Notes

CONSTANT TEMPERATURE WATER BATHS FOR PLANT GROWTH EXPERIMENTS[1]

PREVIOUS articles[2,3] have described construction of relatively inexpensive constant temperature water baths for pot culture studies. The system described in this report differs from others in two ways: (a) several baths of one replication are maintained at different temperatures using one compressor; and, (b) true replication of treatment is provided, independent of location, by using a separate water bath for each temperature treatment rather than several pot "replications" within a single large water bath.

For our needs a complete replicate required 6 water baths, 2 above and 4 below room temperature. A convenient size was 15 inches wide, 35 inches long and 6.5 inches deep (inside dimensions) and tanks were constructed of 28-gauge galvanized iron. Such a bath accommodates six No. 10 cans (6.2 inches in diameter), six 8-ounce jars (2 inches in diameter) and equipment for temperature control. Each can rests on two 3-inch pieces of 0.5-inch O.D. copper tubing soldered to the galvanized lining, which allows circulation of water under as well as around the cans. A rust inhibitor, commonly used for automotive radiators, effectively checks electrolytic action between the copper cooling coils and galvanized iron, and prevents rusting of the No. 10 cans. Each bath is covered with 1/8-inch tempered pressboard with holes through which the cans and jars are inserted. The glass jars are supported by this cover. An insulative jacket is provided for each bath. The baths are arranged in a randomized block design in a growth chamber.

Water circulation is obtained in each bath with a Goode Pump (model GV30, Little Giant Pump Co.),[4] which delivers 260 gallons per hour. The flow from the pump is divided into two streams by plastic tubing.

Temperature in each bath is controlled by a Cenco 99015 bimetallic thermoregulator suspended in the bath. Thermoregulators are suspended, rather than mounted, to eliminate arcing of contact points caused by vibration from the circulation pump. Two of the 6 baths in each replicate are maintained above room temperature with 500-watt Chromolox, tumbler type, immersion heaters, controlled by the thermoregulators. Each thermoregulator is protected by a 0.25-mf. condenser and a Potter–Brumfield PR11AY, DPDT, relay with 25-ampere silver contacts. (A single pole relay would be adequate.)

The other four baths in each replicate are maintained below room temperature by using the system shown schematically in Figure 1. Operation of this system is as follows: The compressor (1/3 H.P., Copeland, model CF331B) is controlled by a Ranco pressure switch, type R-12 (010–1401) low pressure control, (A in Figure 1). This control is set at a differential of 4 pounds per square inch. Liquid refrigerant passes from the compressor through 0.25-inch copper tubing, a Sporlan Catch-all filter-drier, type C-052

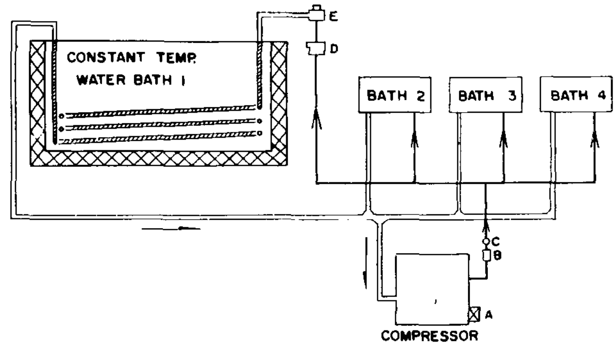

Figure 1—Schematic arrangement for controlling 4 water baths at different temperatures, below room temperature, using 1 compressor. Baths 1, 2, 3, and 4 are identical. A is a low-pressure switch for compressor control; B is a filter-drier; C is a moisture indicator; D is a solenoid controlled by a thermoregulator (not shown), and E is a thermostatic expansion valve.

sealed model, a Sporlan See-all moisture and liquid indicator, type SA-12FW, (B and C, respectively), to a Hoke solenoid valve, normally closed 2-way type B90A380C with 1/8-inch orifice (D). It then passes through a Sporlan thermostatic expansion valve, type GF1/2C (E, Figure 1), through 3 loops of 0.5-inch copper tubing immersed in the bath, and returns to the compressor as indicated by the arrows. The 3 loops of tubing, positioned against the inner sides of the tank, provide more than the 16 feet of 0.5-inch tubing necessary for adequate cooling surface. All tubing connections are silver-soldered or use threaded fittings. This system is flexible in that the number of baths that can be controlled with one compressor is dependent only on the cooling requirement, compressor capacity, and space available.

Temperatures in the 4 refrigerated baths are controlled by Cenco thermoregulators protected by Sigma 11F2 relays with 9000ohm coils and 1-ampere silver contacts. The thermoregulators govern action of the solenoids. When cooling in a bath is required, the thermoregulator contacts close, thereby opening the solenoid which permits the refrigerant to flow through the cooling coils until the cooling requirement is satisfied. The compressor operates only when the pressure of the refrigerant exceeds that of the differential limit. Consequently, the operation of the compressor is controlled by the pressure of the refrigerant and does not run every time a solenoid opens. In this manner, the baths are individually cooled and continuous operation of the compressor is avoided.

Bath temperatures are controlled within ±0.3° F. of the desired temperatures over a range from 45° to 80° F. with room temperature at 72° F. Only one compressor is used for each replicate, as indicated in Figure 1. This permits a random location of baths and a true replication of treatments. Also, the load on each compressor is equal and if a compressor fails, only one complete replication will be affected. If one compressor were used for all baths of one temperature, each would have a different capacity requirement and if the compressor should fail, that particular temperature treatment of all replicates would be affected.

Cost of all equipment and materials for one complete replicate was $532 in 1961.—W. O. WILLIS, J. F. POWER, G. A. BEICHMAN, *and* D. L. GRUNES, *Soil Scientists, USDA Northern Great Plains Field Station, Mandan, N.D.*

[1] Contribution from the Northern Plains Branch, Soil and Water Conservation Research Div., ARS, USDA. Received July 5, 1962.

[2] Cooper, D. J., Nielsen, K. F., White, J. W., and Kalbfleish, W. Note on an apparatus for controlling soil temperatures. Canadian J. Soil Sci. 40:105–107. 1960.

[3] Mack, Alex R., and Barber, Stanley A. A bath for soil temperature control in pot culture work. Agron. J. 52:299. 1960.

[4] Trade names and company names are included for the benefit of the reader and do not imply any endorsement, or preferential treatment by the U. S. Department of Agriculture of the product listed.

TRACTOR AND PLANTER FOR PREPARATION AND PLANTING OF PLOT LAND[1]

AN 8-WHEEL tractor with an 8-row seeding attachment was developed to improve the efficiency and timeliness of testing small grains and other crops in single- and multiple-row plots.

Conventional wheel and crawler tractors used in preparing and seeding experimental plots often leave tracks which cause undesirable differential responses of crop plants located in and between the tracks. To distribute the tractor weight more uniformly over the area covered by standard 8-foot cultivating and seeding equipment, the running gear of a row-crop tricycle type Model 740 Ford[2] tractor was provided with 8 wheels. The wheels were arranged so as to produce 8 tracks spaced 1 foot apart center-to-center and uniformly indented on level land. This new arrangement was produced by replacing the standard rear wheels with tri-wheels and by re-spacing the 2 front wheels so that their tracks are evenly spaced between the 2 inside tracks of the tri-wheels. All wheels have 6-inch tires.

The tractor is equipped with a creeper gear to provide the very slow speeds required for nonstop seeding with the 8-row planter attachment and for cultivating with an 8-row rotary-hoe plot cultivator presently under construction. The tractor, Figure 1, is also equipped with pilot markers, a cab to shelter the planter and its operating crew during inclement weather, and a ballast box on the front end to offset the weight of the planter.

The 8-row planter attachment was built for nonstop, end-to-end seeding of single-row or multiple-row plots in or between the tractor tracks. It is composed of 8 single-row planters operated in unison through two 4-row seed-distributing heads. Each single-row planter has a separate seed channel to permit independent seeding of individual rows, varieties, and rates. Each single-row planter is independently adjusted for depth of seeding and for flotation over uneven seed beds. All the planters, however, are held to a 1-foot spacing by a tie bar.

Seed can be delivered to the seed-distributing heads either in coin envelopes and emptied by hand or in compartmented plastic boxes and emptied semi-automatically. The compartmented plastic box with its sliding lid, Figure 2, holds 24 individual samples of seed, enough to plant 6 consecutive 4-row plots. One such box on each 4-row distributing head permits semi-automatic seeding of six 8-row plots end-to-end, or 48 individual rows, nonstop within 30 seconds. Each emptied box can be easily replaced with a loaded one within 15 seconds.

Plot seeding can be done by a single person or by a 2- or 3-man crew. If seed is delivered to the distributing heads in compartmented boxes, a 3-man crew can easily plant nonstop one 8-row plot 8 feet long every 8 seconds, averaging 1 row a second. A 2-man crew can maintain a nonstop average of 48 rows per minute. A single operator, however, must stop at the end of each plot but can average 16 rows per minute. If seed is packaged in coin envelopes and poured into the swinging funnels, the planting speed averages approximately one-third that obtainable from seed packaged in compartmented boxes.

