. An ordinary house vacuum system, with not too much suction, can be used. The intake nozzle is covered with fine nylon mesh to prevent the roots from being sucked into the vacuum. Removal of roots from the soil is fairly rapid, especially if the material on the sieves is spread in a thin layer.

It is estimated that this method of root extraction is at least 50% faster than the previous method and also yields on the order of 25% more root material. Detailed comparison studies have not been performed to verify the above statement.

Proposed Improvements

It has already been decided to motorize the crusher to achieve more uniform and much more rapid movement of the crushing unit. It would also, perhaps, be of some advantage to let the soil and roots pass through a rubber roller unit to remove small amounts of soil that might still be attached to the roots. This possibility is currently being investigated.

LITERATURE CITED

Milner, C. and R. E. Hughes. 1968. Methods for the measurement of primary production of grassland. IBP Handbook No. 6. Blackwell Sci. Publ., Oxford.