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Effects of Sawdust Mulches

II. Horticultural Crops

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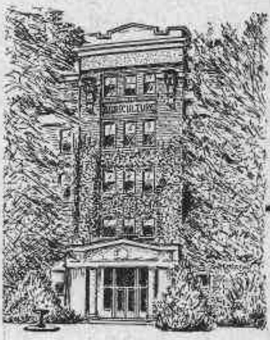

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Effects of Sawdust Mulches

II. Horticultural Crops

Introduction

Horticultural literature contains considerable evidence in favor of heavy organic mulches as a soil management practice for a number of horticultural crops. This practice involves the application of a layer of some suitable organic material such as straw, leaves, manure, or sawdust to the soil surface. Depth will vary, depending on the crop, material used, rate of decomposition, and frequency of renewal.

Limited use of mulching practices in horticultural crop production is due to expense, lack of readily available materials, and little available information as to the economy of their use. From a practical point of view, mulch culture must be evaluated on the basis of costs and results obtained as compared with other methods of soil management. This involves comparing costs of mulch material, application, renewal, and possible additional fertilizer requirement (as in the case of sawdust), with the benefits that may be derived from the mulch in the form of increased yields, weed control, moisture conservation, improved soil structure, and/or increased fertilizer response.

Agricultural scientists have been reluctant to accept sawdust as a desirable material for mulches because of the problems it presents when added to the soil. These problems have been reviewed in detail by Allison and Anderson (1951). The slow rate of decomposition, which may or may not be a disadvantage, and the temporary depression of nitrates have been the principal problems encountered. The very low value of sawdust as a source of readily available plant nutrients is a recognized disadvantage. Sawdust has virtually no fertilizing value. Its composition with respect to nitrogen, phosphoric acid, and potash varies with age and species of the trees and with the age and state of decomposition of the sawdust. Fresh fir sawdust will contain on the average about 4 lbs. of nitrogen (N), 2 lbs. of phosphoric acid (P_2O_5), and 4 lbs. of potash (K_2O) per ton of air-dry material [Salter and Schollenberger (1939), Turk (1943)]. This is less than one-third the total plant food usually contained in wheat straw. Not only is the plant nutrient supply low in sawdust, but it is also relatively unavailable. Sawdust cannot be considered a fertilizing material.

Regardless of these disadvantages, growers of certain horticultural crops have been using sawdust to advantage and have desired more information as to its values in soil management. Studies were conducted between 1944 and 1954 to determine more completely by field and greenhouse tests long and short term effects of sawdust additions on soil, microorganisms, and plants grown therein.

Horticultural studies were concerned primarily with the influence of sawdust and other organic residues as mulches or soil amendments on (1) growth and yield of certain annual and perennial horticultural crops, (2) incidence of red-stele disease of strawberry and (3) fertilizer requirement, particularly nitrogen, as measured by crop response.

Definition of Terms

Since certain terms take on slightly different meanings as they are used in the various disciplines, the following terms are defined to indicate the sense in which they are used in the following discussions:

Organic mulch. Application of a layer of some suitable plant or animal residue such as straw, leaves, manure, or sawdust to the soil surface to protect the soil surface and provide a more favorable environment for plant growth.

Soil amendment. Any material added to the soil to modify its physical or chemical condition.

Decomposition. Physical and chemical changes which organic materials undergo when changed to simple compounds by soil organisms.

Nitrate depletion or **nitrate depression.** Temporary disappearance (in varying degrees) of nitrates from the soil during the period of decomposition of organic matter having a low nitrogen content as a result of microorganism buildup and their competition with higher plants for available nitrogen.

Fertilizer requirement. The quantity of fertilizer required in soil management to supply needs of both higher plants and microorganisms for maximum crop production under existing conditions.

Critical nitrogen percentage [as used by Allison and Anderson (1951)]. That content of nitrogen in undecomposed plant materials when, if optimum conditions for biological activity are present, decomposition will proceed at approximately the maximum rate without depleting the supply of available soil nitrogen.