The devices which channel the seed through each single-row planter are shown schematically in Figure 3. The front portion of a 4-row distributing head with a compartmented box locked in the seed box carriage is shown in Figure 4. The back portions of the seed-distributing head, settling chamber, seeding tubes, remnant bag, and crank assembly for operating the swinging funnels are shown in Figure 5. To commence the planting operation the compartmented box is placed lid down against the lid stop on the seed box carriage. By sliding the box downward on the lid the seed from the first compartment for each planter unit falls into its respective seed hopper, through a swinging funnel, and into the settling chamber. The swinging funnel, when vibrated at 300 strokes per minute, scatters the seed in a nearly uniform pattern on the floor of the settling chamber. The floor of each settling chamber is hung by 2 springs, and when tripped sidewise, empties the seed into 1 of a pair of grooves in the multiple-groove seed belt. Immediately thereafter the seed tube funnel is shifted to the drop-off end of the loaded groove to convey the seed through the seed tube into the boot of a double-disc furrow opener.

As the first plot is being seeded, a second seed sample can be dropped into the settling chamber. This sample is held in reserve on the floor until the planter nears the end of the first plot, when it is tripped into the empty alternate groove. Immediately thereafter the seed tube funnel is shifted from the first groove to the newly loaded alternate groove. This operation completes the seeding of the first plot and commences the seeding of the second. If the first groove was not completely empty at the time the seed funnel was shifted to the alternate groove, the remaining seed drops through the remnant hopper into the remnant bag.

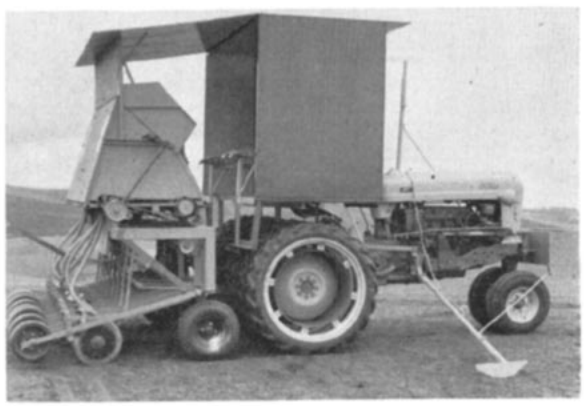

Figure 1—Side view of tractor and planter attachment.

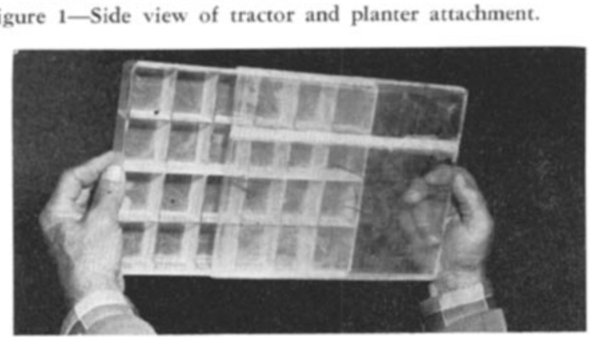

Figure 2—Compartmented plastic box with sliding lid for semi-automatic seeding.

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[1] Cooperative investigations of Crops Research Division, ARS, USDA, and Washington Agricultural Experiment Stations. Scientific Paper No. 2217, Pullman, Washington. This equipment was made possible by a special grant from the Rockefeller Foundation. Received Apr. 30, 1962.

[2] The mention in this publication of a trade product, equipment, or a commercial company does not imply its endorsement by the U. S. Department of Agriculture over similar products or companies not named.

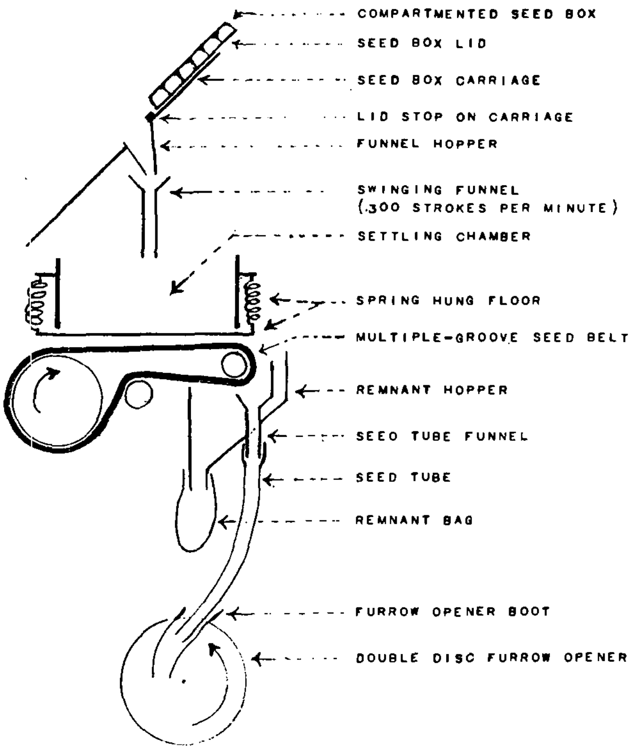

Figure 3—Relative positions of devices which channel seed from box to furrow opener.

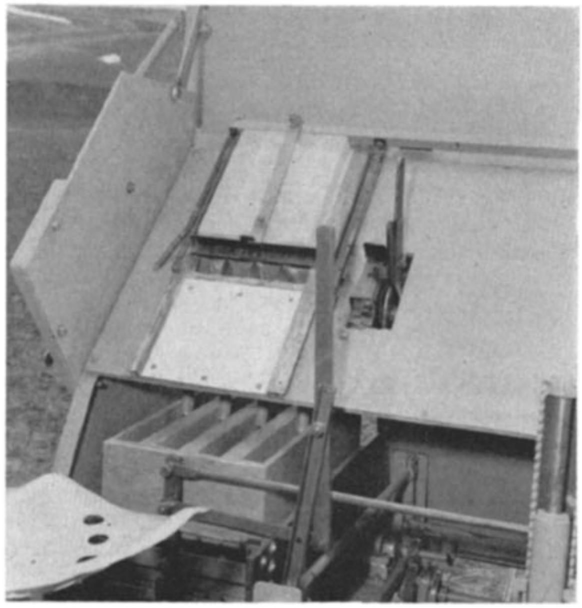

Figure 4—Upper front portion of a 4-row distributing head showing compartmented box, rachet for moving the box, and the trip lever for tripping the settling chamber floors and shifting the seed tube funnels.

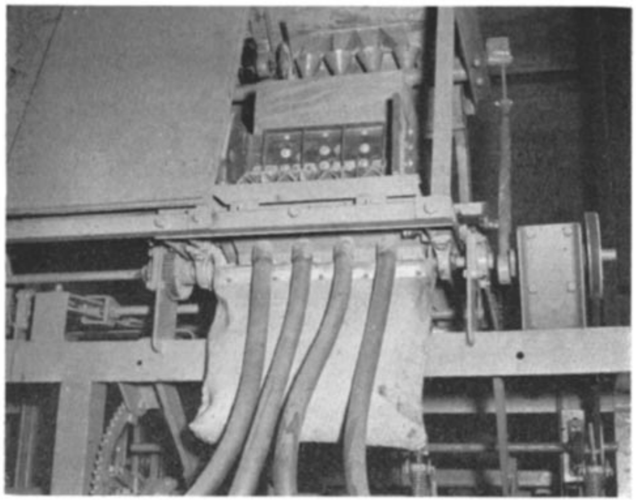

Figure 5—Lower portion of the 4-row distributing head showing the seed tubes, remnant bag, and crank assembly for operating the swing funnels.

By the time the alternate groove is nearly empty the first groove is completely self-emptied and ready to receive the third seed sample. This system of self-cleaning and alternate use of 2 grooves for each single-row planter permits nonstop, end-to-end seeding of plots with no apparent gap or pile-ups between the ends of rows.

Several power systems are employed in the operation of the planter. The seed belt is driven by the undercarriage of the planter. A system of sprockets and gears determines the maximum row length obtainable from one loading of a groove in the seed belt. A train of gears is used for convenient shifting into one-half or one-fourth the maximum row length obtainable from any given combination of sprockets.

The swinging funnels are operated by power from the power takeoff on the tractor. The 3-point hitch and the mechanism which shifts the planter for seeding either in or between the tractor tracks are operated by the hydraulic system of the tractor.

A hand-operated hydraulic jack is used to maintain a level position of the seed-distributing heads when planting up or down hill.

Rate of seeding depends on the quantity of seed deposited in each groove of the seeding belt and on the speed the belt travels.

The planter is equipped with wind and rain shields to permit operation under a wide range of climatic conditions. Soft-centered gauge wheels were used in place of press wheels to permit seeding in powdery, as well as nearly muddy seed beds.

Crops normally planted are wheat, oats, barley, flax, safflower, and lentils. For crops having seeds that roll easily, the distributing heads must be kept level to prevent the seeds from piling up at the low ends of the settling chambers and seeding belts. However, the addition of cracked grain or other angular material to each sample will reduce the amount of pile-up.

Although the planter was designed for operation as an attachment to the modified Model 740 Ford tractor, it can be adapted to other tractors having a standard 3-point hitch. A second best choice would be a standard 4-wheel tractor with the wheels spaced to provide tracks 6 feet apart, center-to-center. The planter would then seed on each side of the tractor tracks. A creeper speed gear, however, is a must for nonstop seeding.

