machinery, the same or possibly less labor is spread over a greater number of acres, thereby lowering the per-acre or per-unit cost of product. Similarly, the addition of more fertilizer, the use of more and better seed and spray, which increases yield per acre, provides more units of product to pay for the cost of labor, land and equipment. They are thus lowering per-unit cost more than they are increasing the cost per acre.

Data are not available for further comparison of the cost of other vegetable crops during a pre-war and a post-war period. We can, however, compare two 3-year post-war periods for selected vegetable crops in the major producing areas of Florida, Table 1. Average yields per acre increased on most crops and in most areas from 1946-48 to 1949-51. Notable reductions in yields occurred only for snap beans and cabbage in the Everglades Area and for cucumbers in the Manatee and Sumter County areas. Behind these data lies the inescapable fact that weather is still a very important factor in determining annual yields of Florida's vegetables.

The total cost per unit for growing, harvesting, packing and initial selling of the vegetables shown has increased for snap beans, cabbage, cucumbers and green peppers in most areas. Decreases in per-unit costs may be noted for celery, Irish potatoes and tomatoes in all areas listed.

Gross returns per unit were higher in 1949-51 than in 1946-48 only for snap beans in the Pompano Area, cabbage in the Everglades and green peppers in Lee County. In all other areas and for all crops shown gross returns were lower during the most recent 3-year period. Net profits per unit of product were lower in 1949-51 than in 1946-48 for all crops except celery in the Everglades and Sarasota Areas. The margin of profit on which the average vegetable grower operates is lower now than it has been for several years. It is lower, too, than consumer prices would lead the general public to believe.

SOME DEVELOPMENTS IN CORN SPRAYING EQUIPMENT APPLICABLE IN THE EVERGLADES

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The solution of many production problems and the development of favorable markets since 1946 have caused an increase in sweet corn production in Florida. Acreage of the crop has increased from 6000 acres in that year to 29,000 acres in the 1949-50 season, and current estimates are all greater for the 1951-52 season. This significant change in Florida's agriculture must be credited to many associated developments all leading to the placement of high quality corn in the hands of the consumer. Efficient precooling and fast transportation facilities combined with modern refrigeration are of extreme importance, but they can only maintain high quality delivered to the packer from the field.

1/ Numbers in parentheses indicate titles in “Literature Cited.”

Climatic conditions in the Everglades are generally favorable to development of plant diseases and insect pests, and extensive culture of sweet corn could not be realized until suitable varieties were available and insects such as earworm, silk fly maggot, and budworm could be successfully controlled. The results of early experiments, and the “pack out” of initial commercial plantings soon showed that dusts could not be relied upon for control of insects in seasons of heavy infestation. (The same later proved to be true of the leaf-blighting fungi). The entomologists then developed an effective spray control program for these pests and acreage began to increase rapidly. As the acreage mounted disease problems also increased, and it was necessary to develop chemical spray programs for their control. This intense program greatly increased the requirements of spraying operations and forced the development of specialized high clearance, high-gallonage corn spraying equipment.
Corn spraying presents problems in equipment and method somewhat different to those found in spraying many other crops. This is especially true in the Everglades because of the low flotation encountered on the muck soils of the area. The insect spray program demanded accurate placement for control of the pests attacking the center whorl and the ears, while the fungicide program was concerned with overall coverage as well as whorl placement. Combined applications of pesticides may often require a 3 to 4 day spray schedule, and plantings in the area are generally quite large. These are some of the reasons why specialized machinery is being developed.

This repeated spraying of large acreages of corn is a relatively new practice, and as yet most farm equipment manufacturers have not developed what could be considered standard corn spraying machinery. Some advancements have been made in development of such machinery, however, and are presented here to show how the job of corn spraying is being done in the Everglades.

**Spraying Machines in Commercial Use**

**COMMERCIAL MACHINERY AVAILABLE** — The Warren spray unit is the only commercial high clearance spraying machine in general use in the Everglades. This unit has a relatively low center of gravity which is made possible by special assembly of basic units from International Farmall tractors. A supplemental frame and 300 gallon supply tank are constructed to give a maximum of crop clearance. Oversize tires are used for flotation. The use of the Warren sprayer for corn requires some modification of row spacing in the Everglades. The center two rows of each six row swath must have 40 inch middles for clearance of the rear wheels and supply tank. The other rows are set to 36 inch middles. Figure 1A shows this unit.

A few growers have modified standard low level spraying equipment by the addition of high clearance "T" booms. When this system is used it is necessary to leave spray middles for passage of the machinery. This of course causes yield loss since nothing can be grown in the spray middles, but it does permit the grower to use conventional equipment for corn spraying. Figure 2A shows a line drawing of one type of "T" boom modification of a standard spraying machine.

