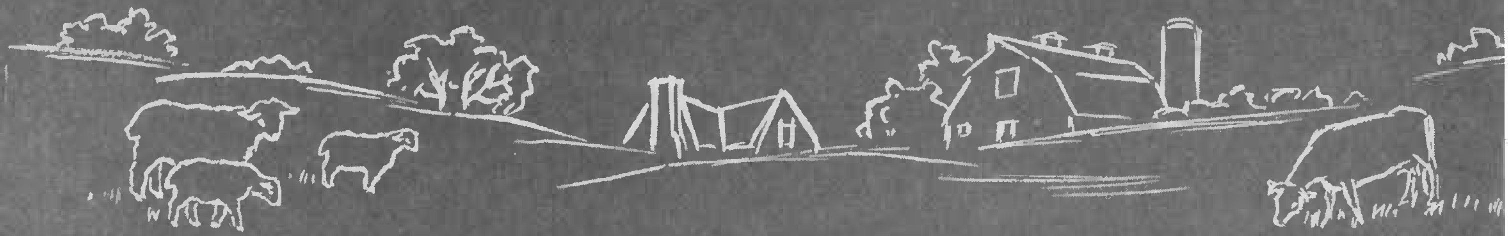
WINTER 1967-68

Oregon's Agricultural PROGRESS

Making the Most of the Mixed-Coniferous Forest • Predators Instead of Pesticides

OREGON STATE UNIVERSITY CORVALLIS



Oregon's Agricultural

PROGRESS

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Features:

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COVER: Studies conducted at the Hall Ranch, a research facility of the Eastern Oregon Experiment Station, show that the forage output of northeastern Oregon's mixed-coniferous forests can be tripled. Good water development is one of the prerequisites. See story on page 4.

MACHINES are replacing the human hand in the harvest of Oregon's small fruit and vegetable crops.

Not that the ease and finesse with which hands can pick such items as strawberries and pole beans has been surpassed. Indeed, it is not likely to be equalled. But across the nation, growers have expressed increasing concern about rising labor costs and diminishing labor supplies. And in Oregon, the situation is complicated by the long-standing reliance on, and the prospective unavailability of, youngsters at harvest time.

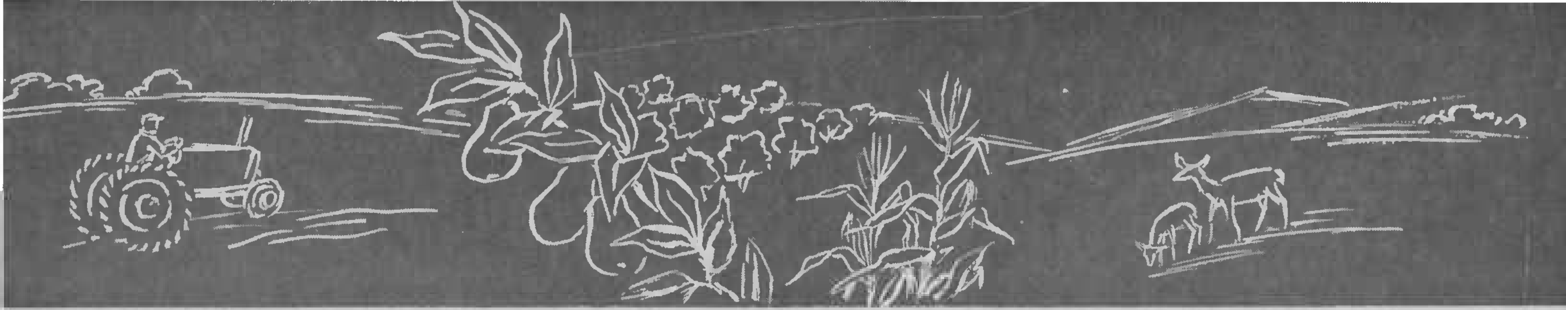
Horticulturists, agricultural engineers, and food scientists at the OSU Agricultural Experiment Station are engaged in a closely coordinated mechanization research program. And researchers in a number of other fields are gearing up for related studies.

Strawberries and snap beans

With the harvest of green peas, sweet corn, caneberries, and most root crops already largely mechanized, efforts at present are focused on strawberries and snap beans. Work also is under way with onions and the cole crops, such as broccoli, cabbage, and cauliflower.

Among the program's major achievements to date is the development of an experimental strawberry harvester. Tested last season at the North Willamette Experiment Station near Aurora, the unit looks extremely promising. Improvements are being made in the prototype this winter in preparation for more extensive tests next year.

Another important research payoff is the development of a new bush bean—the OSU 58 (see page 15). This new variety, which could solve many of the problems being experienced by Oregon's snap bean industry, appears to possess good mechanical harvesting



Small Fruits & Vegetables:

THE MOVE TO MECHANIZE

characteristics. Further studies will be held next season to confirm this finding.

At the outset, it should be noted that there are ways to "increase" the harvest labor supply even without mechanical harvesters. Virtually the entire Oregon strawberry crop is picked with caps off. Yet tests show that when workers are permitted to leave caps on, a production increase of 25% to 30% can be expected. Caps could then be removed in the processing plant by means of counter-rotating rubber rollers or a similar device.

Transplanted cauliflower fields—the usual method—generally mature about 30% of the crop at one time. In tests with direct-seeded 'flower, OSU researchers have achieved as high as 85% maturity at one time. Harvest workers obviously are more efficient in such fields.

Machine harvest a must

Still, in themselves, it seems doubtful that these are more than stop-gap measures. In the long run, mechanical harvesting will be a must.

The switch from hand to machine is never easy. Setbacks, stresses, and strains are bound to occur. A good deal of headway can be made, however, simply by avoiding the common assumption that a machine must do a perfect harvesting job in order to "compete" with the human hand. Studies made during the strawberry harvest, for example, show that hand pickers usually miss a substantial percentage of ready-to-go fruit. By the next picking, most of these berries are overripe or otherwise unmarketable.

Nor are machines guilty of the wide variation that often exists among hand pickers. Under good conditions, certain of the caneberries—blackberries in particular—can be more uniformly harvested by machine than by hand. This is because the machine chooses fruit on the basis of actual maturity—how readily the abcission layer will separate, rather than on the basis of color.

Multiple and once-over picks

Basically, there are two ways to approach mechanical harvesting: multiple picks that select according to size, firmness, or some other variable, and a once-over pick that takes everything. In most cases, it is the once-over concept that seems to be working out best. (The mechanical harvesters that have proved so successful in California tomato fields, for example, are all once-over units.) Interest in the multiple approach centers primarily on asparagus, cucumbers, and, of course, strawberries.

Once-over or multiple, small fruit or vegetable, concentrated maturity is a necessity. And herein lies some difficulty. For many years, high yields have been one of the plant breeder's major considerations. That usually meant selecting varieties that continued to produce as long as possible through the growing season. With the advent of mechanical harvesting, plant breeders have had to "come about" many degrees in making selections.

This raises another question. Let us assume momentarily that a quality strawberry is developed which ripens all or nearly all of its fruit in a week or ten days. This is fine for machine harvest, but Oregon's processing plants do not presently have the capacity to handle such a vast product input. Is there a way around this dilemna?