Close-up pictures of various portions of the planter and tractor, and a colored movie showing the planter in operation are available upon request.—O. A. VOGEL, C. J. PETERSON, *and* R. E. ALLAN, *Agronomist, Agricultural Research Technician, and Genetist, respectively, Crops Research Division, ARS, USDA.*

EFFECTS OF PROLONGED IRRIGATION ON COTTON[1]

PROLONGED irrigation shows some promise as a method of ground water recharge. However, the effect of such over-irrigation on various crops could be a limiting factor. Experiments conducted by Hall et al.[2] on the effect of replenishment irrigation on dormant alfalfa showed that plant mortality was not affected by alternate, week-long irrigations between December 15 and February 1. Stockton et al.[3] found that weekly applications of water on cotton during the irrigation season had no significant effect on yield as compared with that of cotton irrigated at the first visible sign of moisture deficit.

This study is concerned with the effects of prolonged irrigations on the growth, maturity and yields of cotton planted in "solid-block" and "skip-row" (alternate strips of cropped and uncropped land of equal width). The study was conducted during 1960 in southwestern Fresno County, Calif. All experimental plots were part of a farmer's field on Panoche clay loam planted to Acala 4–42 cotton. Tillage, fertilizer application, and planting, along with all other farming operations were the same on the plots and in the adjacent field.

Skip-row Cotton

Design—The plots were strips of four 733-foot rows with a 40-inch row spacing, separated by an equal width of uncropped land. These strips were used to lay out a randomized block design of 12 plots with 3 treatments replicated 4 times. The 3 treatments were: 1-day, 4-day, and 8-day furrow irrigations. Water was applied to the 5 furrows associated with the 4 cotton rows.

Irrigation treatments began with the first post-emergence irrigation and succeeding prolonged irrigations were scheduled at the same time the farmer irrigated the field area adjacent to the plots. The 1-day treatment was a 24-hour "set" the same as practiced by the farmer. On the 4-day and 8-day plots water ran in the furrows continuously for those periods. Water was not allowed to pond over the beds. The crop was irrigated three times during the growing season in addition to the preirrigation. Water was metered on to the 8-day plots which gave an average intake rate of 0.475 ft./day (total depth of water applied/days of application).

Yield and quality—All four rows of each plot were harvested by mechanical pickers. The yields versus treatment for the two pickings are shown in Table 1. Statistically there was no significant difference in yields for the first picking. The second picking yields were based on a composite of the four plots for each treatment, therefore, the significance between the second picking yields, and between the total yields could not be tested.

Samples of ginned cotton from each plot were graded. Grades ranged from Middling to Strict Middling with staple lengths from 1-1/16 to 1-3/32 inches. The 1-day plots tended toward slightly higher grades with shorter staples than either the 4-day or 8-day plots.

Table 1—Yield of seed cotton from skip-row and solid-block plantings and various irrigation treatments.

Skip-row plots				Solid-block plantings			
Irrigation treatment	Lb. seed cotton/A. at 2 pickings			Treatment	Lb. seed cotton/A. at 2 pickings		
	First	Second	Total		First	Second	Total
1-day	4608	528	5136	On-plot, 38 days extra water	2562	390	2952
4-day	4905	1076	5981	Off-plot, farmer irrigations only	3096	286	3382 NS
8-day	4152	1352	5504				
	NS						

Growth and maturity—During the early part of the season plants on the 4- and 8-day plots had a noticeable delay in growth (height of plant) compared to the plants on the 1-day plots.

At maturity the plants on the 1-day plots were more compact and had attained an average height of 40 inches. Plants undergoing the 4- and 8-day treatments reached an average height of 52 and 53 inches, respectively. Figure 1 shows the contrast in growth between 1-day and 8-day treatments of cotton 2 weeks before harvest. The earlier maturity of the cotton receiving 1-day treatments is easily seen by the open bolls in Figure 1. The delayed maturity of the 4- and 8-day plots was reflected by a greater amount of cotton harvested on the second picking (Table 1). The rank vegetative growth of the 8-day treated cotton caused difficulty in defoliation prior to machine picking. Even after two sprayings by airplane, plants on the 4- and 8-day plots were not as well defoliated as the plants on the 1-day plots after one spraying.

Solid-block Cotton

Design—The wetted area in solid-block cotton was 53⅓ feet wide and 1256 feet long with a 40-inch row spacing. This strip of cotton within the field was furrow irrigated for a total of 38 days in addition to the 1-day irrigations by the farmer. The prolonged irrigation schedule was as follows: no water after the preirrigation, irrigated for 15

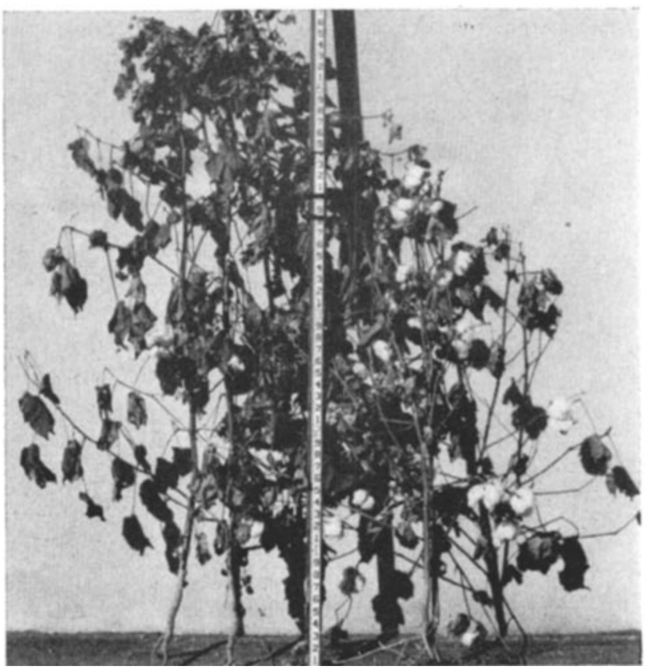

Figure 1—Comparison of cotton for maturity and growth: 8-day plot on left and 1-day plot on right.

[1] Contribution from the Southwest Branch, Soil and Water Conservation, Research Division, ARS, USDA, Fresno, Calif. This study was supported in part by the California State Department of Water Resources and the California Agricultural Experiment Station.

[2] Hall, W. A., Hagan, R. M., and Axtell, J. D. Recharging ground water by irrigation. Agr. Eng. 38:98–100. 1957.

[3] Stockton, J. R., Doneen, L. D., and Walhood, V. T. Boll shedding and growth of the cotton plant in relation to irrigation frequency. Agron. J. 53:272–275. 1961.

days after both the first and second irrigations, irrigated for 8 days after the third, and no water after the fourth. The average intake rate, obtained by metering water onto the plot, for the extended periods of irrigation was 0.385 ft./day (total depth of water applied/days of application).

For yield purposes, 2 strips of 4 rows were harvested 2 rows in from either edge of the plot. For comparison a strip of four rows on either side of the plots was harvested. The off-plot strips were 5 or more rows away and were not influenced by treatment of the plot. Thus 2 samplings for yield were obtained from the plot area and 2 from the adjacent field area.

Yield and quality—Table 1 shows the yield of seed cotton for the two samples from each location. The data indicates slightly lower total yields on-plot as compared to off-plot, but the differences are not statistically significant.

Both on- and off-plot samples graded Middling with staple lengths of 1-3/32 inches.

Growth and maturity—A depression in the growth was also noticed in the solid-block cotton under prolonged irrigation at the beginning of the season. This may have been caused by the lack of nitrogen or a lack of soil aeration as evidenced by yellowing of the leaves; however, the cotton plants recovered during the period between the first and second excessive irrigations and the yellowing of the leaves was barely perceptible in comparison to the off-plot cotton. Ten days after the first 15-day irrigation the number of blooms per plant were approximately the same for both the on- and off-plot plants. Yellowing of the leaves occurred again during the second 15-day irrigation and recovery of green color was not complete when the last 8-day replenishment irrigation was applied.

After this last prolonged irrigation the on-plot cotton leaves were very yellow and no bolls were open. The off-plot cotton had 3 to 4 open bolls per plant. Ten days later the on-plot cotton showed a few open bolls.

Root development of the plants receiving no extra water was similar to the plants receiving 38 days of extra water (as shown in Figure 2). The whitened areas (on-plot cotton root) are enlarged lenticels and were found predominantly on roots of plants subjected to prolonged irrigation.

