Mechanized Agriculture

engineering applied to farm problems enables 15% of the population to feed the nation with surplus for export

Roy Bainer

In California less than 10% of the population is engaged in operating 140,000 farms—a condition representative of the United States.

One hundred years ago, 85% of the nation's total population was engaged in agriculture in order to feed themselves, as well as the other 15%. Today, the figures are reversed—15% of the population produces enough food for themselves and the other 85%. Actually a surplus is being produced that is going to other parts of the world at the present time.

It is doubtful if any period in history has contributed so many changes in agricultural practices as have taken place during the past 20 years through the mechanization of agriculture.

The major changes in the field of power have been: the application and acceptance of the Diesel engine in farm tractors; rubber tires on tractors and other field equipment; high compression engines in tractors; the variable speed governor; the continuous running power take-off; better engine protection, including improved air and oil filters; increased use of the general purpose tractor with integral equipment; hydraulic controls and the torque converter.

The number of California farms receiving electric current has doubled. The average energy consumption for 78,000 farms in northern California, served with electric current during the past year, amounted to 25,000 kilowatt hours. When converted to horsepower hours, this is equivalent to the output of a 40 horsepower tractor for the period of 1,000 hours.

Seed processing practices—decortication of sugar beet seed; coating of small, irregular shaped seeds; second cut and acid delinted cotton seed; all aimed at more uniform planting—have appeared. Planting equipment capable of uniform metering of seed is fast becoming available. Crop thinners working on a random principle or actuated more precisely by an electric eye are in the picture.

The airplane has become a farm tool. Today 90% of the California rice crop is seeded from the air. A large portion of the crop is fertilized and covered with selective weed sprays by plane. In addition, the plane is used for applying insecticides and defoliants.

The changes in the harvesting picture include: power mowers, improved side delivery rakes; pick-up choppers, green forage harvesters; most of the development in pick-up balers—including slicing and automatic tying; bale and sack loaders; self-propelled combines; accessories such as rubber covered rolls for beans and flax; trends toward bulk handling of grain; artificial drying of grains such as rice and grain sorghums; sugar beet harvesters; cotton pickers; general acceptance of corn pickers; suction harvesters; brush pick-ups for nut crops; tree shakers; steel squirrels; pneumatic shears for pruning; and blowers for frost protection.

Great strides have been made in developing equipment for preparing land for irrigation. The land plane belongs to this era. In addition to giving the farmer control over the amount of water applied, the portable sprinkling system has permitted the farming of acres that are too rough for economical leveling.

New developments in chemical herbicides, insecticides, fungicides and defoliants are a constant challenge to the manufacturers of application equipment.

Changes in agricultural practices, such as noncultivation of tree crops and vines and chemical weed control, may have a far reaching effect upon tillage equipment. Permanent irrigated pastures, of which there are over 600,000 acres at the present time will affect the demand for haying equipment. The acreage in irrigated pastures, which is equal to the combined acreage in sugar beets, beans and potatoes, is almost sure to be increased. More pastures will be required to meet the demand for more meat animals in California. Part of the land for this purpose will be provided in new areas where irrigation water will be made available, such as the Folsom project. Other land will become available due to the curtailment of acreages in other crops.

These new developments in practices and equipment, while not complete, give some idea of what is taking place. In some instances the equipment is so new that widespread adoption has been impossible. A sample case is the mechanical cotton picker. Between 800 and 900 of these machines will pick 10% to 15% of California's cotton crop this season.

Immediately following the acceptance of processed seed, a demand arose for improved planting equipment. Growers recognized that the use of the new seed in planters capable of uniform metering and placement offered further possibilities in labor saving during the thinning operation. Furthermore, improved stands offered the possibility of substituting mechanical thinning for the hand operation. A planter development program was inaugurated which resulted in the development of equipment capable of metering one seed at a time and placing it in the furrow in a uniform manner.