OSU researchers are investigating several promising avenues. These include: the use of three or four varieties with staggered maturity dates; the application of plant hormones or growth regulators, such as giberellic acid, to speed up or slow down fruit development; and the use of a single variety that produces two crops spaced, say, two weeks apart. Several strains under study exhibit the latter tendency.

Specifically with the mechanical harvester in mind, researchers also are selecting toward strawberry varieties that produce firmer, more accessible fruit, as well as less foliage.

Bean yields boosted 80%

Among the most basic changes in store—particularly for vegetable crops—is a very substantial increase in plant populations. These high-density plantings will not only contribute to maximum mechanical harvesting effi-

(*Continued, page 16*)

Making the Most of The Mixed-Coniferous Forest

A THREE-FOLD INCREASE in forage output. That's the prospect in store for managers of northeastern Oregon's mixed-coniferous forests, thanks to a new management plan developed by OSU scientists. The result of a continuing search for ways to make the most of these tough-to-manage lands, the plan also provides for basic improvements in timber potential.

Worked out by range researchers D. W. Hedrick, J. A. Young, J. A. B. McArthur, and forester R. F. Keniston, the strategy consists of several closely coordinated forest, range, and livestock management techniques, including selective logging and subsequent slash disposal, water development and adequate fencing, and use of the right class of livestock at the right time.

AUM's tripled in tests

A measure of the plan's forage-boosting ability: A 500-acre mixed-coniferous forest test site, estimated in 1956 to have a maximum grazing potential of 45 AUM's (animal-unit months), for the past five years has delivered an average of 150 AUM's.

This dramatic increase in forage utilization was achieved on the Hall Ranch, a research facility of the Eastern Oregon Experiment Station at Union. This 2,000-acre ranch, which serves as summer range for the Station's beef-cattle herd, is situated in the foothills of the Wallowa Mountains.

As is true for a large acreage of foothill range in this part of Oregon, much of the Hall Ranch supports a mixed-coniferous forest of grand fir, Douglas-fir, western larch, and ponderosa pine. In such areas, grand fir reproduction tends to be dominant under all degrees of undisturbed crown cover, and is virtually the only conifer reproduction found under dense stands.

The grand fir is subject to severe heart rots, however, so it is not as desirable a species on these lands as Douglas-fir or ponderosa pine. Moreover, the first essential step toward increased forage utilization is opening up the forest canopy.

So in 1960, the OSU researchers logged about half of the 500-acre test forest to permit the regeneration of Douglas-fir and ponderosa pine, and to determine the effects on forage production. Trees marked for cutting included: 100% of the grand fir 16 inches d.b.h. (diameter at breast height) and larger; 70% of the larch and Douglas-fir 16 inches d.b.h. and larger; and 50% of the old-growth ponderosa pine. Smaller trees infected with disease, infested by insects, or badly deformed also were taken.

Logging helps and hinders

The logging both helped and hindered forage production. A substantial increase in the quantity and quality of herbaceous and browse forage showed up where old openings were enlarged or new openings created. Some areas

Adequate fencing generates the use of forage that might otherwise be wasted—as shown by the striking contrast in use below (left) and above drift fence.

Tests showed this slash accumulation caused loss or inaccessibility to grazing animals of much good forage.

Good water development is one of the keys to obtaining more uniform use of forage in mixed-coniferous forests.

were taken out of production by heavy soil disturbances and slash accumulations.

Soil disturbances were relatively easy to repair through seeding to forage species compatible with timber establishment and growth. Research now in progress indicates that timothy should be a good introduced grass and blue wildrye a desirable native species for this purpose.

Slash is a serious hazard

But what about slash accumulations? Here was a far more serious hazard, for, unless steps were taken to correct it, the overall benefits of opening up the forest canopy could have been largely offset due to the loss or inaccessibility to grazing animals of much good forage. To solve this problem, the management plan calls for close coordination of logging and grazing operations. The researchers advise that timber sale contracts be written so that all skid trails are left free of debris; all cull trees are felled up-and-down slope, then bucked into short lengths; and all slash is disposed of.

The crux of the plan, however, is proper manipulation of livestock. One of the toughest jobs in grazing the mixed-coniferous forest is to obtain uniform use. Animals naturally congregate in openings or other more accessible portions, such as stream bottoms and along trials. In an effort to improve livestock distribution, the upland portion of the Hall Ranch was cross-fenced in 1962. After analyzing utilization patterns from the 1962 grazing season, a drift fence was added to help hold cattle in the mixed-coniferous forest.

An ambitious program of water development also was launched in these forested areas in 1963. The objective here was to reduce the distance to stock water on any portion of the ranch to less than a quarter mile. To enhance the accessibility of these water developments, old logging roads were cleared of down logs and slash piles.

The OSU researchers found that younger animals use the mixed-coniferous forest most efficiently. During the 1962 season, yearling heifers grazed these areas voluntarily. Cows and calves, on the other hand, could not be kept in them. For the most uniform use, then, replacement heifers or yearling steers are the best class of livestock. If it is necessary to graze cows and calves, the use of first- or second-calf females that grazed the same range earlier as replacement heifers is recommended.

Riding and salting

Occasional riding to disperse concentrations of livestock and the salting of areas where good forage was available, but lightly grazed, helped improve utilization patterns. But these practices are of little value without adequate fencing, water development, clear access trails, and the use of younger animals.

Proper season of use is a particularly important consideration in improving livestock distribution as well as performance. Since compaction by trampling is not a problem on most mixed-coniferous forest soils, grazing usually can be started as soon as the principal forage plants (primarily pinegrass) are 6 to 8 inches high. Early grazing is preferred, in fact, because it makes better use of the pinegrass, which becomes less palatable later in the summer. An early start also utilizes valuable leguminous forbs, such as green lupine and Cusick's vetch, which are dry and unavailable after mid-July.

Early weaning specified

Instead of keeping cows and calves on this forage after mid-summer, the plan specifies that it is better to wean early and graze calves on meadows and hay aftermath following a second cutting. Hall Ranch calves moved to crop aftermath continued to gain weight. And cows, freed of suckling calves, used forested ranges more effectively even after pinegrass had matured.

The Oregon Agricultural Experiment Station currently is preparing a publication which will cover this important management plan in detail. When it is completed, copies of this publication will be available from county Extension agents.

Photo: U. S. Bureau of Sport Fisheries and Wildlife

OSU research findings have helped assure that the annual mortality rate of the dusky Canada goose population will not exceed the flock's capacity to reproduce itself during most years.

Future Now Secure

For the Dusky Canada Goose

EACH WINTER, Oregon plays host to some 20,000 to 30,000 dusky Canada geese. Residents of the Willamette Valley can see these old friends almost any evening now, flying in thin wedges across the gray December skies.

The dusky Canada is unique among the Canada geese of North America. One of the darkest races of white-cheeked Canada geese, this majestic 6- to 10-pound bird also possesses a highly restricted breeding and wintering range that, to a large degree, is separated by the open Pacific Ocean.

Most dusky Canada geese spend the winter in the Willamette Valley, where they concentrate in quite large, easily visible flocks. But probably the bird's most unique feature is its extremely restricted breeding range—the Copper River delta on the south-central coast of Alaska. This delta, produced by the out-wash of the Copper River, is about 50 miles long and 7 to 10 miles wide. Here, beginning in late May, the dusky Canada goose nests.