Growers in other areas with difficult pest control programs requiring high gallonage applications, are using the largest available commercial orchard type sprayers equipped with outrigger booms. One of the advantages to the outrigger assembly is that the area of crop sprayed from one middle is double the boom length in a complete spray round, but off center loading presents some difficulty in accurate vertical nozzle placement. Figure 2B shows a line drawing of how such a large wheel type machine could be converted to a truss-wheel-track wagon with a large capacity pump and tank for large operations in the Everglades. The indicated hydraulic controls for the boom are developments that can reasonably be expected as manufacturer's standardizations.
LOCAL GROWER DEVELOPMENTS -
The lack of suitable commercial spraying equipment has forced growers to meet spray requirements by designing and building their own spray rigs. The most serviceable units have been built on the so-called Everglades swamp buggy. A standard truck chassis is equipped with airplane tires and the front wheels are stabilized with braces and pivot connections. This allows the wheels to act independently and the unit remains level while in motion. The pump and supply tanks are generally center mounted and booms and drops are built to meet the individual growers requirements. Figure 1B shows one of these high clearance spraying machines built in the Wedgworth plantation shop near Belle Glade. This machine differs from others of the same type, in the mounting of two supply tanks between the wheels. This gives better crop clearance, but present problems in equal tank suction and mixing of the spray load.

AN EXPERIMENTAL SPRAY MACHINE

Stoner (3) in 1950 had shown that control of northern leaf blight of sweet corn was possible experimentally with fungicidal sprays. Applications in these experiments were made with a hand wand. Consequently the application of the results to field spraying operations was uncertain. A decision was made to build an experimental power sprayer for further control investigations so that data obtained could be used directly by the grower. Since the machine was to be primarily for small plot use it was necessary that the following characteristics be incorporated: adjustable high clearance, minimum vertical displacement, maneuverability, speed control, spray pressure control, quick changing of materials without contamination of mixtures, ease and speed of cleaning, corrosion resistance, and rapid filling.

At first appraisal this would seem to be too much to incorporate in one unit. However, a high-clearance, tricycle type, low-gallonage spray-rig possessing many of the basic features
was already in existence at the Everglades Experiment Station. This so-called "Everglades Mule" had been developed to meet special needs in the application of herbicides and insecticides. The machine used a conventional automotive transmission and enclosed gears instead of open chain drives. Engineering details of the machine have been reported by Randolph and Dull (1, 2). This is the machine that was modified to meet the service needs of the experimental corn spraying program and adequately fulfills field trial requirements such as those specified by Wilson (4).

HIGH CLEARANCE—Overall high clearance was built into the machine as a unit. Adjustment to the growing plants is obtained in three ways. The base height of the header boom is determined by placement of the bolt mounts on the machine chassis. (Figure 1C-A). Nozzle drop length is also part of the basic height. Various drops can be quickly coupled to the header boom as needed. Fine field adjustments are rapidly and easily made by a spring counter-balanced lever situated near the driver's seat. (Figure 1C-B). This lever will move the header boom 24 inches vertically through a four-bar linkage that supports the header boom. Entire boom assemblies for this machine are quickly interchangeable. Thus, the machine can be used for several types of application experiments with little loss of time.

VERTICAL DISPLACEMENT — Tricycle construction presents the least cross sectional area which can be obtained with a self propelled unit. In this machine the two cylinder 10 H. P. Onan K-MS drive engine is cross mounted in front of the front drive wheel 47 inches from the ground (Figure 1C-C). When shielded, the engine in this position does not materially interfere with the plants. The upper level drive shaft is located close to the front drive wheel (Figure 1D-A). The tanks are tapered, curved sections mounted longitudinally within the width limits of the drive wheel. (Figure 1D-B). These features prevent damage to the plants.

MANEUVERABILITY AND SPEED CONTROL — The power from the drive engine is transmitted through an automatic Mercury clutch and "V"-belts to a sheave on a cross mounted four-speed Ford truck transmission with a reverse gear (Figure 1C-D), and thence through two sets of bevel gears to the front drive wheel. The twin cylinder drive engine is smooth running and particularly sensitive to throttle adjustments. The use of the Mercury clutch eliminates the necessity for manual clutch control. The movement of the machine is largely controlled by the hand throttle, since clutch engagement is determined by engine speed. Some of the advantages of such fine control are minimum use of the foot brake, availability of drive engine power to facilitate turning, smooth operation at low speeds in any gear, and a minimum of gear shifting. These factors all save time and enhance the maneuverability of the machine. Ground speed of the machine is indicated by a low range speedometer located on the handle bars in easy view of the operator. Actual rate of application is dependent upon ground speed, pressure, and size and number of nozzles. All
of these factors can be controlled and a wide range of conditions duplicated with the modified Everglades Mule. The investigator can, with this machine, study spray patterns and test nozzle designs for specific spraying conditions.