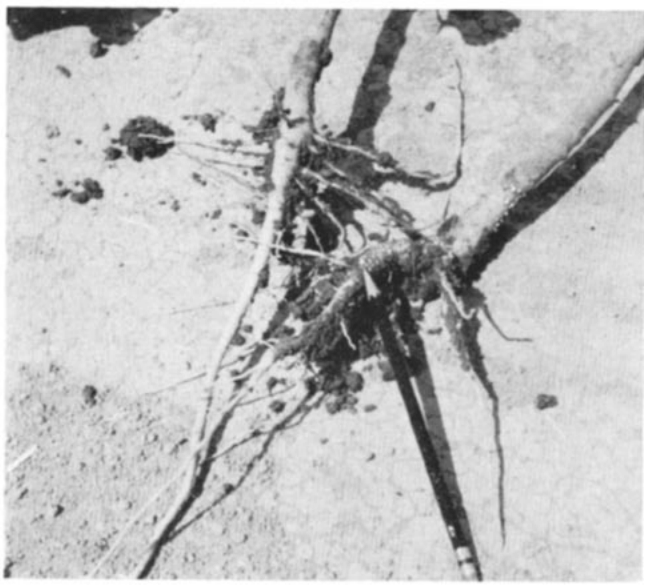

Figure 2—Roots of cotton plants from on-plot (pencil) and off-plot.

Conclusions

Prolonged irrigations produced no significant differences in crop yields of Acala 4–42 cotton compared to the usual irrigations practiced by the farmer, even though some early season growth depression occurred and maturity was delayed. Therefore, cotton may lend itself to a replenishment irrigation program. However, further studies with cotton and other crops over more than one season are needed if replenishment irrigation is to become an important means of ground water recharge.—E. E. Haskell, Jr., *and* W. C. Bianchi, *Geologist and Research Soil Scientist, Southwest Branch, Soil and Water Conservation Res. Div., ARS, USDA, Fresno, Calif.*

DISTRIBUTION OF NET RADIATION WITHIN SORGHUM PLOTS[1]

THE amount of evapotranspiration from any locality is governed primarily by those factors affecting water and heat supply to soil and plant surfaces.[2] The net radiation, the difference between incoming and outgoing radiant energy, is the principle source of heat. This experiment was initiated to determine if row width and plant population influence the total net radiation and its distribution between the grain sorghum crop and the soil.

Four RS 610 grain sorghum plots with north-south orientations were selected for this experiment. Treatments were as follows:

1. 20-inch rows with 105,000 plants per acre
2. 20-inch rows with 13,000 plants per acre
3. 40-inch rows with 105,000 plants per acre
4. 40-inch rows with 13,000 plants per acre.

"Economical" net radiometers, as described by Suomi and Kuhn,[3] were used to measure the net radiation. On each plot 1 radiometer was placed approximately 1 foot above the crop. In the row beneath the foliage 3 radiometers were connected in parallel; 1 was situated in the center of the row and 1 was placed to each side of the row near the sorghum stalks. The bottom windows of the lower radiometers were 1 foot above the soil surface. All radiometers were connected to a recorder and radiation data were recorded 24 hours per day.

The upper radiometers measured the total net radiation absorbed by both crop and soil; the lower radiometers measured that net radiation absorbed by the soil alone. The difference between upper and lower net radiation was absorbed by the crop. Similar procedures were used by Aubertin and Peters[4] and Tanner and associates[5] to measure the net radiation in cornfields. Aubertin and Peters suggested that separate measurements of the net radiation absorbed by the crop and by the soil make possible individual estimates of transpiration and evaporation.

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[1] Contribution from the Soil and Water Conservation Research Division, ARS, USDA, and the Kansas Agricultural Experiment Station. Department of Agronomy Contribution No. 767.

[2] Tanner, C. B. Factors affecting evaporation from plants and soil. J. Soil and Water Cons. 12(5):221–227. 1957.

[3] Suomi, V. E., and Kuhn, P. M. An economical net radiometer. Tellus. 10:160–163. 1958.

[4] Aubertin, G. M., and Peters, D. B. Net radiation determinations in a cornfield. Agron. J. 53:269–272. 1960.

[5] Tanner, C. B., Petersen, A. E., and Love, J. B. Radiant energy exchange in a cornfield. Agron. J. 52:373–379. 1960.

Table 1—Daily net radiation absorbed on sorghum plots at two plant population rates.

Days, 1961	Daily net radiation absorbed, cal./cm.²/day											
	20-inch row width						40-inch row width					
	105,000 plants/A.			13,000 plants/A.			105,000 plants/A.			13,000 plants/A.		
	Tot.	Crop	Soil	Tot.	Crop	Soil	Tot.	Crop	Soil	Tot.	Crop	Soil
7-29	358	258	100	368	144	224	379	268	111	382	180	202
7-30	377	282	95	388	194	194	393	259	134	401	177	224
7-31	339	249	90	345	179	166	380	250	130	381	161	220
8-1	240	173	67	237	101	136	254	142	112	260	114	146
8-5	390	288	102	382	151	231	398	320	78	393	200	193
8-7	377	291	86	350	154	196	368	275	93	374	161	213
8-8	365	279	86	314	128	186	349	254	95	374	179	195
8-9	204	141	63	200	60	140	216	163	53	208	119	89
8-10	381	279	102	355	157	198	377	279	98	376	168	208
Mean	337	249	88	327	141	186	346	246	100	350	162	188

Table 1 gives the total daily net radiation absorbed in each treatment and the amounts absorbed by the crop and the soil.

The results of an analysis of variance showed that only the row width significantly influenced the total net radiation absorbed by both plants and soil in each treatment. The significance level was 0.001 ($F = 20.24$; d.f. $= 1, 24$). From the average of the means, the net radiation measured above plots with 40-inch rows was 16 cal./cm.²/day or 4.8% greater than above plots with 20-inch rows.

Analysis of variance on the net radiation absorbed by soil showed that only the plant population significantly influenced this measurement. The significance level was 0.001 ($F = 159.35$; d.f. $= 1, 24$). Those soils with low plant population absorbed, on the average, 93 cal./cm.²/day more than did those with high populations.

Only the plant population significantly influenced the net radiation absorbed by the crop. The level of significance was 0.001 ($F = 170.28$; d.f. $= 1, 24$). From the average of the means, the high plant populations absorbed 96 cal./cm.²/day more than did the low populations.

For the 9 days of measurement on plots of equal plant populations, the soil absorbed 55.3% of the total net radiation absorbed on plots with 13,000 plant per acre and 27.5% of the total absorbed on plots with 105,000 plants per acre. These percentages indicate that even with extremely high plant populations considerable radiant energy is available at the soil surface for evaporation.

Under the conditions of this experiment it is evident that total net radiation absorbed under cropped conditions is only slightly influenced by row spacing. The division of this energy between crop and soil appears to be strongly dependent on the plant population. There was no evidence of a significant influence by the row width-plant population interaction on the total net radiation.—S. A. Bowers, R. J. Hanks, *and* F. C. Stickler, *Soil Scientists (Physics), USDA, and Associate Professor of Agronomy, Kansas State University, Manhattan, Kans., respectively.*

A SMALL SIRUP PAN DEVELOPED AT MERIDIAN, MISSISSIPPI, 1960[1]

FOR several years the standard experimental sirup pan used at the U. S. Sugar Crops Field Station, Meridian, Miss., required 40 pounds of juice and was heated with steam. Both quantitative and qualitative data from this equipment were excellent but its use was limited by the amount of juice required for each test. Consequently, a normal day's "run" for sorgo was only 7 samples and for sugarcane about 12 samples. Thus, the number of sirup samples that could be processed during the year was extremely limited. Also, the approximately 100 pounds of stalks required to furnish 40 pounds of juice made it necessary to delay sirup evaluations until sorgo lines were included in the agronomic nurseries and sugarcane selections were in line tests in 1/200-acre plots.

A smaller pan requiring less juice was constructed at Meridian in the fall of 1960. It is 18 inches long by 13.5 inches wide by 11.5 inches high. The ½-inch brass steam coil is 35 inches long (Figure 1). Only about 10 pounds of juice is required for each sirup sample.

The small pan was compared directly with the standard pan. Comparative samples (10 pounds for the small pan and 40 pounds for the standard pan) were drawn from the same lot of juice and processed into sirup at the same time in the 2 pans. Eight such comparisons, involving several different varieties of sorgo, were available and used.

Table 1 includes the results of this comparative study. The average percent of sirup was only 0.7% less for the small pan than for the standard. Variety comparisons were excellent in both cases, as indicated by the highly significant variance due to samples. The correlation coefficient for percent sirup was +0.9477, which is highly significant and indicates excellent agreement between the pans.

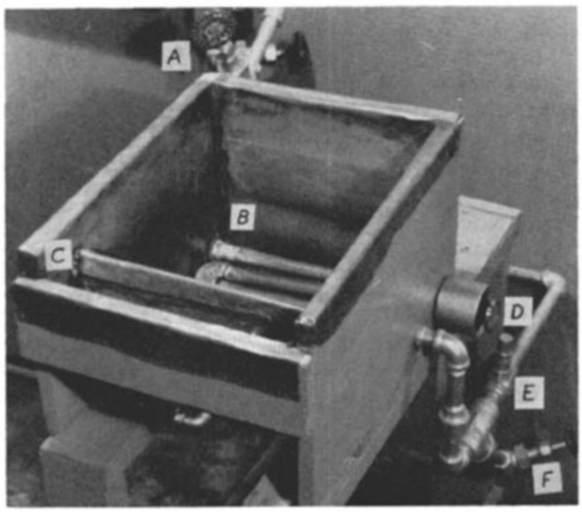


Figure 1—Small sirup pan, showing: A, steam control valve; B, steam coil; C, skimming trough; D, thermometer; E, Steam trap; and, F, steam exhaust valve.