Nesting densities are high

Unlike most other Canada geese, the dusky Canada will tolerate high nesting densities of up to 100 nests per square mile in the best habitat. This makes it possible for wildlife researchers to gain access to the nesting geese—another unique feature, for most of the other species nest in very remote areas at densities of only two or three nests per square mile.

For some years, wildlife biologists for the State of Alaska and the U. S. Bureau of Sport Fisheries and Wildlife have conducted joint studies of geese productivity on the Copper River delta. Birds also have been banded every year since 1952. When combined, these studies and aerial counts of geese on the Willamette Valley wintering grounds in late January provided a basic picture of the flock's travels and population status.

With this information as a starting point, a study of the dusky Canada goose was launched at Oregon State University in the fall of 1964. This three-year effort, carried out by a group of students under the direction of OSU wildlife ecologist Howard Wight, concentrated on determining the sex and age composition of geese killed by hunters and how the kill was distributed in the Willamette Valley.

Most of the information was collected at a private hunting club located about 5 miles east of Corvallis, where much of the Oregon kill takes place. This club, developed over the years by intensive game management practices, has attracted a large portion of the dusky Canada geese that winter in the valley.

Hunters' bags checked daily

With the cooperation of members of the hunt club, hunter's bags were checked daily for three seasons. These findings were then coupled with an analysis of the banding records of geese banded on the Copper River delta. The further addition of information obtained in the nesting studies enabled the OSU research team to learn precisely what has been happening to the dusky Canada goose population over the years.

Many important facts were learned about the goose flock. For instance, it was found that an immature bird is more than three times as likely to be shot as an adult bird. The study also revealed that more than 60% of the geese taken are shot in Oregon, and that about 60% of these are shot in the Corvallis-Albany area.

This concentration of geese in the Corvallis-Albany area, and the increasing kill that has taken place there in recent years, has been matched by a declining kill in the southern Willamette Valley. In 1952, 45% of the Oregon kill occurred between Junction City and Eugene. But during the years of the OSU study (1964 to 1966), few birds were taken in that area.

One major goal of Wight and his students was to determine the relationship between annual production and annual harvest of the dusky Canada goose. Obviously, if the population is to remain stable, as many birds must be produced as are killed. The researchers discovered, however, that the annual mortality rates in recent years have slightly exceeded the maximum production that could be expected on the Copper River delta. Moreover, if severe weather or predators caused production to drop below the maximum, the population was in jeopardy.

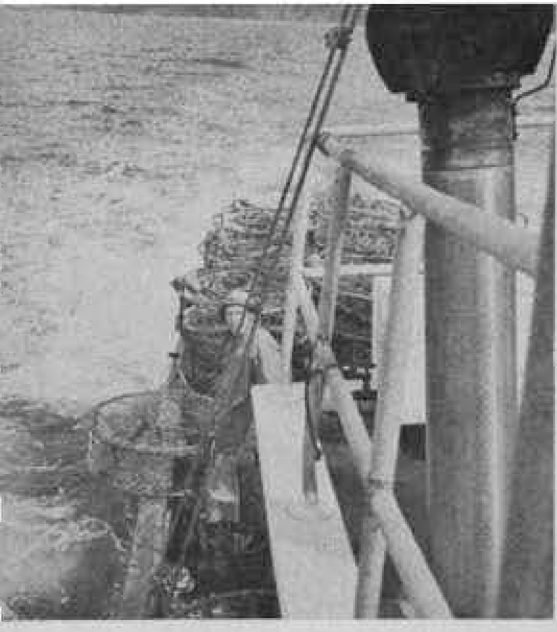
Based on this finding, the U. S. Bureau of Sport Fisheries and Wildlife and the Oregon Game Commission have issued a joint recommendation that the daily bag limit for dusky Canada geese be reduced from three to two birds. This reduction applies to a six-county area—Benton, Lane, Linn, Marion, Polk, and Yamhill counties—where most of the Oregon harvest takes place.

This reduction in the bag limit is expected to reduce the Oregon kill of dusky Canadas by about 20%—sufficient to assure that the annual mortality rate will not exceed the flock's capacity to reproduce itself in most years.

Questionnaires sent to a large number of Oregon goose hunters show that a reduced bag limit will not affect many hunters. Few of them are fortunate enough to hunt where the possibility exists of taking three geese in one day.

Crucial questions answered

The future of the dusky Canada goose now seems secure. The OSU study has answered many crucial questions about the movements, production and mortality rates, harvest and natural mortality, and sex and age composition of the flock. This information will be particularly valuable in the management of an important new refuge system which currently is being developed for the wintering birds. This program, in combination with careful management of the harvest, will assure continued enjoyment by all Oregon residents of the majestic dusky Canada goose.



What Affects I

Most of the variation in prices paid Oregon crab fishermen stems from cycles in average total U. S. production

THE DUNGENESS CRAB industry generates a substantial slice of Oregon's increasing income from the sea. Most years, the catch of this tasty shellfish represents at least 10% of the total value of all fish harvested by the state's 3,000-plus commercial fishermen.

During the 1964-65 ocean season, for example, the crab catch of 6.24 million pounds brought fishermen $1.13 million. Processors added another $680,000 to the value of the catch. Dungeness crab also is significant when viewed as an export commodity. Out-of-state shipments, chiefly to California, injected more than $1 million into the Oregon economy in 1965.

All is not well with the Dungeness crab industry, however. Over the past decade, several problems have combined to threaten its growth and stability. In search of ways for the industry to improve its position, OSU agricultural economists James Youde and John Wix have devoted nearly two years to a study of Dungeness crab marketing and pricing methods.

A Dungeness crab is handled by several market intermediaries on its journey from the ocean floor to the dinner table. Fishermen, of course, initiate the marketing process by landing crabs in baited wire traps called "pots" and delivering them to processors or, on occasion, to fresh marketers. From the processor, crabs are sold—either directly or through brokers — to fish wholesalers and major fish retailers.

About 20% of the catch is sold directly by processors to chain-store retailers. The most prevalent marketing method, however, is through brokers to wholesalers. Fish wholesalers presently handle almost 80% of Oregon's total Dungeness crab catch, a significant portion of which moves to restaurants and hotels.

Marketing margin found constant

A comparison of average wholesale prices received by processors during the 1964-65 and 1965-66 ocean seasons shows that the price for crab meat dropped 4¢ per pound, and that the price for shell crab fell 3¢ per pound from one season to the next. During this same period, the average price received by fishermen for "green" crab (crab not yet cooked) also dropped about 4¢ per pound.

This indicates, the OSU researchers point out, that the absolute marketing margin—the difference between wholesale prices received by processors and the prices they pay fishermen—is relatively constant. Thus, the level and stability of prices to fishermen are crucial elements in assessing the Dungeness crab industry's economic performance.

Seasonal trend in prices

Dungeness crab prices undergo a definite seasonal trend. Over the 10-year period 1956-65, prices paid fishermen averaged 13.97¢ per pound during December, the opening of the season, then rose continuously to a peak of 20.30¢ per pound in August, when the season closes. This is reasonably easy to explain. Peak demand for Dungeness crab apparently occurs during the summer months, yet the size of the catch, as well as the supply of crab meat in cold storage, generally decreases as the season progresses.

But monthly averages do not tell the whole story. The economists also found that Dungeness crab prices are subject to cyclical fluctuations—variations that occur on a systematic basis over a period longer than one production or marketing season. Within the last decade, prices received by Oregon fishermen for green crab have ranged from 8.2¢ to 24.9¢ per pound. Why?