THE LIQUID SYSTEM — Pesticides are often corrosive compounds and for this reason the principal parts of the liquid system of the unit are made of corrosion-resistant materials. Spraying solutions are carried in three separate 35 gallon stainless steel tanks, which are connected to the pump through common intake and return manifolds. Three-way and two-way valves are so located that any tank may be used. Strainers, cleanouts and plugs are so placed that mechanical cleaning of any portion or the total system is facilitated. When material in tank number one has been applied the return from tank two is used to flush the system and dumped to tank one or on the ground through an out valve. Tank three follows in like manner. If treatments are applied where spray materials are used singly and in combination six treatments and a check are possible from the three tanks at one delivery pressure if the cleanout is dumped outside the system.

FILLING — The tanks can be filled from the tops with the usual standpipe or with a venturi tube connected by hoses to the manifold system. This unit is placed in a screened sump in a ditch and with a pump pressure of 300 pounds will fill all tanks (105 gallons) in 3 to 5 minutes depending on the manifold valve settings. This quick filling venturi attachment saves time, and the use of field water sources coincides with grower practices.

SOME MECHANICAL FACTORS AFFECTING COVERAGE

The object of any good spraying program is complete protective coverage of the plant with the proper material. The three related factors of nozzle type, spray pressure, and pump capacity will determine the effectiveness of the spraying operation after the problem of nozzle placement has been met.

NOZZLE SELECTION — It will be up to the grower to choose the pattern of nozzle used, but the fish tail, or solid fan, type has been used successfully in experimental corn spraying at the Everglades Experiment Station. Narrow-angled nozzles give greater penetration into the whorl of the plant, and wide-angled nozzles allow side or zonal coverage with fewer outlets. The size of orifice used is determined partially by the physical characteristics of the spray mixture, and the gallonage necessary for complete wetting of the plant surface. In general fine nozzles are used for true solutions or oil emulsions, and larger orifices are necessary for suspensions. Nozzles with a 0.036 inch orifice, trade designated 0.02 on the basis of delivery capacity, have proved satisfactory in experimental and commercial spray work using materials currently recommended for insect and disease control on sweet corn.

SPRAY PRESSURE CONTROL — Control of spraying pressure is necessary if an accurate,
effective amount of spray material is applied, and proper nozzle action maintained. Spraying units which derive pump power from the drive unit may have fluctuating spray pressure below a given speed. (Figure 3 shows nozzle angle changes and output fluctuations at varying pressures). Consequently, it is highly desirable to have pump power independent of the prime mover. Independent pump power also allows adequate agitation of the spray mixture regardless of ground speed. If pump power must be derived from a take-off of the prime mover it will be necessary to know and maintain the minimum RPM required for the desired spray pressure. This means that ground speed will be correlated closely to coverage and output with this type unit.

PUMP CAPACITY — The capacity of the various spray pumps in use is determined at a given pressure and speed. This speed must be maintained, or the capacity at lower speeds known, to calculate actual spray output in relation to the size and number of nozzles in use. The total output is limited by pump capacity and the size and number of nozzles must not exceed the capacity at a given speed or the pressure will not be maintained. These figures must be considered in relation to the maximum necessary output of the spray program. Figure 4 shows the relation of pumps of various capacities to number of nozzles, orifice size, ground speed and output per acre, and is given as a method for determining the acreage that six different spray units can adequately handle per hour of operation. Calculations for this Figure incorporate correction factors for filling time, mixing, and end turning. The following example shows how to use the diagram of figure 4.

A crop of 150 acres must be sprayed on a 3 day schedule on the basis of a 10 hour day. The question then, is what size spray unit will adequately meet this schedule throughout the growing season. A minimum of five acres must be sprayed per hour. Locate the 5 acre per hour horizontal line on the left vertical scale. Look to right along this line for limits of various machines indicated by the intersection of the 5 acre per hour line and lines, designating the various units. All units, above this line failing to intersect have more than adequate capacity. Various intersections show limits of the respective units in relation to the number of nozzles per row in use. Thus machine II, spraying six rows is limited to 2 nozzles per row under the stated conditions. Machine III, spraying 8 rows can meet the conditions using up to 5 nozzles per row, and with good weather and slight overtime could handle six nozzles per row. Machine III is the unit of absolute minimum capacity for 150 acres of corn under the stated conditions.

The above does not allow any factor for emergencies. For practicality the grower should use a machine of greater capacity, or have supplemental spraying equipment available. Early in the program when fewer nozzles are required, maximum efficiency can be obtained by the addition of auxiliary boom extensions to spray additional rows. This will reduce time requirements per acre.

Appropriate corrections to minimum and maximum capacities of a given spray machine in relation to ground speed, gallonage per acre, nozzles per row (at the stated rows per machine) and capacity of supply tank can be determined on the diagram at the intersection point of the lines representing two or more known factors.

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