Literature Review

A review of the literature on the subject [Gibbs and Werkman (1922), Viljoen and Fred (1924), Newton and Daniloff (1927), Odland and Knoblauch (1935), Latimer and Percival (1947), Pinck, et al. (1946), Turk and Partridge (1947)] indicates that growth and yield of crops grown with organic mulches vary with crop, organic material used, local conditions of rainfall, temperature, soil fertility, soil type, soil drainage, soil nitrifying power, and other factors not clearly defined. Increases in crop yields from use of such mulches have generally been attributed to the following: (Evidence of these factors may be found in the references listed.)

Improved growth and crop production. Halsted (1895), Rosa (1923), Tiedjens (1940), Savage and Darrow (1942), Johnson (1944), Latimer (1944 and 1947), Gourley (1946), Grigg's and Rollins (1947), Wells (1950), Judkins (1950), Harris (1951), Shutak and Christopher (1949), Denisen, et al. (1953), Pratt and Comstock (1958), and Isenberg and Odland (1950).

Improved structure and aeration of heavy soils. Alderfer and Merkle (1944), and Stephenson and Schuster (1945).

Increased water infiltration and reduced surface runoff. Harris and Yao (1923), Duley and Russel (1939), Turk and Partridge (1941), Sudds and Browning (1941), Pillsbury and Huberty (1941), Chandler and Mason (1942), Alderfer and Merkle (1944), Mooers and Washko (1948), and Denison, et al. (1953).

Better moisture conservation through weed control and reduced surface evaporation. Harris and Yao (1923), Denisen, et al. (1953), and Pratt and Comstock (1958).

Maintenance of more uniform soil temperatures. Thompson and Platenius (1931), Magistad and Baldwin (1933), Darrow and Magness (1938), Chandler and Mason (1942), Johnson (1944), and Denisen, et al. (1953).

Improved aggregation of surface soil. Alderfer and Merkle (1944), and Boller and Stephenson (1946).

Reduced soil erosion. Duley and Russel (1939), and Borst and Woodburn (1942).

Increased soil organic matter and eventually humus. Gibbs and Werkman (1922), Newton and Daniloff (1927), Gibbs and Batchelor (1927), Waksman (1938), Zak and Eisenmenger (1939), Hughes (1949), Allison and Anderson (1951), and Salomon (1951 and 1953).

Improved soil nutrient supply in the case of some materials. White (1889), Turk and Partridge (1947), Baker (1948), Salter and Schollenberger (1939).

Improved root distribution of shallow rooted crops. Havis (1937), Beckenbach and Gourley (1933).

Humus, which profoundly modifies soil fertility, is a complex aggregate of brown to dark-colored amorphous substances. According to Waksman (1938), these substances are largely a ligno-protein complex formed when soil organisms bring about decay. As organic matter changes to humus, most of the nitrogen and a considerable portion of the soil phosphate, sulfate, and other inorganic substances become a part of the humus fraction of the soil.

It is recognized that this process of humus formation is complex, but evidence to date indicates that a large part of the humus aggregate is derived from lignins. These lignins are an abundant constituent of organic matter and are especially resistant to decay organisms. For these reasons lignins are receiving attention in research dealing with benefits to be derived from organic amendments to the soil [Dunn, et al. (1950), and Aries (1950)]. Sawdust, according to Kurth (1950), is composed of approximately 20-30% lignin, 50-60% cellulose, and 10-20% pentosans, along with various waxes, resins, and oils.

While research on the value of sawdust as a mulch or soil amendment and its effects on soil and crop has not been as extensive as that with straw and the more commonly accepted materials, there is considerable information from past experiments.

Although Koch (1914) found that the sawdust constituents—tannin, resin, and turpentine—may be toxic to plants when added in large amounts to the soil, many workers believe the chief reason for reduced crop yields following sawdust incorporation is depletion of available soil nitrogen following an application. Gibbs and Werkman (1922) demonstrated that reductions in plant growth following large additions of wood wastes to the soil were due to their inhibitory effect on ammonia and nitrate accumulation. The degree of inhibition depended on the type and rate of decomposition of the sawdust used. Viljoen and Fred (1924) substantiated these findings, and attributed the loss of available nitrogen to the great increase in the assimilation of nitrates by microorganisms. They thought the quantities of tannins, resins, and turpentine in the sawdust were insufficient to account for the suppression in plant growth which followed the addition of sawdust to the soil.