Several plausible reasons exist. The Oregon Dungeness crab catch during 1956-65 followed a cyclical pattern, varying from a low of 3.2 million pounds to a high of 11.8 million pounds. Total U. S. production—the Oregon, Washington, California, and Alaska catches combined—followed the same pattern.

In recent years, production of Alaska king crab has increased steadily from

Dungeness Crab Prices?

8.8 million pounds in 1956, to more than 131 million pounds in 1965. Yet, prices received by Alaska king crab fishermen have remained relatively constant.

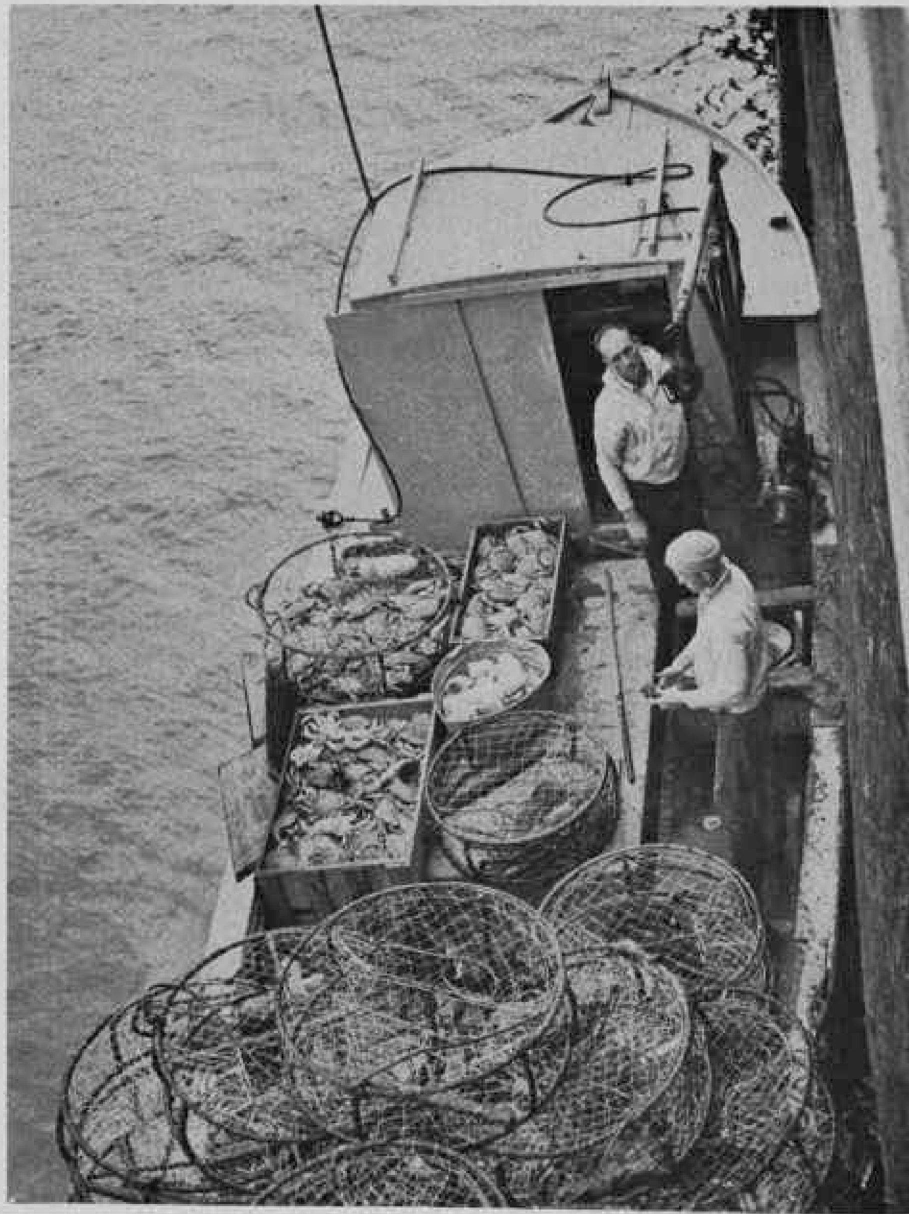
To find out which of these developments actually explains the variation in Oregon Dungeness crab prices during 1956-65, the OSU researchers used a statistical technique known as "least-squares multiple regression." With this technique, it is possible to derive an equation which reveals the degree of variation in one quantity that is associated with variations in other quantities.

Fluctuation explained

The equation shows that nearly 93% of the cyclical fluctuation in Oregon prices is explained by the cyclical pattern of total U. S. Dungeness crab production. The economists found that Oregon prices vary inversely to fluctuations in total production. In other words, as the total catch of Dungeness crab increases, the price received by Oregon fishermen decreases.

Another 5% of the variation in prices paid to Oregon fishermen is attributed to the average prices Alaska fishermen receive for king crab.

How can Oregon's Dungeness crab industry meet these problems? Youde and Wix offer several suggestions. These include: increased advertising and promotional activity; expansion into new market areas; intensified research aimed at increasing the state's crab production and reducing cyclical fluctuations in the catch; and further economic studies to pin down where the industry can cut its harvesting, processing, and marketing costs.



At extreme upper left, a crab fisherman heads out to sea. Immediately above, the marketing process gets under way when catch is delivered to a processor.

Predators Instead of Pesticides

OSU scientists are working out an "integrated" approach to pear pest control that cuts spraying costs, reduces problems of resistance, and diminishes the hazard of chemical residues

INSECTS CAN MAKE A MEAL of just about anything. Fortunately, many of the world's million or so species of insects choose to dine on each other.

Armed with this agreeable fact, researchers at the Southern Oregon Experiment Station near Medford are developing a new and urgently needed weapon in the Oregon pear grower's struggle against mite and insect pests. The new approach, being worked out by OSU entomologist Peter Westigard and OSU horticulturist Porter Lombard, is known as "integrated pest control."

Insects and mites are a serious threat to the production of quality pears in Oregon's Rogue River Valley. For many years, growers have relied exclusively on pesticides as a means of protection. And while this method generally has provided acceptable and, at times, exceptional control, it also presents difficulties.

The application of a pesticide may result in illegal residues on fruit at harvest.

$1 million for protection

Pesticides are expensive. In recent years, southern Oregon growers have been investing nearly $1 million annually to protect the area's 11,000 acres of orchard. Moreover, materials that do a good job of controlling pests today do not always achieve control tomorrow. Insects and mites can and have become resistant to numerous chemicals.

Because of their generally indiscriminate killing power, some chemicals decimate populations of species that are natural enemies of mite and insect pests.

Scientists, in an effort to overcome such problems, have shifted emphasis from strictly chemical control to integrated control. This approach takes advantage of the fact that some pests can be controlled biologically. In other words, various predators and parasites, if given a chance, will eat certain mite and insect species in sufficient numbers to keep them in check. As a result, only those pests that cannot be suppressed by natural enemies require chemical control measures.

How are the prospects for successful integrated pest control in Oregon orchards? To find out, the OSU researchers have kept close track of the insect situation in both sprayed and unsprayed orchards for the past five years.

The outcome: only three or, perhaps, four of the Rogue Valley's eight major pear pests actually appear to require the use of pesticides. Predators and parasites evidently can take care of the other four or five pest species.