The present interest in coating or pelleting certain small seeds has worked in well with this program. Some experimental work was carried on using precision equipment for planting pelleted tomato seed. Approximately four coated seeds were planted to the foot—.15–.2 pound of original seed an acre—in rows that were five or six feet apart. The stand thus obtained was thinned to approximately 50 plants a 100 feet. A 95-acre field planted with coated onion seed at the rate of 10 seeds a foot gave a final stand of six plants a foot. Precision planting equipment has been used for planting spinach, peas and beans. Some work is under way in the Salinas Valley with coated lettuce, cabbage and broccoli seed.

Preëmergence spraying for weed control in certain crops offers some promise for eliminating early competition with weeds which might encourage further attempts toward mechanical thinning.

Cotton production in California is falling into the mechanical pattern.

Experimental work indicates that cotton can be planted to final stand, thereby eliminating chopping. However, mechanical chopping has certain advantages where weed growth is encountered. A uniform stand of cotton lends itself to mechanical thinning quite well. The field losses occur because of the inability of the mechanical picker to harvest all of the cotton from the lower part of the plant. Plant breeders are working toward changing the characteristic of the plant to the extent that it will not set bolls on this part of the plant. The lowering of grade is primarily due to trash, weeds and staining by green leaves. More work is underway toward better defoliation of the plant prior to harvest. The weed problem is the real bottleneck in a complete

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MILK

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prices paid by Midwestern creameries and the net value of butter and nonfat solids. There is some evidence that California prices were relatively low from mid-1947 to mid-1948, but the actual and formula prices have been nearly identical for the past year.

The price calculations for condenseries—shown on the upper graph—do not show such a close relation to actual prices. While the prices paid by California condenseries increased rapidly during the last half of 1947, this increase lagged behind the increase in Midwestern condensery prices and the net value based on the price of evaporated milk. California producers were at a disadvantage compared to Midwestern producers until September, 1948. During the last of 1948 and the first quarter of 1949 this situation was reversed and California producers enjoyed an advantage ranging from 25 to 40 cents per 100 pounds of milk above adjusted Midwest prices. Since April, prices in the two areas have been nearly identical.

Prices paid producers by condenseries in California and in the Midwest were nearly $1.00 per hundredweight below computed net values throughout all of 1948 and 1949. The rapid drop in producer prices from September, 1948, to June, 1949, brought some narrowing of this margin, but paying prices were below estimated net values by more than 75 cents per hundredweight during the summer of 1949. Increases in producer prices during the fall months—reflecting normal seasonal patterns plus increases in Government support prices—plus more recent drops in the price of evaporated milk reduced the margin to less than 40 cents in November. This is about as low as the margin during the fall months of 1947.

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TREATER

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uniform application of soluble or wettable fungicides or insecticides to all types of seed.

In the operation of the treater, seed is metered into one end of the rotating drum—three feet in diameter—and is spilled out of the opposite end after being treated. On the inside of the drum is a liner made from sheets of corrugated aluminum roofing. As the drum rotates, the corrugations carry seed up from the bottom, spreading it over a band about one to two inches thick, extending from the lowest part of the drum up through an angle of 80° to 100°.

The spray material is directed onto this band of seed by a fan-type weed nozzle mounted inside the drum about two feet from the inlet end.

The corrugated liner is self-cleaning because of the absence of sharp corners, the flatness of the corrugations with respect to the drum, and the resultant scouring action of the seed.

To obtain a constant rate of application or dosage of the treating material, it is necessary that the seed be accurately metered into the drum at a constant rate and that the nozzle flow rate be constant. Metering of the seed is accomplished by means of a 4½-inch diameter vaned wheel 14 inches long, which maintains a practically constant volumetric rate at a given number of revolutions per minute.

The spray system is the most involved part of a spray-type seed treater and is the part most likely to give trouble in field use, primarily because most of the presently used treating materials are insoluble powders which must be kept in suspension—usually in water—during application. Continuous agitation of the material in the spray tank is required, and the suspended materials tend to clog screens and nozzles.