Table 1—Comparison data from standard and small experimental sirup pans.

Sample number	Brix	Percent sirup		Percent skimmings		Finishing temp. °C.	
		Standard pan	Small pan	Standard pan	Small pan	Standard pan	Small pan
1	19.3	20.5	19.0	7.5	8.0	110	110
2	17.5	21.0	18.0	8.0	8.0	109	109
3	19.7	21.5	21.0	5.5	7.0	110	109
4	20.2	29.8	29.0	8.5	10.0	104	105
5	17.1	18.8	19.0	6.5	7.0	110	109
6	14.0	15.8	17.0	6.0	5.0	110	110
7	16.5	19.2	18.0	7.0	6.0	110	110
8	19.6	22.0	22.0	7.0	8.0	108	108
Aver.		21.1	20.4	7.0	7.4	108.9	108.8

Variance analyses:

Source of variation	D. F.	Mean squares: Sirup	Mean squares: Skimmings
Samples	7	30.33**	2.78*
Pans	1	1.95	0.56
S × P	7	0.80	0.49
Total	15		
r_{xy}		+0.9477**	+0.7583*

* 5% level of significance. ** 1% level of significance.

[1] Cooperative investigations of the Crops Research Division, ARS, USDA, and Mississippi Agricultural Experiment Station. Received May 24, 1962.

One characteristic of varieties or treatments in sirup manufacture is the amount of skimmings. These data are usually somewhat more erratic than the percent sirup. Even so, there was a relatively high correlation (+0.7583) between the 2 pans for this characteristic.

A very critical evaluation of sirup is the final density as measured by the finishing temperature. The standard finishing temperature for sorgo sirup at Meridian is 110° C. Results from the 2 pans were very close, the widest discrepancy (1° C.) being well within the sampling error. The average temperatures of the finished sirups in the 2 pans were within 0.1° C.

Advantages of the small pan over the standard are: *(1)* the number of samples processed per day was increased from 7 to 12 for sorgo and from 12 to 16 for sugarcane; *(2)* it is now possible to test breeding lines of sorgo as early as the F_4 generation in 1/1000-acre plots and to evaluate sugarcane lines in the 1/1000-acre advanced nursery plots; *(3)* early evaluations for sirup make it possible to discard undesirable lines 1 to 5 years earlier than before; and *(4)* the smaller juice sample required for the sirup test reduces the cutting and harvesting cost in regional sorgo variety experiments. Ten-stalk samples rather than 15- to 20-stalk samples are collected. In many cases, it is possible to use a smaller vehicle for the harvesting trips and thus reduce the over-all cost of operation.

The development of this small sirup pan is the most significant improvement in sorgo and sugarcane sirup evaluation techniques since the Station started using steam heat several years ago.—O. H. COLEMAN, *Research Agronomist, Crops Research Division, ARS, USDA, Meridian, Miss.*

A SMALL, VERSATILE, TRACTOR-MOUNTED DRILL FOR EXPERIMENTAL PLOTS

A CONSIDERABLE number and variety of specialized, nursery drills have been described by workers who have designed and constructed such equipment for their particular needs in crops research. The construction and operational features of the drill described here differ in many respects from any described heretofore, to the knowledge of the authors. The principal advantages of this drill include (a) simplicity of design and construction, (b) ease of operation, requiring only the tractor driver, (c) all controls within easy reach of the operator, (d) clear visibility of all functional parts during operation, (e) excellent maneuverability, (f) rapid and accurate adjustment of rate and depth of planting, and (g) ease and rapidity with which seed hopper can be emptied and cleaned for the purpose of planting successively several crops or varieties with little delay in the field.

The drill is mounted on an Allis-Chalmers Model G tractor (Figure 1). Although no longer manufactured, this tractor is currently in widespread use. The drill utilizes the tractor's hydraulic system and split-type front lift shaft for raising the gang of disc-type furrow-openers and packer wheels. The 10 double-disc furrow-openers are manufactured by International Harvester Company and are mounted with 6-inch spacing between centers, resulting in a drill width of 5 feet. The tractor wheels are mounted 5 feet apart on centers so that all wheel tracks occur on plot boundaries when the popular 5-foot plot width is used—an important feature in experimental work where compaction caused by tractor wheels may grossly alter plant performance.

The seed hopper (1),[1] with about a 1-bushel capacity, was taken from a small lawn-fertilizer spreader. All but 10 of the round holes for fertilizer delivery at the bottom of the hopper were welded shut. These 10 holes, evenly spaced along the length of the hopper, were enlarged by filing to an elliptical shape ½ inch wide by ¾ inch long, with the long dimension perpendicular to the long dimension of the hopper. The flared cup atop each flexible seed downspout is fastened to a stationary bar and positioned directly under one of the delivery holes in the bottom of the hopper.

A movable shutoff plate (2) governs the opening of the seed delivery holes by its sliding movement just under these holes at the bottom of the hopper. This shutoff plate, also part of the lawn-fertilizer spreader, is controlled by forward or backward movement of a control handle (3). This handle, and consequently the shutoff plate, is held in either open or closed position by a movable catch (4) and a fixed catch (5). Rate of sowing is altered by changing the posi-

[1] Numbers in parentheses refer to construction features identified in Figures 2 and 3.

Figure 1—Side view of drill mounted on tractor.

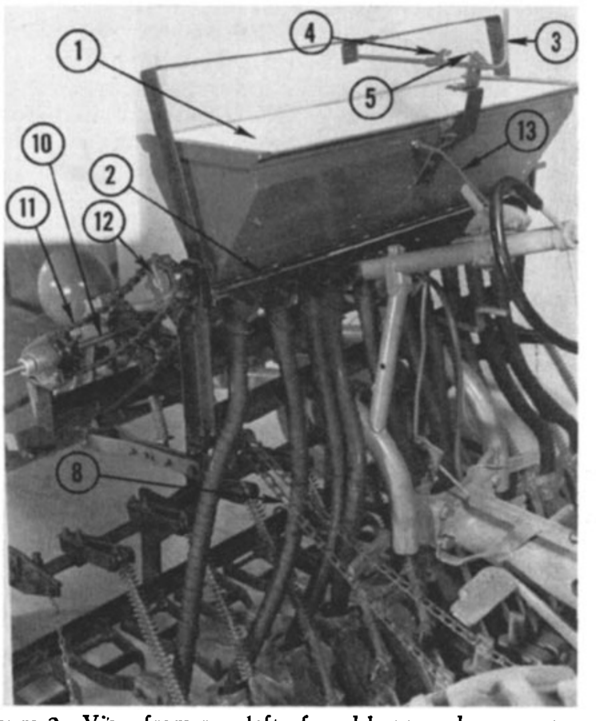


Figure 2—View from rear-left of seed hopper, downspouts, and agitator drive.

tion of the movable catch (4) which governs the area of delivery holes that will be uncovered when the control handle (3) is moved from the closed to the open position. Movement of catch (4) along the threader shaft of handle (3) is accomplished by releasing the locknut butting against the catch, turning the catch to the desired position, and finally resetting the locknut against the catch to prevent further movement.

The appropriate location of the movable catch (4) for the desired rate of delivery for each crop to be sown is determined by calibration runs before going to the field. To accomplish calibration, the lower ends of the five flexible downspouts on each half of the drill are removed from the disc furrow-openers and placed into a pail wired onto the tractor frame. Seed dispensed and caught in the two pails over a measured distance, at the rate of travel to be used in the field, is weighed to determine the rate of sowing.

The agitator in the bottom of the seed hopper was altered from the design used in the lawn-fertilizer spreader. The original agitator was a series of small-diameter metal rods mounted in a cylindric arrangement around, and parallel to, the main agitator shaft. It was found that this agitator crushed some seeds, especially peas. The present agitator, as shown in Figure 3, utilizes the original agitator shaft (6) with short collars of pipe (7) bolted to this shaft immediately above each of the 10 delivery holes in the hopper. Six short fingers were welded to each collar. When the agitator turns, these fingers cause effective agitation and uniform delivery of the seed without damaging it.

The agitator is driven by a series of two chains. The first and longer chain (8) is driven by a sprocket (9), made by the tractor manufacturer, attached to the left rear tractor wheel. This chain drives an idler shaft (10) which in turn drives the shorter chain (11). This shorter chain then drives the sprocket (12) affixed to the end of the agitator shaft (6) which protrudes from the seed hopper.

The hopper is so constructed that its only mounting attachments are the two end bearings of the agitator shaft and a small, support rod (13). Removal of a wing nut from the support rod (13) permits the hopper to pivot on the agitator shaft bearings and tip forward as shown in Figure 3. All seed is easily and quickly removed as illustrated. A metal cover (14) for the seed hopper is shown in place in Figure 1. This cover, when inverted, is used to catch seed when the hopper is tipped forward for emptying as shown in Figure 3.