The key, of course, is to design spray programs that make it possible for predators and parasites to survive. Basically, this involves using chemicals only when pests approach destructive levels—as opposed to the common practice of adding materials for "insurance" regardless of pest abundance; using selective materials which reduce pest levels without eliminating predators or parasites; and using timing and rates of application that avoid disruptive influences on natural enemies.

Three species of spider mite normally account for about 50% of the pear grower's spray bill — the two-spotted mite, the carpini mite, and the European red mite. Under proper conditions, however, these destructive pests can be controlled by a predaceous mite called *Typhlodromus occidentalis.*

Although *T. occidentalis* seems to find two-spotted and carpini mites more to its liking, it also is effective on the European red mite when mixed populations occur on the same tree. But where the red mite is the only species present, chemicals still will have to be used. To prevent elimination of *T. occidentalis* during the critical summer months, a miticide can be applied during the pre-bloom stage. If summer sprays prove necessary, the researchers suggest using a nondisruptive material such as spray oil.

Psylla checked by natural foes

The pear psylla, one of Oregon's most persistently destructive pests, also seems to be brought under control by natural enemies. While moderate to high numbers of psylla occurred during the spring months of 1966 and 1967, this insect was virtually eliminated in unsprayed trees by early July of both years. And no fruit injury was noted at harvest.

It remains to be seen, however, whether these spring psylla populations will reduce tree growth and productivity. Until this is established, a prebloom and post-harvest spray will be needed. (Note both sprays are timed to avoid killing the predator mite.)

Three of the most destructive pests in southern Oregon are pear-leaf blister mite, pear-leaf rust mite, and San Jose scale. Although blister mite was not a problem this past season in one study orchard, these pests generally have caused severe losses in unsprayed test blocks. All three have natural enemies. But they apparently are not able to hold populations below economically significant injury levels.

Fall and spring attack advised

Westigard and Lombard recommend, however, that a concentrated chemical attack on blister mite, rust mite, and San Jose scale during late fall and early spring be given careful consideration. This would get around the problem of removing predators and parasites of pear psylla and the spider mites when they are needed most.

Unlike spider mites, which damage foliage, codling-moth damage renders fruit worthless for both fresh market and processing. Growers risked losing their entire crop to "worms" (the larval stage of codling moth) if up to four summer pesticide applications were not made.

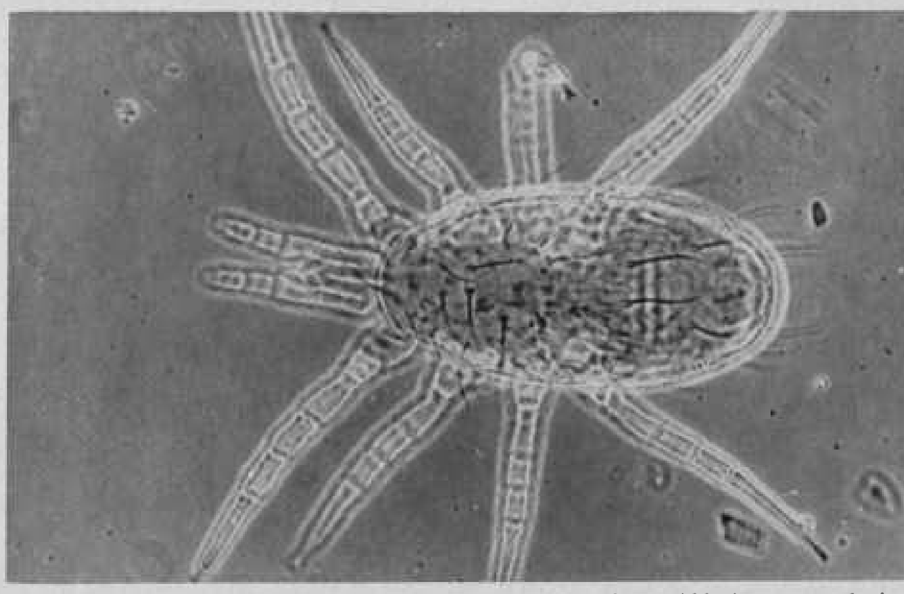
Now, based on U. S. Department of Agriculture research, a new technique should soon be available which will eliminate the need for codling-moth sprays. This technique consists essentially of releasing sterile male codling moths, reared in the laboratory, into the orchard. If the proper ratio of sterile to native, fertile moths can be maintained, the native moths will mate with the sterile males.

The result: no viable eggs, no larvae, no wormy fruit.

Some of the particulars that can influence the success of an integrated pest control program are not yet, and may never be, pinned down. Because the delicate relationship between insect species and various chemicals is subject to change, continuing research will be essential.

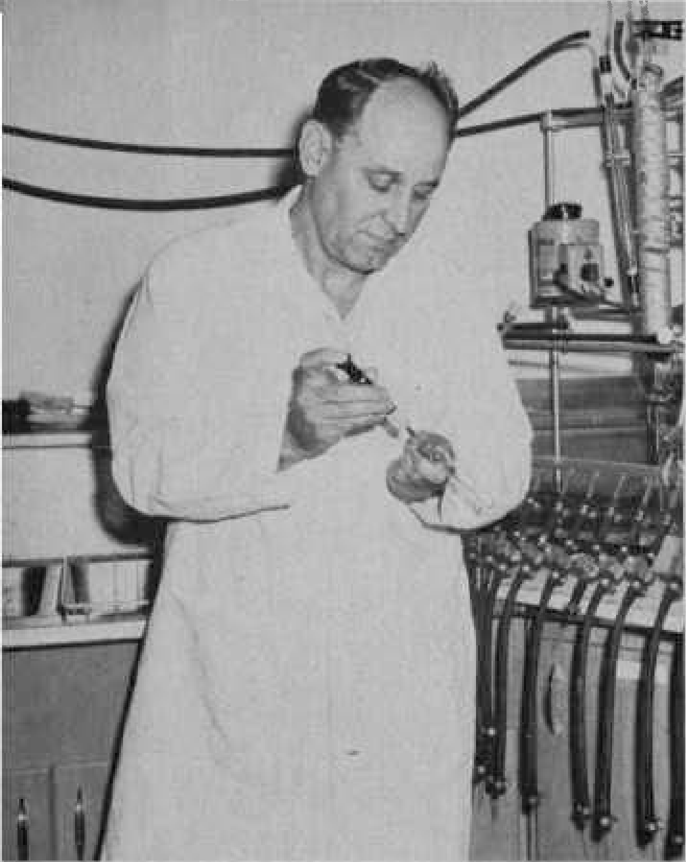
Basic strategy outlined

Still, the OSU researchers have assembled enough information to foresee a basic integrated control strategy: prebloom or post-harvest pesticide applications to control San Jose scale, the rust mite, and, if necessary, the blister mite; biological control of spider mites during the summer months and, pending further study, of the pear psylla; and control of the codling moth through the release of sterile moths.



The predaceous T. occidentalis *mite, shown here about 100 times actual size, is a particularly effective natural enemy of two-spotted and carpini mites.*

Entomologist Peter Westigard checks codling moth trap to determine population in test block of pears. Trees in this block have not been sprayed since 1962.



Plant physiologist Harold Evans injects bacterial extract into tightly sealed, oxygen-free test tube.