Nozzle pressures from 25–60 pounds per square inch were found to be satisfactory for treating seeds such as sugar beets, on which uniform coverage is difficult to obtain. The lower pressure is more desirable from the operational standpoint, as it allows the use of a larger nozzle and thus reduces the tendency to clog.

Pressures somewhat less than 25 pounds per square inch can be used when treating smooth-coated seeds, such as beans, where redistribution from seed to seed contributes to uniform coverage.

In general, the uniformity of application obtained with a particular spray pattern, especially on seeds where there is no appreciable redistribution, is affected by the following conditions:

1. Small seeds are more difficult to treat than larger ones, because the chances of exposure when passing down through the spray zone are fewer.

2. Uniformity of application improves considerably as the seed rate is decreased.

3. Increasing the drum speed improves uniformity of coverage. However, speeds much above 25 revolutions per minute are not desirable because seed would tend to shower down through the spray or carry over the top.

4. Increasing the drum slope below horizontal improves uniformity, until a slope is reached where the seed band becomes so thin that it is unstable and has excessive slippage on the drum.

This seed treater is essentially a high capacity constant rate machine and is not particularly suited to the treatment of small lots of seed.

The maximum seed rate is determined by the ability of the machine to apply the treating material uniformly. The minimum seed rate when applying materials suspended in water is determined chiefly by the minimum size of nozzle which can be used without clogging and by the maximum percentage of moisture which can be added to the seed. The principal problems encountered in the use of such a treater are:

1. Clogging of nozzles and screens by suspended materials. Proper selection of nozzle and screen sizes minimizes this problem. The use of soluble or liquid materials and the improvement of present formulations of insoluble materials would also help.

2. Abrasive action of suspended materials. Pump troubles have been eliminated by use of a pressurized supply tank with the agitator shaft entering from the top. Erosion of nozzles apparently can be kept within reason by use of stainless steel instead of brass.

3. Settling of suspended materials in pipe lines. Overcoming this problem requires the use of small-diameter lines to maintain adequate velocities and involves flushing the lines with air or water whenever the machine is shut down.

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MECHANIZATION

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mechanical program. Work aimed at better weed control is now underway.

California ranks 9th in total cotton acreage, 4th in total yield, and 1st in yield per acre. The high yield, plus a mechanical production program, along with the absence of certain cotton insects, will keep California in cotton production in competition with the rest of the country. The labor requirement on a 90-acre test plot in Fresno County last year was reduced from 160 man-hours per acre for hand methods to 40 man-hours for the mechanical system.

High speed mowers, new rakes, automatic balers and loaders, and field choppers have reduced much of the labor requirements for hay making.

Mechanical tree shakers have become quite common as an aid in harvesting prunes, walnuts and to a limited extent almonds. Sloping catching frames, under the trees, collect and deliver the fruit to field boxes. Vacuum and brush pickups have appeared for gathering nuts off the ground. Pneumatic shears and portable pruning towers offer promise in labor saving in orchards.

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WATER

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water are not carefully examined when additional supplies are secured.

Ground Water and the Courts

Until recently the sole limitations imposed by the courts upon rights to pump were that the water should be put to a reasonable beneficial use, and that, in the event of a shortage, water could not be exported from a ground water basin. Even this latter rule was modified by the provision that if a party other than an owner of lands overlying the ground water basin obtained water for a period of five years without being served with an injunction, his right was secure. Neither of these rules provides an effective control over competitive pumping and overdraft.

This year the California Supreme Court has attempted a more satisfactory solution. In an important decision—the so-called Raymond Basin Reference Case—it was ruled that mutually prescriptive rights had been established as between landowners and others pumping from an overdrawn basin, and draft was limited to *safe yield* by a proportionate reduction of pumping by all users.