The popular assumption that sawdust increases soil acidity to dangerous levels has likewise not been substantiated [Boller and

Stephenson (1946), Gourley (1946), McCool (1948), and Johnson (1950)].

Soderbaum and Barthel (1924), in Sweden, found that 2% by weight of dry sawdust in a soil decreased crop growth, but no more than did cellulose in cotton fibers. They concluded the reduction in growth was due to a lack of available nitrogen, since the addition of sufficient nitrogen overcame the inhibitory action of these materials. Recently, Midgley (1950) supported these earlier findings. If woody products decreased crop growth, the decrease could be attributed to a wide carbon/nitrogen ratio in the soil. He produced normal crops on soils to which large amounts of tannin or tannin-containing materials had been added and to which supplemental nutrient elements had been supplied.

The amount of supplemental nitrogen necessary for normal plant growth, when sawdust used as a mulch or soil amendment is decomposing, has been determined under field and greenhouse conditions by several workers. Newton and Daniloff (1927) stated that the depression of growth and yield following the addition of low nitrogen materials to soil may be largely overcome by applying 75 lbs. of nitrate of soda per ton of sawdust used (12 lbs. N/ton). Turk (1943) found in greenhouse tests that nitrogen added in sufficient quantities to give the sawdust the equivalent of about 2% by weight nitrogen (40 lbs. N/ton) would overcome the detrimental effects of the sawdust in soils low in available nitrogen. Lunt (1951) observed marked reductions in crop yield the year following the addition of wood chips to the soil unless a pound of nitrogen for each 100 lbs. of dry organic matter (20 lbs. N/ton) was applied. Results obtained by Johnson (1944) indicated that old pine sawdust could be incorporated with the soil without harmful effects to a tomato crop if 120 lbs. of nitrogen per acre (2 lbs. N/ton) was applied with each 2-inch mulch incorporated (approximately 40 tons dry matter). His yield data indicated a depression of nitrates only during the first growing season. Data obtained by Salomon (1951 and 1953) showed that additions of pine chips at the rate of 10 tons per acre may have a deleterious effect on growth of beets and spinach unless accompanied by heavy applications of soluble nitrogen.

It is apparent that although workers are in agreement as to the cause of suppressed yields with sawdust incorporations, they are not in agreement as to the supplemental nitrogen requirements for satisfactory C/N relations during the decomposition process. This is not surprising when we consider the several factors which determine the rate at which the process proceeds and its need for nitrogen. The cited authors have shown that the type of wood waste, its composition, and the physical (temperature, moisture, and aeration), chemical, and biological properties of the soil are factors influencing the degree of nitrate depletion. The amount of sawdust applied and whether it is left on the surface or mixed intimately with the soil will have a bearing on the problem.

Another factor, often overlooked in attempting to arrive at a *critical nitrogen percentage* for optimum soil biological activity without depletion of available nitrogen for plants, is the varied nitrogen requirements of plant species. Horticultural crop plants differ greatly in their nitrogen requirements for successful crop production and their response to sawdust applications either on or in the soil thus vary.

It has been shown by Pinck, et al. (1946), with fresh undecomposed plant materials, that if nitrogen content is about 1.2-1.5% and with optimum conditions for biological activity, decomposition will proceed at approximately the maximum rate without depleting the supply of available soil nitrogen. If the nitrogen percentage is higher than 1.2-1.5%, nitrogen will be released to the growing crop. There is some quantitative information available to support this figure as the critical nitrogen percentage for sawdust. Allison and Anderson (1951) are of the opinion that in the case of poplar, beech, and some species of pine which decompose most rapidly, the nitrogen content must be brought to approximately 1.2-1.5%, if the initial harmful effect to crops is to be avoided. They reason that since sawdust usually contains about 0.2% nitrogen, addition of approximately 24 lbs. of nitrogen per ton of dry wood would be required.