Cracking the Code to Nitrogen Fixation

Researchers have discovered how legumes convert nitrogen in the air into ammonia

OSU PLANT SCIENTISTS have cracked the chemical code to one of nature's most intricate and indispensable processes—the conversion of atmospheric nitrogen into a usable form of nitrogen by leguminous plants like alfalfa, clover, beans, and peas.

The discovery is a result of several years of intensive research by plant physiologist Harold Evans and a team of botanists.

For decades, scientists have sought a fuller understanding of the complex biological process known as nitrogen fixation. Yet the basic biochemistry of leguminous fixation remained a riddle until Burton Koch, Sterling Russell, and Evans recently learned how bacteria found in the root nodules of legumes convert nitrogen in the air into ammonia.

Why is it essential to understand fully just how nitrogen fixation works?

At the outset, it is of immense value to agriculture. The amount invested in nitrogen fertilizer by Oregon farmers in 1966 was about $15 million. The value of nitrogen supplied by biological fixation to Oregon crops, range lands, and forests during the same year is estimated at more than $200 million.

An equally striking estimate is that more than 90% of all the nitrogen required by plant and animal life on earth is provided by biological fixation. And probably the most important nitrogen-fixing organisms are the legumes.

A difficult business

Unraveling the processes of nature in the laboratory is a very difficult business. Here's how the OSU scientists went about achieving the first laboratory duplication of nitrogen fixation by legumes. (A previous finding by Evans and his associates—that nitrogen-fixing bacteria need minute amounts of cobalt —is reported in *Oregon's Agricultural Progress*, Summer 1966.)

Inside each nodule found on the roots of legumes are many millions of bacteria. These bacteria more or less "float" around in a red protein solution called leghemoglobin. In order to study the bacteria, they must be separated from the leghemoglobin and other parts of the nodule.

The researchers ground up soybean nodules under oxygen-free conditions, then added polyvinylpyrrolodone (an insoluble material that often is used to clarify beer and wine) to absorb interfering compounds. Separation of the bacteria was completed by a centrifuge, a device that uses centrifugal force to separate materials of different densities.

A "buffer" compound, such as potassium phosphate, was added to hold pH (the acid-alkaline ratio) steady, and the bacteria were subjected to five tons of pressure in a special steel compression cylinder known as a French press. When released, the bacteria burst due to the rapid change in pressure.

The scientists then took this slurry of broken bacteria and centrifuged it at a very high force. The result: cell walls and other cellular components settled, leaving a clear, amber-colored extract which retained a capacity to catalyze the conversion of atmospheric nitrogen to ammonia.

A key to successful preparation of the extract, Evans notes, was learning that polyvinylpyrrolodone must be added in order to remove interfering compounds from the nodules. Without this material, activity in the extract would be destroyed.

Once the extract had been obtained, the researchers were ready to tackle the major question: "What chemicals will supply the energy needed for the extract to reduce atmospheric nitrogen to ammonia?"

First, small amounts of the extract were injected into sealed, oxygen-free test tubes. Then, various chemicals were added, followed by an injection of pure nitrogen gas. The test tubes were agitated for a period of one hour, and the contents checked for ammonia.

The chemical combination that turned the trick consists of an ATP (adenosine triphosphate) generating system, and $Na_2S_2O_4$ (sodium hydrosulfite).

What is ATP?

ATP is an organic phosphate compound which contains energy derived from the oxidation of sugars or other food materials in plants. In fact, this compound is the universal medium through which energy generated by the oxidation of certain food materials in living organisms is transferred to synthetic reactions that require energy.

The nitrogen-fixing reaction also requires energy in the form of a reducing agent. Handling this part of the job

Researcher Burton Koch grinds up soybean nodules in oxygen-free chamber.

is sodium hydrosulfite, which the OSU scientists found effective in the reduction of atmospheric nitrogen (N_2) to the form of nitrogen in ammonia (NH_3).

Although the discovery is quite recent, indications of its potential for agriculture already are emerging. Suppose, for example, that alfalfa fields in some area suddenly lose their nitrogen-fixing ability. Now that the basic biochemistry of fixation is understood, researchers are in a better position to attack the problem. For instance, a testing kit might be developed which would make it possible to go into a field of sick alfalfa, and, within an hour or so, find out whether the bacteria are performing up to capacity. If not, corrective measures could then be taken on the basis of scientific evidence.

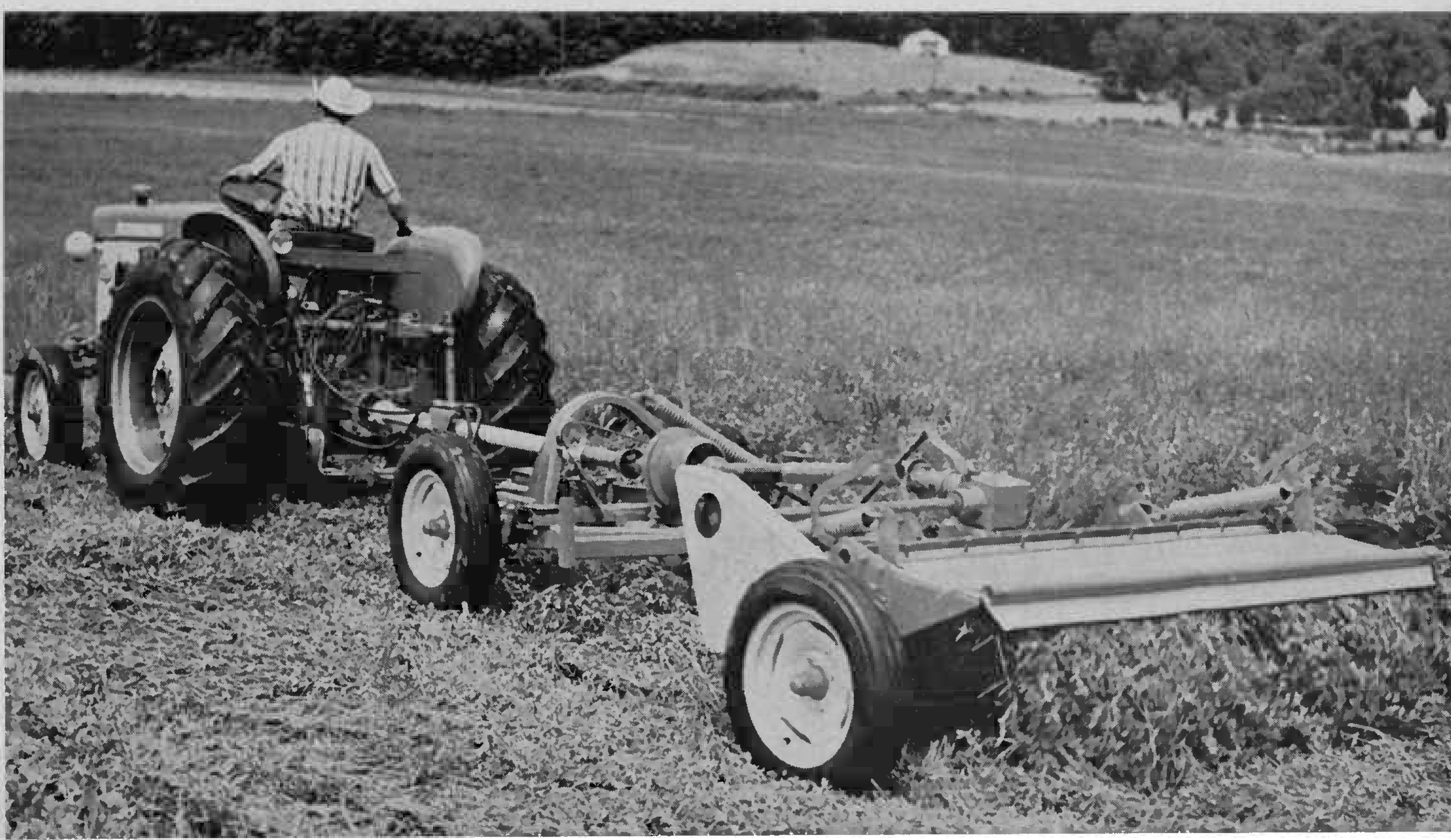
Further study needed

Some difficult questions remain. While very effective, sodium hydrosulfite is not the reducing agent at work in fixation under natural conditions. Efforts to isolate and identify the natural reducing agent are under way.