Important Problems Remain

The court has power to allocate rights only in cases brought before it. Should the entire burden of apportioning pumping rights be left to costly litigation? Should legislation provide administrative control over overdraft? If so, what form should such legislation take? Is an all-round reduction of pumping rights the most desirable basis economically and socially for preventing overdraft? Is a period of five years appropriate for establishing whether pumping by outside users is causing overdraft?

There is an elaborate system of statutory and administrative controls upon the use of surface waters. Social institutions governing the use of ground water are at once less diverse and less adequate.

Further Studies Needed

Most of the research relating to ground water problems in California has been concerned with the physical aspects of overdraft. While it is necessary to continue such studies, the most urgent need is an understanding of the economic and social causes and effects of overdraft in their regional setting and historical development. With such an understanding, the various attempts which have been made to deal with the problem of overdraft, and the reasons for their success or failure can be investigated. Possible improvement of the social institutions under which ground water is used in California might then be explored. The Giannini Foundation is undertaking a series of ground water studies with this end in view.

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The first of the Giannini Foundation Ground Water Studies, "Ground Water in California—the Present State of Our Knowledge," may be obtained without cost by addressing the Agricultural Information Office, 22 Giannini Hall, University of California, Berkeley 4, California.

MECHANIZATION

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Farm tractors have also received considerable attention in recent years. Much interest has developed in new small general purpose tractors. The latest has a rear-mounted engine which gives the operator full vision of the attached equipment. These small units have a full complement of attached tools and are adapted to the 40- and 50-acre farm.

Hydraulic controls for both mounted and trailed machines give the operator complete finger-tip control of his implements. The shifting of a simple control raises or lowers a plow or angles a disk harrow through a properly placed hydraulic cylinder.

While many of California's field crops are lending themselves to mechanization, the fruit and vegetable industry still has a long way to go. Many operations connected with the fruit industry can never be mechanized because human judgment is necessary in such operations as pruning, thinning, and harvesting.

A successful onion harvester has been developed recently and a group of flower bulb growers in San Diego County plan to try it hoping to solve some of their harvest problems with it.

An electronic grader and color sorter is under development. The machine, while originally designed to separate lemons into six sizes and five color grades, may have other applications.

The sorting of adobe lumps out of beans is no problem with a new machine that uses the difference in skin friction between the two for effecting a separation.

These are some of the many significant changes in the farm equipment field as well as in the agricultural practices in California during the past 20 years.

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The foregoing report is a condensation of a paper presented before the California Farm Equipment Dealers Association in Santa Barbara, November 11, 1949.

PIPE

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them, but this has not yet been verified. It may be desirable to avoid the condition where the pipe is alternately wet and dry. On slopes, this can be done by using float valve stands. Where this is not practical, loose fitting but rather air-tight covers placed on top of all stands should have somewhat the same effect. These should cut down on the circulation of air through an empty or partly full pipe, this permitting the building up of humidity in the pipe. Humidity without actual wetting is surprisingly effective in causing some wetting expansion. Expansion at constant temperature has even been observed when the relative humidity was increased from 32% to 48%.

As the pipe is laid, an initial backfill should proceed behind the pipe, say, not less than two sections nor more than five sections behind actual laying; this initial backfill to cover the pipe to a depth of at least six inches. If the weather is humid and somewhat overcast, or if the initial backfill soil is somewhat moist—above the permanent wilting percentage—no other precautions are necessary. Otherwise, the initial backfill soil should be wet—from a tank truck if necessary. Such precautions will take the peak off of wetting expansion, but a desirable amount will still be retained. The pipe should be dry at the time of laying.

Pipe lines should be plugged as much as possible to prevent air circulation during laying. Open ends should be plugged when the work stops for an hour or more, and should be kept plugged until water is placed in the pipe line four days to a week following laying.

Expansion joints and presoaking of the pipe before laying are to be avoided. Riprings imbedded in the pipe are ineffective.

More trouble is experienced in adobe clay soils than in other types. In such soils it is suggested that a 4-inch layer of sand or sandy loam be placed on the bottom of the trench, and, as much as possible, similar soil be used for the initial backfill. Such precautions should prevent most such trouble.