Influence of Sawdust on Growth and Yield of Certain Horticultural Crops

Three separate experiments were used in these studies to determine the influence of sawdust as a mulch or soil amendment on the growth and production of certain perennial horticultural crops. Since the crops used, methods employed, and results obtained are rather specific for each experiment, they will be presented separately.

The three experiments were all conducted at the Lewis-Brown Horticultural Farm near Corvallis on a Chehalis silty clay loam soil using supplemental irrigation in each case.

Experiment I: 1946-1956 (Raspberries, Blueberries, Roses, and Azaleas)

This experiment was designed to compare sawdust, oak leaves, and grain straw as mulches with clean cultivation in the culture of McGredy's Yellow rose, Mollis azalea, Jersey blueberry, and Willamette raspberry.

Methods

Plantings were made in 1946, and consisted of duplicate 40′ x 40′ blocks for each mulch material and for clean cultivation arranged at random in an area 80′ x 160′. A row of each crop was included in each block. Plants were spaced 4 feet apart in the row, and rows spaced 10 feet apart, thus allowing 10 plants or hills of each crop in the block. Observations made are on the basis of 20 plants located in two separate blocks.

An attempt was made to maintain each of the mulching materials about 4 to 6 inches deep when fully settled. To do this required annual additions of about 8 to 10 inches of loose material in the straw and oak leaf mulches. Every other year sawdust was renewed at the rate of about 1 inch per year.

Nitrogen in the form of ammonium sulfate or ammonium phosphate (16-20) was applied to all crops and all plots at the rate of 100 lbs. of actual nitrogen per acre each year. Fertilizer was placed in a band around each plant. The form of nitrogen used was alternated from year to year during the experiment. Irrigations were timed to keep soil moisture in the clean cultivated plots at a reasonably favorable level for growth without overwatering the mulch plots. Excellent soil drainage made this possible.

Plant stand and growth on the individual plots was quite uniform during the first eight years of the experiment, but during the last two years, it became increasingly difficult to maintain uniform stands in the rose and raspberry blocks. In the raspberry plots this lack of uniformity was due primarily to the destruction of the hills in the clean cultivated blocks by the Strawberry Crown Moth, *Synanthedon rutilans*. There appeared to be a certain degree of repellant value in mulch treatments.

Fruit yields from the raspberry and blueberry plots were taken from the time they came into bearing in 1949 up to and including the 1955 season, a period of seven years. In the early years, a count was made of the blooms produced by the roses, but this was later abandoned as a practice and in later years only general observations were made of the response of the roses and azaleas to mulch treatment. Since the azaleas responded in a manner similar to that of the blueberries and the roses to that of the raspberries, data presented is confined to fruit crops, where definite yields were obtained.

Results and Discussion

Yields for the seven-year period from the blueberry and raspberry plots under the four systems of soil management are graphically summarized in Figure 1. Response of the shallow-rooted blueberries to sawdust mulching was pronounced. Yields increased progressively with plant age in contrast to relatively low yields obtained from the straw and oak leaf mulch or the clean cultivated plots. The low yields on all plots in 1955 were due to blossom injury as a result of frost. The fibrous, shallow-rooted azaleas, also an ericaceous plant, responded in a manner similar to blueberries. The more deeply rooted raspberries failed to show any significant differences in yield due to mulch treatment regardless of material used. There was a tendency in later years for mulched plots to outyield clean cultivated ones, but this could be explained on the basis of insect infestation in these plots mentioned previously.

These data indicate a decided difference in response of various crops to mulching practice and also a preference in the case of some for certain types of mulching material. While a complete explanation of these differences cannot be made on the basis of the data collected, certain speculations may guide further research.