A thorough understanding of the nitrogen-fixing process also will call for more study of the enzyme or catalyst which makes this reaction possible.

Most of the important life processes take place on the surface of specific types of proteins known as enzymes. The enzyme required to transfer the energy of ATP and sodium hydrosulfite into the process of nitrogen fixation is referred to as nitrogenase. Attached to this enzyme are the elements molybdenum and iron, both essential trace mineral nutrients for the growth of leguminous plants. The OSU researchers currently are in the process of purifying and characterizing this vital nitrogen-fixing enzyme.

Increased yields of alfalfa, for example, could result from this discovery through the development of a testing kit which would make it possible to find out rapidly if bacteria in the root nodules are performing at capacity.



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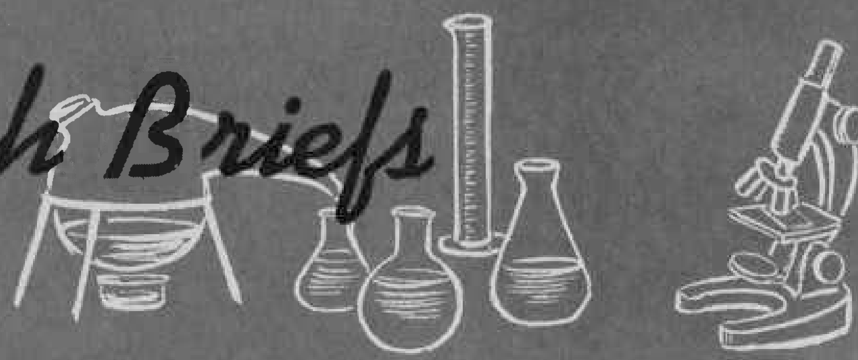


Tests Show Confinement Works for Brood Swine

SUCKLING AND GROWING PIGS are not the only Oregon "porkers" that prosper in confinement. OSU animal scientist David England reports that pig producers also can use this efficiency-boosting technique to house their brood swine, at virtually no sacrifice in reproductive performance.

Adding up six breeding seasons of research results, England finds that brood swine maintained in confinement will reproduce just as well as brood stock that is maintained outdoors in less convenient pastures or drylots.

Confined brood sows come in heat regularly, breed and conceive normally, and farrow litters of the usual number, strength, and vigor. Confined gilts show some interference with coming into heat regularly for first breeding. But after farrowing a first litter, these animals come in heat and breed normally. Boars kept in confinement show normal breeding interest and ability to settle sows.

153 females used in tests

A total of 153 females was used in the confinement tests—85 sows and 68 gilts. Half of the test females were confined individually in pens 2 feet wide and 8 feet long from before breeding until a few days before farrowing. For farrowing, they were moved to individual farrowing crates, then to nursing pens until the baby pigs were weaned. After weaning, these animals were returned to the confinement pens for breeding and gestation.

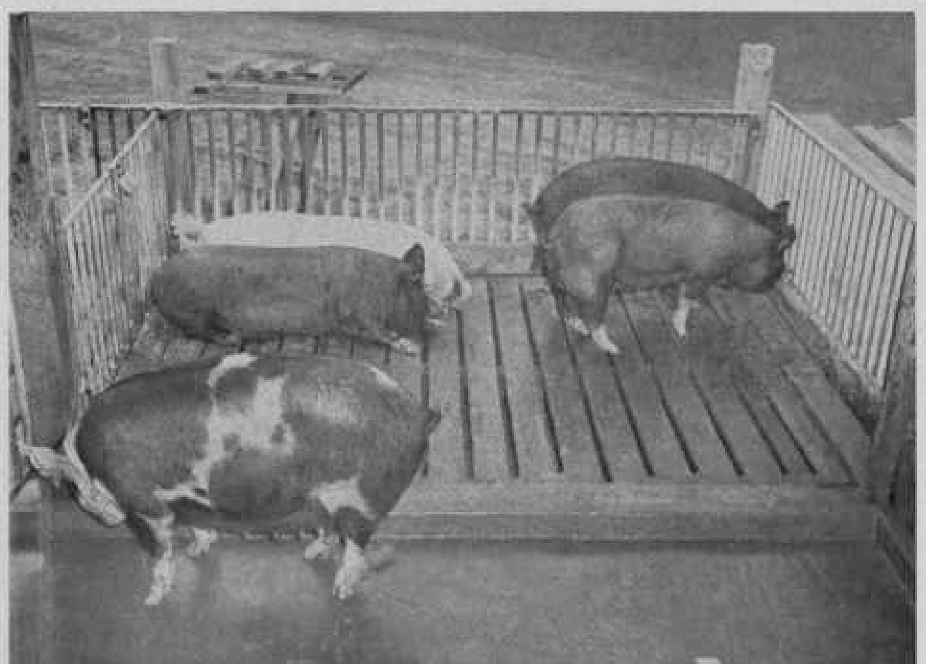
The other test females were kept in groups of 8 to 12 per pen with a minimum of 30 square feet per animal. Sows and gilts were kept in different groups, although severe fighting among group-housed sows was rare. Animals were fed once a day in individual feeding stalls, and floors were slotted for self-cleaning.

During the tests, only 2 of the 85 confined sows failed to come in heat after weaning their litters. About 93% of all sows bred within six days after weaning: 77% of these conceived immediately, and 95% had conceived by the second heat period. Of the 68 gilts, 12% failed to come in heat. Another 10% was slow to come in heat, reluctant to breed, or showed inconsistent and prolonged signs of heat.

How gilts performed

Breeding behavior was nearly normal in group-housed gilts, with 94% bred and 10% of these showing some interference. Individually housed gilts did not perform as well, with 83% bred and 10% showing some interference. But after the first litter, their performance was normal.

Lack of exercise did not appear to affect gestation in either type of confinement. However, England notes, the possible benefits of individual housing did not materialize in these tests.



Each group-housed animal was provided a minimum of 30 square feet. Animals were fed in individual stalls, and floors were slotted for self-cleaning.

Activated Charcoal Prime Prospect For Safer Herbicide Use

APPLICATIONS of activated charcoal may be the answer to one of Oregon agriculture's increasingly serious problems: how to "turn off" an herbicide once its weed-killing work is done. Trials conducted at the Southern Oregon Experiment Station by OSU agronomist John Yungen indicate that this highly adsorptive form of carbon, widely used in water purification, has considerable potential as a deactivating agent of soil-active herbicides.