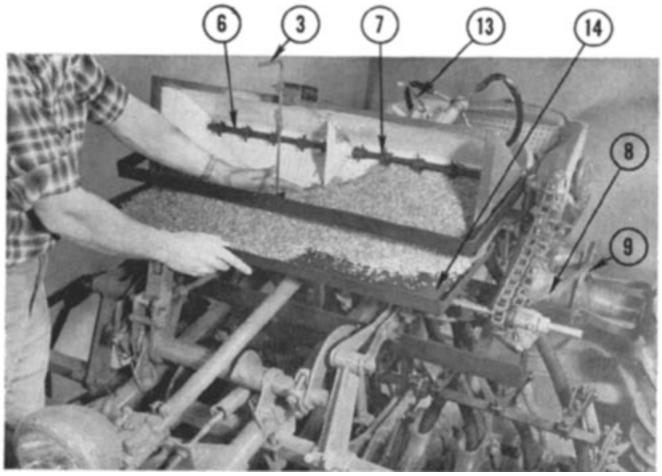


Figure 3—Front view of seed hopper tipped forward for emptying.

This drill has given very satisfactory service for five years at this station. Barley, oats, wheat, rye, and peas have been planted. Much credit for the design and the construction of this drill is due Lucius M. Ross, formerly agronomic technician with this department, now deceased. The authors gratefully acknowledge the assistance of J. J. Koranda in providing the photographs used here.—L. J. KLEBESADEL *and* R. L. TAYLOR, *Agronomist and Senior Agronomist, Alaska Agricultural Experiment Station, Palmer, Alaska.*

ZERO TILLAGE FOR CORN FOLLOWING SOD[1]

THE concept has been advanced that zero tillage for certain soil conditions may be the ultimate limit of minimum tillage for corn.[2, 3, 4] Zero tillage means the elimination of all tillage or soil manipulation in planting corn in sod, except for the narrow slit needed to get seed and fertilizer into the soil.

Moody et al.[2] in Virginia reported growing corn without tillage following an orchard grass sod. The old sod served as an excellent mulch. However, instead of machine planting, they removed a soil core with a tube sampler, dropped in the seed, and crumbled soil on top of the seed. The first reported trials of zero tillage by Davidson and Barrons were also made in grass sod.[4]

Zero tillage was tried in New York on Honeoye silt loam over the 3-year period, 1959–61. For all trials, the crop preceding corn was a heavy growth of alfalfa containing some grass. Fertilization for corn each year was 100, 44, and 83 pounds per acre of N, P, and K, 80% of which was topdressed prior to planting and 20% applied in bands with a conventional planter at time of seeding.

Trials with different herbicides and times of application in 1959 and 1960 showed that a spray mixture of Atrazine and Amino-Triazole (3 and 2 pounds per acre, respectively) applied 4 to 6 weeks before planting was particularly effective in killing the existing sod and in controlling weeds. This was the only herbicide treatment used in 1961.

Protective crop residues left on the soil surface continued to protect the soil to some degree during the whole growing season. Probably more residues and an even better soil condition would have been present with a higher percentage of grass in the alfalfa mixture.

Yields under zero tillage, shown in Table 1, averaged 95 bushels per acre in 1960 and 128 bushels in 1961. Although not significantly different, this was 10% less than the yields under conventional plowing, fitting, and cultivating.

[1] Contribution from the Northeast Branch of the Soil and Water Conservation Research Division, ARS, USDA, in cooperation with the Department of Agronomy, Cornell University.

[2] Moody, J. E., Shear, G. M., and Jones, J. N., Jr. Growing corn without tillage. Soil Sci. Soc. Am. Proc. 25:516–517. 1961.

[3] Free, G. R. Minimum tillage for soil and water conservation. Agr. Eng. 41:96–99. 1960.

[4] Davidson, John H., and Barrons, Keith C. Chemical seedbed preparation—a new approach to soil conservation. Down to Earth 10(3):3–4. The Dow Chemical Co., 1954.

Table 1—Yields of corn with conventional tillage and zero tillage.*

Year	Conventional tillage	Zero tillage	
	Bu./acre	Bu./acre	Relative
1960	109.4	94.6	86%
1961	137.1	127.9	93%

* Differences in yields between tillage treatments were not significantly different at the 5% level.

Soil tests in 1961 just after planting showed bulk densities in the plow layer ranged from 1.03 to 1.06 g. per cc. under conventional tillage, compared with 1.19 to 1.24 under zero tillage. The corresponding comparisons of percentage large soil pores—those drained at 60 cm. water tension—were 20 to 24 for conventional, and 13 to 15 for zero tillage.

The possibilities of zero tillage for different soil and climatic conditions and for various cropping practices need further study. Results to date indicate that the herbicide treatment used in these studies is not compatible with the establishment of winter cover crops sown at the normal time of last cultivation.

In summary, on Honeoye silt loam, average yields of corn following an alfalfa grass sod without any seedbed preparation or cultivation ranged from 95 to 128 bushels per acre in 1960–61. These yields were only slightly less than yields under conventionally prepared and cultivated seedbeds.—G. R. FREE, *Soil Scientist and Project Supervisor, Northeast Branch, SWCRD, ARS, USDA, and Associate Professor, Soil Technology;* S. N. FERTIG, *Professor, Department of Agronomy, Ithaca, N. Y., and* C. E. BAY, *Soil Scientist, USDA, Marcellus, N. Y.*

COMPUTER PROGRAMMING OF YIELD DATA

COMPUTING acre yields from experimental plot samples is a time-consuming task when desk calculators are used. Time consumed in such computations becomes an expensive item in experiments with multiple-harvested crops such as Coastal bermudagrass which may be clipped five times in one season.

Modern computors with suitable programs make it possible to go from field plot yields to acre yields to statistical analysis with a single entry on appropriate information sheets.

Such procedures should materially reduce the time spent calculating yield data and the time lapse between the collection of data and its publication. Such automatic equipment would help to reduce calculation errors to a minimum with a resulting increase in accuracy of reported research.

The 1620 Computer program reads wet and dry weights of sample and subsamples and a conversion factor and computes the yield. The input is on cards and the output may be punched on cards and/or typed on the console typewriter under the control of sense switches.

The format for input cards is as follows:

Card Column	*Information*
1–3	Sample number
4–10	Plot number
11–20	Gross wet wt. of sample
21–30	Gross dry wt. of sample
31–40	Wet wt. of subsample
41–50	Dry wt. of subsample
51–60	Conversion factor

Card columns 1–3 and 4–10 are in fixed point; however, the data in fields 11–20, 21–30, 31–40, 41–50 and 51–60 must contain a decimal punched in the card. The output cards are identical to the input cards through column 60. Columns 61–70 of the output cards contain the yield. The program is written in 1620 Fortran with format control; thus, if the data are punched in a format differing from the above, the input format statement can be changed and the program reassembled.

The program was developed at the University of Georgia Computer Center.—YATES C. SMITH, BRIT WILLIAMS, *and* E. R. BEATY, *Graduate Research Assistant, Assistant Statistician, and Associate Agronomist, College Experiment Station, University of Georgia, College of Agriculture Exp. Sta., Athens, Ga.*

APPARATUS FOR TAKING SOIL-ROOT CORES[1]

MANY studies of soil-plant relationships would not be complete without adequate root data. Researchers have expressed interest in fabricating an inexpensive apparatus which would afford them the capability of taking large numbers of relatively undisturbed cores in a rapid fashion. The purpose of this note is to describe such an apparatus and to present detailed drawings which will permit others to construct it.

The apparatus is used on a tractor drawbar which has hydraulic power in both upward and downward movement. A heavy tractor, such as a 300 or 400 series International Harvester was used to give the necessary weight at the drawbar to force the steel tube into the soil. The sampling tube is forced into the soil through the use of the rachet, the hydraulic power at the drawbar, and the weight of the tractor itself (Figure 1).

Mitchell, working on Delaware soils, fabricated the original apparatus using a 6-inch diameter tube and sampled to a depth of 24 inches. (See Delaware Agr. Exp. Sta. Tech. Bul. 341, 1962 for a brief description of the original

[1] Authorized for publication on July 6, 1962 as paper No. 2681 in the journal series of the Pennsylvania Agr. Exp. Sta. The authors are indebted to John Boehle, Sr. for his preparation of the engineering drawings. Received July 13, 1962.