The manner of rooting and the distribution of the root system of the two crops might explain the favorable response of the blueberry and the lack of response of the raspberry with the several mulching treatments. The blueberry with its shallow, fibrous roots responds quite markedly to a medium which contains abundant moisture and at the same time is well aerated. These two properties are more

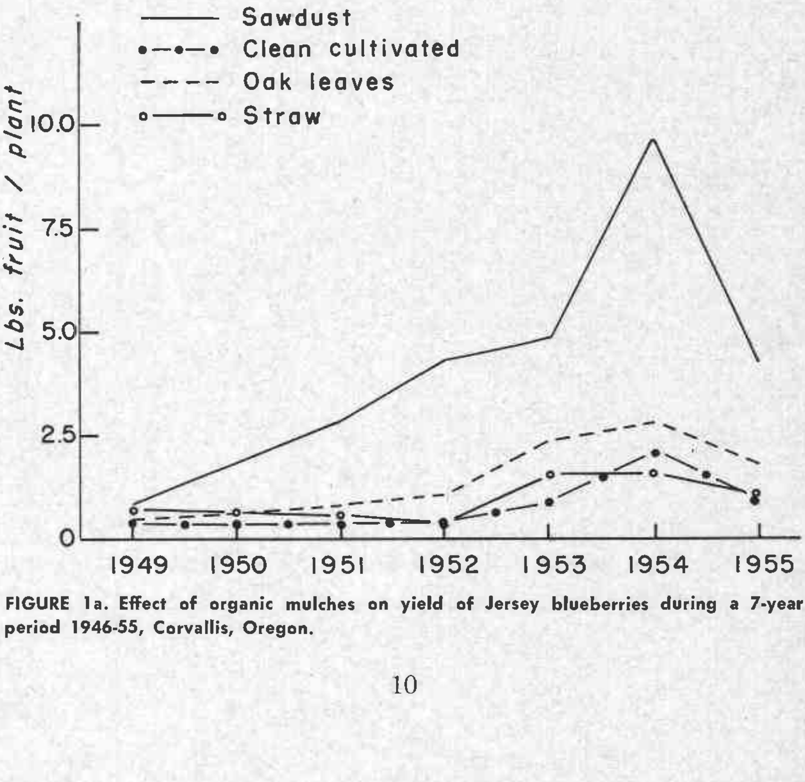

FIGURE 1a. Effect of organic mulches on yield of Jersey blueberries during a 7-year period 1946-55, Corvallis, Oregon.

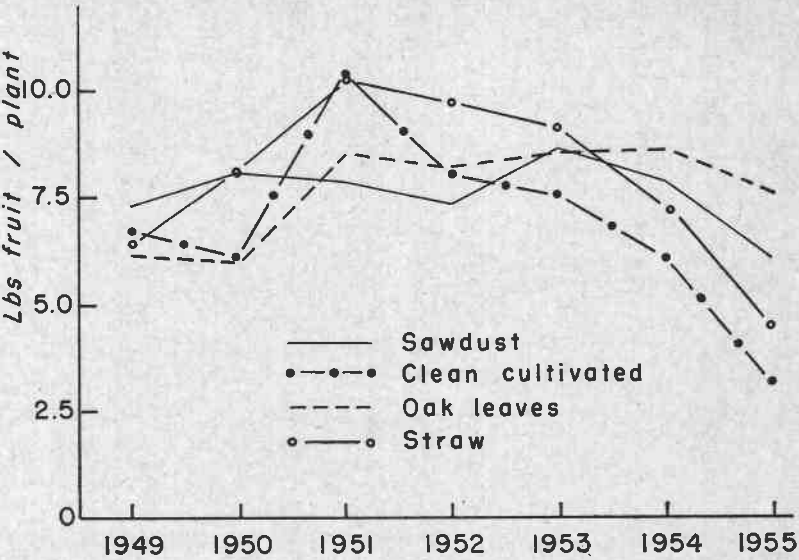

FIGURE 1b. Effect of organic mulches on yield of Willamette raspberries during a 7-year period 1946-55, Corvallis, Oregon.

readily obtained with a sawdust mulch than with either straw or oak leaves. The latter two materials decompose more rapidly and tend to expose the surface root system unless they are renewed regularly. The deeper rooted raspberries are not benefited as much by the reduced surface evaporation with a mulch, particularly with regular summer irrigations.