Other procedures and practices—such as uniform line and grade, at least two feet cover over pipe, banding—are more or less customary.

Plain concrete pipe lines have been and still are the most desirable and efficient means of distributing irrigation water on the farm for surface irrigation. Where water is scarce, as in southern California, their use is almost axiomatic. Previously there has always been a small percentage of failure of such systems. Recent investigations of the College of Agriculture point the way to slight modifications in

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BUDS

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The part that light of varying intensity may play in retarding or hastening the ending of the rest is still not very clear. It may at winter intensities and duration be a retarding influence and become a stimulating influence at the higher intensities and longer duration of spring and summer.

The gardner and orchardist in regions of mild winters is thus confronted with a rather complicated situation involving temperature, light, variation of response of different kinds of plants, and possibly other factors, all of which affect spring growth. It appears clear from experience, however, that shade in winter is beneficial for plants with strong rest periods. It seems a reasonable deduction from the experimental results described above that plants subjected to fluctuating outdoor conditions may require a longer exposure to break the rest of buds than would be required under continuous low temperature.

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The above progress report is based on Research Project No. 989.

PIPE

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fabrication and installation procedure that should largely eliminate such failure at no appreciable increase in cost.

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The above Progress Report is based on Research Project No. 860.

SOILS

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applied fertilizer could be expected—provided other elements were not limiting.

No-nitrogen yields above 50% indicate high nitrogen supplies and little chance of field response to fertilizer.

Soils giving a no-phosphorus yield of 20% or less are so low in available phosphorus that they will, as a rule, produce a field response to applied fertilizer where other nutrient elements, specific soil conditions and water are not restrictive.

Phosphate responses in the field were especially noticeable during the cooler seasons of the year.

Soils producing no-phosphorus yields above 30% probably will not justify phosphate fertilization.

Low phosphate levels appear to be widespread in California, especially in hardpan soils and in the soils in the hills and mountains.

In contrast, the recent alluvial soils are somewhat better supplied with available phosphorus and have the additional advantage of having great depth which provides a large nutrient reservoir.

Available phosphorus in soils with either pronounced acid reaction or with pronounced basic—alkaline—reaction tends to be in low supply. Soils which are neutral or with only slight acid or alkaline reactions are, on the average, better supplied with available phosphorus.

Of the 105 soils tested which had a pH—the measurable acidity and alkalinity—of below 5.9, which indicates strong acidity, 79% were low in available phosphorus.

Of the 20 soils tested which had a pH of above 8.3—markedly alkaline—80% were low in available phosphorus.

Of 116 soils slightly off neutral only 26% were found to be low in available phosphorus.

Nearly all of the soils investigated appear to be well supplied with potash for the requirements of the crops used in this study.

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—now ready for distribution—

Each month, new publications of the College of Agriculture are listed in this column as they are received from the press.

Single copies of these publications or a catalogue of Agricultural Publications may be obtained without charge from the local office of the Farm Advisor or by addressing a request to: Publications Office, 22 Giannini Hall, University of California, College of Agriculture, Berkeley 4, California.

DAIRY FARM MANAGEMENT IN CALIFORNIA, by Arthur Shultis and G. E. Gordon. Ext. Cir. 156, September, 1949.

SELECTIVE WEED KILLERS, by Alden S. Crafts and W. A. Harvey, Ext. Cir. 157, September, 1949.

GENERAL-CONTACT WEED KILLERS, by Alden S. Crafts, Ext. Cir. 137, revised October, 1949.

GROUND WATER IN CALIFORNIA—The Present State of Our Knowledge, by S. V. Ciriacy-Wantrup and Patricia McBride Bartz. A special publication by the Giannini Foundation which is available only by addressing a request to the Agricultural Information Office, 22 Giannini Hall, University of California, Berkeley 4, California. The publication is free.

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