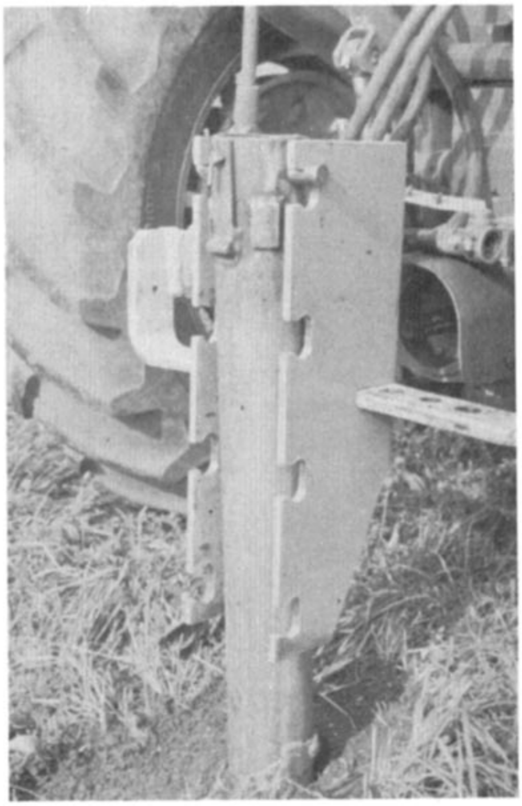


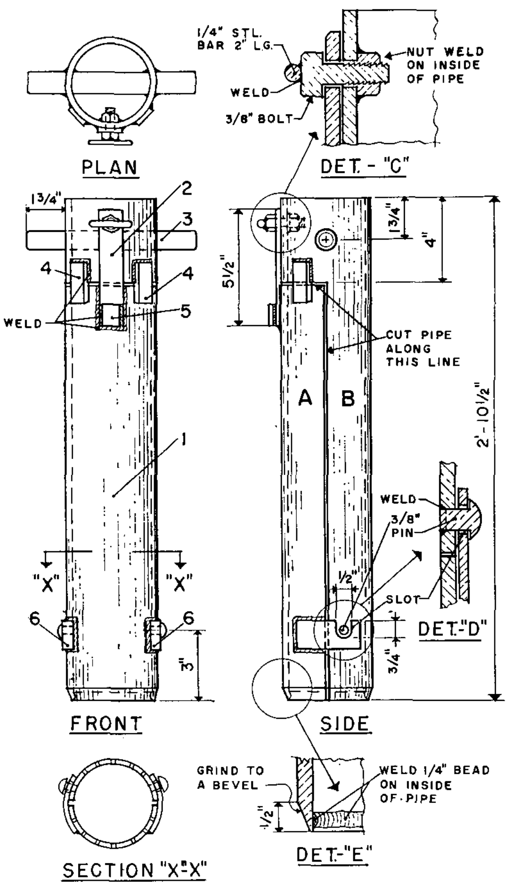
Figure 1—Apparatus mounted on tractor drawbar.

apparatus and an example of one method of handling the soil cores and root measurements.) Later Kresge, at Maryland, modified the tube to a 4-inch diameter. Boehle and Kardos modified the apparatus as described in this note. It takes a 4-inch diameter sample to a depth of 30 inches.

Figure 2 is a drawing of the sampling tube. It is fabricated from standard 4-inch inside diameter steel pipe. The pipe is cut lengthwise in half into parts A and B as shown in the side view.

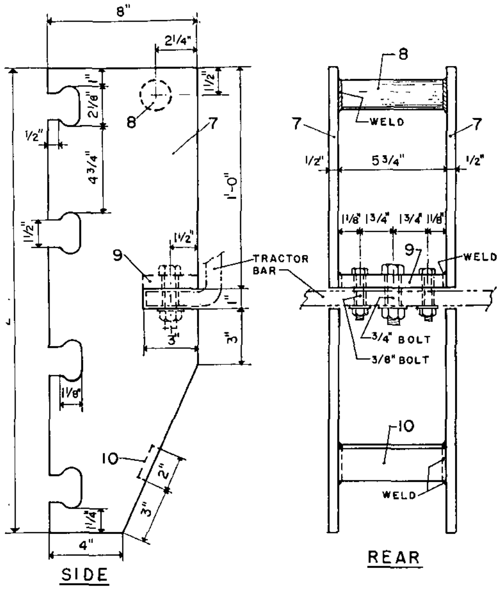
Item 6, which is welded to the A half of the tube, is locked on the B half as shown in detail D. Item 4 (front view) holds the upper half of A in place with the aid of Item 2 (See also detail C). Item 5 is a lug plate which can be used to help open the tube after a sample has been taken. Detail E shows a ¼-inch bead which is welded on the inside of the tube. This forces the sample to be smaller than the inside diameter of the tube, thus diminishing friction between the tube face and the sample. The outer edge of the tube is ground to a bevel after the weld is made.

Figure 3 is a drawing of the rachet device which attaches to the drawbar of the tractor. Items 8 and 10 add rigidity to these upright plates (Item 7). Item 8 is also used as a handle for mounting and unmounting. The spacing of the holes in Item 9 should, of course, coincide with the holes



1 — 4" DIA. STEEL PIPE
2 — 1¼" x 5½" x ¼" STEEL PLATE
3 — 1" SOLID ROUND STEEL BAR
4 — 1¼" x 2" x ¼" STEEL PLATE
5 — ¾" x 1" x ⅜" STEEL PLATE LUG
6 — 1½" x 3" x ⅛" PLATE WITH SLOT

Figure 2—Drawing of sampling tube.



7 — ½" THICK STEEL PLATE
8 — 1½" SOLID ROUND STEEL BAR
9 — 3" x 5¾" x ¾" STEEL BAR
10 — 2" x 5¾" x ½" STEEL BAR BRACE

Figure 3—Drawing of rachet device.

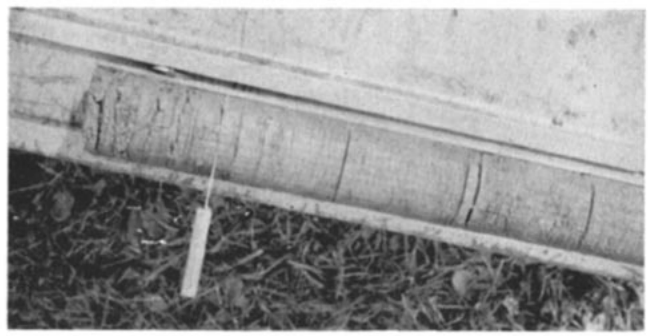


Figure 4—Picture of soil-root core prior to being segmented.

in the drawbar. Also, the notch below Item 9 should be made wide and deep enough to accommodate the drawbar. This rachet may be modified to take a larger-diameter tube simply by increasing the width of and the distance between the upright rachet plates (Item 7) at the time of fabrication.

The soils which have been successfully sampled by the respective authors are: Conotton gravelly sandy loam, Hagerstown silt loam, Lindside silt loam, Ottawa loamy fine sand, and Wallington silt loam by Boehle and Kardos; Matapeake silt loam, Norfolk sandy loam, Pocomoke sandy loam, and Sassafras silt loam by Mitchell; and Wickham loam by Kresge. It has been found, through experience, that in order to avoid difficulty and to facilitate sampling to a full 30 inches, the soil should be at a moisture status near field capacity. Figure 4 is a picture of a soil-root core taken by the apparatus prior to being segmented for storage in sample containers.—JOHN BOEHLE, JR., *formerly research assistant Pennsylvania Agr. Exp. Sta. (now Agronomist, Ortho Div., California Chem. Co.);* W. H. MITCHELL, *Extension Agronomist, Univ. of Delaware;* C. B. KRESGE, *Assistant Professor of Soils, Univ. of Maryland; and* L. T. KARDOS, *Professor of Soil Technology, Pennsylvania Agr. Exp. Sta.*

PLANT TEMPERATURES[1]

THE purpose of this note is to present some exploratory plant temperature measurements that are of interest in connection with three areas of plant research: *(1)* plant temperature as related to air temperature, *(2)* antitranspirants, and *(3)* detection of moisture stress differences between plants under different regimes. A few qualitative remarks on plant temperature measurements are in order.

The magnitude of the temperature difference either between plants or between plants and air is difficult to determine simply because we have no way of defining and measuring plant temperatures. A leaf with the surface normal to incident solar radiation will be at a substantially higher temperature than a leaf that has a large angle of incidence or one that is shaded. Thus severe sampling problems exist; further, there is no single temperature value that represents the plant and which has been demonstrated to be useful for any given research problem. Of importance also is the fact that either attaching or inserting thermal sensors may affect the plant temperature that is to be measured.

Developments in infrared thermometry in recent years have provided instruments that surmount the sampling problem—the thermal radiation from all plant surfaces in the field of view of the instrument are integrated into a single measurement. A temperature measurement with an infrared device gives a temperature with a particular definition—the black body temperature that would produce the radiation entering the instrument from plant parts in the field of view. Because the thermal radiation emissivity of green plants is high (0.95 to 0.97) the measured (apparent) radiation temperature can be converted to the plant temperature with little error. It remains to be determined if this temperature definition is useful to plant studies; however, the type of temperature sample from the radiated upper part of the plant should give weight to the plant portions participating most actively in transpiration, heat exchange, and assimilation.

Many studies relating plant growth to temperature have used the measured air temperature as an index to the plant temperature and numerous studies indicate plant response differences when the air temperature changes only a few degrees centigrade. Many micrometeorology experiments have shown that in the field the plant is rarely at air temperature. When plants grow under conditions where strong solar and thermal radiation exchange exists, the plants are often warmer than the air during the day and cooler at night. Often air advected from dry surroundings during the day may be at a higher temperature than the plants.

Energy balance considerations show that if the transpiration of plants decreases and if the radiation balance and wind structure maintain the same, the decrease in latent heat exchange will result in an increase in plant temperature. For example, estimates from the author's data for a typical day at noon in early September indicate that a decrease in transpiration of 10% from a full cover of alfalfa-brome would cause a temperature increase of about 1.0° C. (in this instance the wind at 1 m. was 3.1 m./sec., the net radiation was 660 watts/m.^{2}, and the evapotranspiration was 530 watts/m.^{2} or 0.76 mm./hr.). Thus a sensitive measurement of the temperature difference between plant samples may provide an indication of transpiration differences. This is of interest in studies on antitranspirants and studies relating moisture stress in plants to changes in transpiration, even though the measurement by itself cannot provide quantitative estimates of the transpiration difference.