Results obtained in this study are supported by work of others. Savage and Darrow (1942) found that looser forms of mulch, such as rye, straw, and oak leaves are somewhat better than clean cultivation, but not as good as sawdust for blueberries. Kramer, et al. (1941) obtained increased yields of both highbush and dryland blueberries with various mulches, but mulching decreased plant survival of dryland blueberries. Chandler and Mason (1942) found that a mulch retains soil moisture by keeping the mean above that for clean cultivation, maintains a lower soil temperature, reduces growth of blueberry plants in sandy soils, and increases growth of blueberry plants in clay loam soils. Griggs and Rollins (1947) found that blueberries grown with a sawdust mulch produced longer shoots and had higher yields than those clean cultivated or mulched with hay. Sawdust also facilitated pruning, harvesting, and weed control operations. Sawdust mulch was superior to both hay mulch and clean cultivation with blueberries in trials of Christopher and Shutak (1947). The same authors reported in 1949 that sawdust-mulched plots produced significantly higher yields than plots under straw mulch, clean cultivation plus cover crops, or clean cultivation alone.

Little is reported in the literature on response of raspberries to mulching. However, the results obtained correspond somewhat with those of Clark (1939), Havis (1937), and by Darrow and Magness (1937) at Beltsville. Darrow and Magness found growth and fruiting under mulch satisfactory but not superior to what is usually found under cultivation in good raspberry areas. Clark in New Jersey and Havis in Ohio were working on better soils and reported increased growth and production from use of mulch on raspberries but not as great as that obtained by workers with other crops.

Experiment II: 1946-48 (Strawberries)

This experiment dealt with effect of fir sawdust used as surface mulch and fir and alder sawdust incorporated in soil on runner and fruit production of Marshall strawberry. These treatments were supplemented with three rates of complete fertilizer.

Methods

The plots, established in 1946 were 1/166 acre in size. Plants, spaced 18 inches apart in rows 3½ feet apart, were maintained as single hills by removing all runners that developed. Five rows were accommodated across each plot with 10 plants in the row or a total of 50 plants to the plot. A guard row separated each plot from the adjoining one.

Prior to setting plants, four-plot blocks were selected at random to receive either: (1) a 4-inch fir sawdust mulch, (2) 4 inches of fir sawdust incorporated with the top 8 inches of soil, (3) 4 inches of alder sawdust incorporated with the top 8 inches of soil, or (4) clean cultivation with no sawdust treatment. One plot in each of these four blocks was selected at random to receive a 7-10-4 fertilizer at the rate of: (1) 1440 lbs./acre (100 lbs. available N), (2) 2880 lbs./acre (200 lbs. N), (3) 5760 lbs./acre (400 lbs. N), or (4) no fertilizer. There was no replication of individual treatments for a test of interactions between sawdust and fertilizer effects. Each served as replication for the other (see Table 1).

Sawdust incorporated plots were established in fall of 1946. Strawberry plants were set on all plots early the following spring. After the plants were well established and making considerable growth, the mulched plots received a 4-inch application of sawdust. The same volume and type of sawdust was used in mulching these plots as was used the previous fall on sawdust incorporated plots. The

Table 1. RUNNER PRODUCTION OF MARSHALL STRAWBERRY PLANTS OBTAINED FROM FIR SAWDUST MULCHED, FIR AND ALDER SAWDUST INCORPORATED, AND CLEAN CULTIVATED PLOTS, SUPPLEMENTED WITH VARIOUS RATES OF A 7-10-4 FERTILIZER IN THE FIRST CROP YEAR, 1947

Sawdust Treatment	Pounds Nitrogen per acre*				Mean
	None	100	200	400	
	runners per plant	*runners per plant*	*runners per plant*	*runners per plant*	
None	9	10	11	10	10.00
Fir Sawdust Incorporated	9	11	12	13	11.25
Alder Sawdust Incorporated	6	11	10	12	9.75
Fir Sawdust Mulch	7	9	9	10	8.75
Mean	7.75	10.25	10.50	11.25	

* From 7-10-4 fertilizer
L.S.D. for fertilizer treatment means—5% = 1.54
1% = 2.21
L.S.D. for sawdust treatment means—5% = 1.54
1% = not significant

entire amount of fertilizer to be used on each plot was applied at time of mulching. The following spring (1948), an equal amount of the same fertilizer was applied to those plots receiving fertilizer treatment.