Herbicides sometimes persist in the soil long enough to cause damage or impart illegal residues to succeeding crops. Several years ago, Yungen ran a preliminary trial to see if activated charcoal might be of help. The results were encouraging, so a more detailed test was set up. The herbicide selected for this study was atrazine, a material that is known to persist for relatively long periods in certain soils.

Herbicide applied at three rates

In addition to an untreated check, the herbicide was applied to test plots at three rates—1.6, 3.2, and 4.8 pounds per acre. Immediately after application, the material was incorporated into the soil to a depth of 4 inches, and three days later the plots were sprinkler-irrigated with 3 inches of water.

On July 30, finely powdered activated charcoal was broadcast at per-acre rates of 25 and 50 pounds. Again, an untreated check was left. The charcoal was incorporated to a depth of 4 to 5 inches, and the following day another 3 inches of water was applied.

On August 4, Yungen seeded the test plots to Park oats. Irrigations between seeding and harvest totaled about 8.5 inches of water, and another 1.5 inches was added by rainfall. The oats were harvested as forage on October 20 in the late-boot stage of maturity.

Where no charcoal was applied, test-plot yields averaged 386 grams of oven-dry forage. But where charcoal had been applied at the 25-pound rate, yields averaged 614 grams. And at the rate of 50 pounds of charcoal per acre, average yields exceeded 810 grams—more than double the plots which did not receive charcoal.

The cost situation looks equally promising. Activated charcoal presently costs around 18¢ a pound. On many Oregon farms, where 6 to 10 months often elapses between crops, the OSU agronomist thinks that 20 to 30 pounds of charcoal per acre, if mixed as deeply as the herbicide has gone, probably would be sufficient.

On the strength of Yungen's findings, researchers in several states have launched activated-charcoal trials. Additional work also is planned at OSU. Should activated charcoal "prove up," agriculture will be able to improve overall safety in the use of soil-active herbicides. It also seems likely that the use of some of the more effective but more persistent herbicides could safely be broadened.

New Bush Bean Developed

THE FIRST BUSH BEAN to approach the Blue Lake pole bean in pod quality and, at the same time, to possess a moderately good growth habit has been developed by OSU horticulturists. Christened OSU 58, the new bush bean originates from a single plant selected in 1965 out of bulk plantings at the North Willamette Experiment Station near Aurora.

OSU plant breeder W. A. Frazier says the variety has great commercial promise, in addition to its value as a base for further improvements in Oregon bush beans. Many crosses already have been made with other varieties. During our current winter, New Zealand seed growers are increasing the presently small seed supply, and it is hoped that enough seed will be available next spring for initial trial plantings by processors.

Much of the OSU 58's promise lies in its improved growth habit. Considerably better in this vital area than the earlier-released varieties OSU 949 and 2065, the new bush bean also appears less sensitive to high temperatures and changes in day length. However, Frazier notes, it does not have as desirable a growth habit as G-50 (a variant of the Tendercrop variety).

Taste scores are satisfactory

As for processing quality, OSU food scientist George Varseveld has found that the canned 58 pod has a "taste" character which closely approximates the Blue Lake pole bean pod. In panel tests, processed 58 beans have been given satisfactory scores for taste, color, and texture by most tasters.

Quality is particularly good in large 58 beans (sieve size 6 through 7). The color of these seive sizes is well above average, and with good growing conditions, seed sizes are not excessive. Larger sieves also are above average in smoothness, but young pods are slightly rough in appearance.

A number of plantings of OSU 58 were made this past summer in order to observe pod set and growth habit. The new variety sets well throughout the summer, and, in most cases, it was three to six days earlier than G-50.

Sieve sizes develop fast

Frazier points out that the 58 develops into large sieve sizes quite rapidly. Thus, if left in the field to secure heavy yields, sieve sizes go well beyond the generally desired range of 50% sieve size 4 and smaller. A preliminary experiment suggests, however, that the 58 may produce high yields of relatively smaller sieve sizes in very high-density plantings—6 inches on the square, for example.

At conventional spacings—36 to 38 inches between rows, and with good cultural conditions, the new variety can be expected to average 4 to 6 tons per acre, with sieves tending to be large.

On the disease front, OSU 58 is relatively resistant to rust, but susceptible to root rot, white mold, and halo blight. The researchers are trying to build increased halo-blight resistance into the variety by backcrossing it to OSU 10183, a resistant breeding line. Attempts also are in progress to decrease the 58's moderate tendency to skip seeds in the pod.

Mechanization demands a far more precise agriculture; the margin for error is extremely small.

(Continued from page 3)

ciency, but will result in much higher yields. In tests at the OSU Vegetable Research Farm, bush bean yields, for example, have been boosted up to 80% by closing down plant spacings and modifying plant arrangements. However, these plantings create some changes in immediate plant environment; so changes in some cultural practices are likely to be required. Fertilization, irrigation, pest, disease, and insect control techniques are being studied to learn just where new methods will be needed.

It should be emphasized that excellent chemical weed control is a prerequisite in high-density plantings. There is no room for a tractor and cultivator in such fields. Precision seeding is just as essential. Plants must be given an equal opportunity to take in sunlight, water, and nutrients if concentrated maturity is to be achieved.

Precision seeding alone leads to increased yields. In tests held last season, precision-seeded onion plots outyielded check plots by nearly 50%. Improved size and shape control of root crops also appear possible with precision seeding.

Crops must be marketable

No matter how successfully a crop can be machine harvested, it is not worth much if there is no market for it. Thus, OSU food scientists are working with other researchers on several fronts. For example, through evaluations of the final product, the plant breeder is able to proceed on a sounder basis in making crosses and selections. The engineer, equipped with similar information, is better able to design harvesting machines that deliver a marketable product.

Food scientists also are concerned with developing processing techniques to accommodate mechanically harvested products, and with learning how to make use of what we generally throw away today. A case in point: the mechanical strawberry harvester selects fruit on the basis of size rather than color. Inevitably, some immature berries are picked. The benefits that would result from finding a use for this fruit are obvious.

Other important projects planned or in progress at OSU include: continuing development of a precision seeder that singulates seed by means of the vacuum principle; tests with minimum-coated seed—a new method that makes it much easier to precision-plant small vegetable seeds such as carrots and lettuce; and research on new handling procedures to improve efficiency both in the fields and at the processing plants.

Answer depends on growers

How successfully will Oregon switch to the machine? To a considerable extent, the answer depends on Oregon growers. Mechanization demands a far more precise agriculture. The margin for error is small . . . extremely small. With mechanical harvesting, all the operations that go into producing a crop must be pointed toward that end. In fact, the entire process can be thought of as a single chain with many links. And as the old adage points out, a chain is only as strong as its weakest link.

A director of the American Society of Agricultural Engineers recently said, "Either we mechanize the harvesting of fruits and vegetables, or those things which are now common to the tables of us all will be completely unavailable or available only to the favored few."

Oregon a horticultural paradise

Oregon has justifiably been called a horticultural paradise. Vast reserves of fertile land, plenty of irrigation water, and just the right kind of climate are among its priceless assets. With a strong research program and a diligent effort by growers and processors, there is no reason why Oregon cannot play an even greater role in insuring that small fruits and vegetables continue to be common to the tables of us all.

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