In September of 1961 a Barnes[2] radiation thermometer was available for 2 short periods. This instrument is a special model of greater sensitivity than many other commercial models and has an 8–13 micron spectral band-pass filter. This filter is necessary for viewing over a path length greater than a few meters. The instrument had a 20° field of view. The output was recorded on an Esterline–Angus strip chart recorder. Some "spot" crop temperature measurements were taken of several crop surfaces. Auxilliary measurements (e.g., air temperature, radiation, soil water suction, albedo, etc.) were either scanty or could not be obtained prior to the availability of the thermometer. Moreover, the surfaces measured were not replicated. In spite of these shortcomings, the temperature measurements are of exploratory interest and are presented.

During the period September 9, 10, 1961, several crop surfaces at the Hancock Experiment Farm (soil is a Plainfield sand) were viewed in sequence. This required moving the instrument without interrupting its operation and only few measurements were made. Two surfaces, hay and potatoes, are of particular interest. The hay, a 4-year old stand of alfalfa-brome, was over 2 feet high and was two-thirds in blossom. The hay was irrigated until August 20. One section of the alfalfa, about 7 meters wide and 30 meters long, was sprayed with an emulsion of an evaporation suppressor at a rate of 1.6 g. net weight of suppressor per square meter. The suppressor was OED[3] emulsion which is a mixture of alkanols, $C_{22}H_{45}O(CH_2CH_2O)H$ and $C_{18}H_{37}O(CH_2CH_2O)H$. Its mixture in water is viscous and was sprayed with 600 psi pressure to obtain a fine mist. The application rate is heavy and is about that which Mihara[3] and co-workers have found active for suppression of evaporation from soils. Spraying was completed by 10:00 a.m. (1000 hour).

The potato plots measured were available in triplicate. Two treatments were measured: irrigated (last irrigation September 5) and unirrigated (1.27 inches rain August 19 to September 9, with 0.9 inches on September 3). No difference in symptoms of water stress could be observed visually between irrigated and unirrigated potatoes. The wind at 2 meters during the afternoon of September 9 varied from 3 to 4 m./sec. (6.7–9 mph) and on the morning of September 10 from 4.5 to 5.4 m./sec. (10–12 mph). There were only a few thin and high clouds on September 9 and the sky was clear on the following morning. Both September 9 and 10 were unusually warm days for these dates. The minimum temperatures for the preceding nights were 19.5 and 20.5° C., respectively. No condensation on leaves occurred either night.

The measurements at Hancock are presented in Figure 1. The standard deviation of readings on potato replicates was 1.4° C. This includes error due to temperature drift during the time required for instrument moves. By reading the 2 treatments alternately for 5 readings, and eliminating

[1] Contribution from the Department of Soils, University of Wisconsin. Published with the permission of the Director of the Wisconsin Agr. Exp. Sta. This work was supported in part by Army Electronic Proving Ground Contract DA-36-039-SC-80282.

[2] Barnes Engineering Co., 30 Commerce Rd., Stamford, Connecticut.

[3] Nikken Chemicals Co., Japan. OED has been used effectively by Y. Mihara and co-workers, National Inst. of Agr. Sciences, Nishigahara, Kita-ku, Tokyo (personal communication).

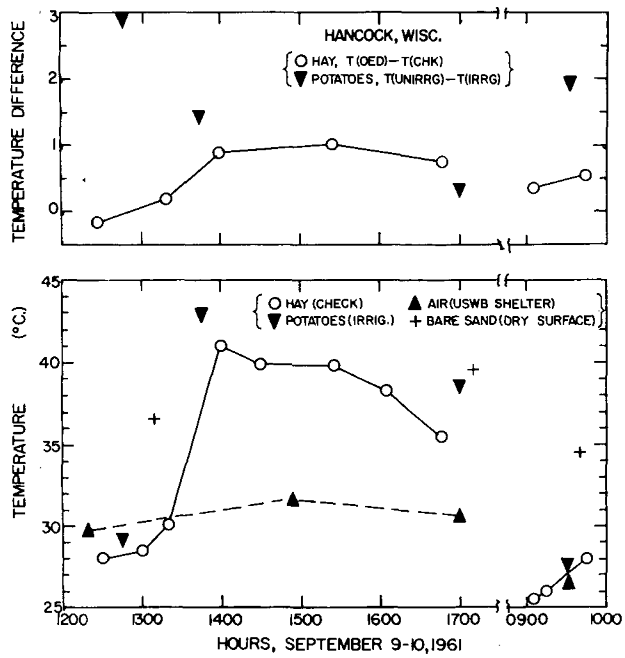


Figure 1—Temperature of alfalfa-brome hay and potato plants and of sand surface and air.

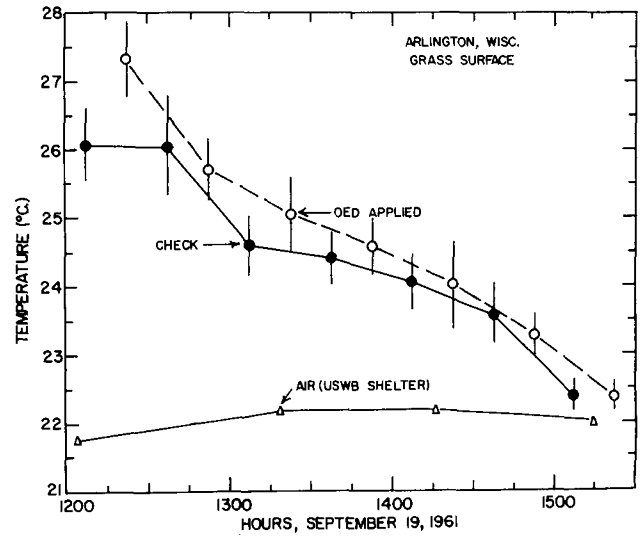


Figure 2—Temperature of grass, grass treated with evaporation suppressor, and of air.

relatively steady time drifts, the standard deviation of the temperature difference between the 2 treatments was about 0.4° C. The standard deviations of repeated readings of a given hay plot temperature (without correcting for drift with time) and of the difference between hay plots were about 0.6° C. and 0.25° C., respectively.

On September 19 the radiation thermometer was again available and the temperature was measured on 2 bromegrass areas (20 × 35 feet) at Arlington, Wis. (soil is Parr silt loam). The grass on both plots was about six inches hight. One plot was sprayed with OED at rates described above on September 18, 12:30 p.m. The dewpoint was 10° C. at the beginning of the measurements and was 9.5° C. at the end. A total of 4.4 inches of rain accumulated September 12–14 and from September 14–19 skies were clear with no rain. During the afternoon of September 19, there were no clouds and the solar radiation varied from 770 watts/m.^{2} at noon to 490 watts/m.^{2} at 1500.

The temperature measurements on the grass plots were made holding the thermometer on a stand, reading each plot for 15 minutes alternately. The recorder trace was averaged over each 16 minutes to give the temperature plotted in Figure 2. The temperature trace fluctuated (primarily wind effect on surface temperature) and the maximum peak to peak range of the fluctuation in each period due to occasional strong gusts or to wind decreases of short duration is shown as a vertical bar through the data points. The standard deviation was considerably less than the peak to peak range and was about 0.2° C.

The data of both figures clearly indicate that plant temperatures may be greatly different from air temperature. Plant temperature measurements made with black and white "economical" radiometers[4] gave similar results. Alfalfa temperatures 5 to 10° C. below air temperature at night and 5 to 10° C. above air temperature during parts of the day have been frequently observed. This raises doubt as to the value of air temperature as an index of plant response, particularly if short periods of extreme (high or low) temperatures may affect the plant.

The temperature results from the evaporation suppressor treated plants are somewhat uncertain. Though a small but real temperature difference was found, the lack of replication and the fact that the plant albedo may have been different makes any definitive conclusion impossible. At any event, the transpiration difference would not be much greater than about 10 to 15%.

The abrupt increase in plant temperature about 1330 to 1400 is of interest. There was no associated abrupt meteorological change to account for this temperature increase. The increase could be accounted for by a decrease in transpiration due either to an increase in moisture stress in the plant or to stomatal closure for other reasons. Several days had lapsed since irrigation and both the hay and the irrigated potatoes could be suffering from moisture deficiency, particularly in the afternoon on the Plainfield sand with its low conductivity. Instrument error may be suspected but the measurements of the bare sand were consistent with proper instrument performance. The temperature difference between the irrigated and unirrigated potatoes also is consistent with stomatal closure. The largest differences were found at the 1230 on September 9 and 0930 on September 10 when the difference in soil moisture between treatments would result in the greatest difference in transpiration. Stomatal closure would decrease the difference in transpiration.

Though these data are incomplete, they do support a conviction the author has held since beginning micrometeorological work about 7 years ago—that plant temperature may be a valuable qualitative index to differences in plant water regimes. Coupled with a better understanding of transfer processes at the plant surfaces, they may serve to provide quantitative data on plant-water status.—C. B. TANNER, *Professor of Soils.*

[4] Swan, J. B., Federer, C. A., and Tanner, C. B. Economical radiometer performance, construction, and theory. Soils Dept. Bul. 4, Univ. of Wisconsin. (1961).