Runner plants were counted and removed periodically from all plots during growing seasons of 1947 and 1948. Berries were harvested the second year and a record made of total production, as well as average fruit size.

Results and Discussion

Data on runner production for 1947 are presented in Table 1, and those for 1948 in Table 2. Fruit yields from the plots in 1948 are found in Table 3. Data for fruit size are not given since samples were not sufficiently large to give reliable comparisons. However, there was a tendency for larger fruit size with fir mulch treatment.

Runner production during the first year was used as a measure of growth response to the sawdust and fertilizer treatments. It is apparent (Table 1) that sawdust, whether used as a mulch or incorporated, had little influence on vegetative growth of the plant during the first year. Runner production in the strawberry is often used as a measure of vegetative extension. Fertilizer treatment likewise had no great influence on runner production the first year. Approximately 100 lbs. of actual nitrogen in the form of a 7-10-4 commercial fertilizer did increase runner production over that of control plots receiving no fertilizer. Increasing nitrogen, phosphorus, and potassium above this amount did not significantly increase runner production.

Table 2. RUNNER PRODUCTION OF MARSHALL STRAWBERRY PLANTS OBTAINED FROM FIR SAWDUST MULCHED, FIR AND ALDER SAWDUST INCORPORATED, AND CLEAN CULTIVATED PLOTS, SUPPLEMENTED WITH VARIOUS RATES OF A 7-10-4 FERTILIZER IN THE CROPS SECOND YEAR, 1948

Sawdust Treatment	Pounds Nitrogen per acre*				Mean
	None	100	200	400	
	runners per plant	*runners per plant*	*runners per plant*	*runners per plant*	
None	41	38	41	54	44
Fir Sawdust Incorporated	30	42	37	48	39
Alder Sawdust Incorporated	32	55	56	69	53
Fir Sawdust Mulch	28	49	67	75	55
Mean	33	46	50	62	

* From 7-10-4 fertilizer
Differences for sawdust treatment not significant
L.S.D. for fertilizer treatment means—5% = 14
1% = 20

Runner production during the 1948 season (Table 2) is more indicative of plant response to the several treatments. As in 1947, sawdust treatment did not significantly influence runner production. However, runner production increased significantly with increasing amounts of fertilizer, but significance level decreased at the higher rates.

When fruit yields rather than runner production are used as a criterion of plant response, results are reversed (Table 3). In this case no significant difference in fruit yield can be attributed to fertilizer treatment, but greater fruit yield can be attributed to sawdust mulch.

These data indicate that sawdust mulching can increase strawberry yield over that obtained with clean cultivation. It is also apparent under some conditions that rather large amounts of fir or alder sawdust can be incorporated into soil without depressing strawberry yields during the first crop year, even though supplemental nitrogen is not applied. Data also supports the often expressed contention that factors other than soil nutrient-element content limit production of Marshall strawberries under Willamette Valley conditions.

Runner production increased with fertilizer application in both years and not with sawdust treatment, while increased fruit yields did not accompany this increase in runner production. It has been a common opinion that runner production can be used as a criterion of potential fruit production. These data indicate there is no direct correlation between runner production and potential fruit production by the mother plant, and growth factors that favor one do not necessarily favor the other. The common observation that increased runner production is followed by increased fruit production is more likely due to the increased number of plants and not to increased fruit production of the mother plant.

Table 3. Yield of Marshall Strawberries Obtained from Fir Sawdust Mulched, Fir and Alder Sawdust Incorporated, and Clean Cultivated Plots, Supplemented with Various Rates of a 7-10-4 Fertilizer in the Crops Second Year, 1948

Sawdust Treatment	Pounds Nitrogen per acre*				Mean
	None	100	200	400	
	grams per plant	*grams per plant*	*grams per plant*	*grams per plant*	
None	293	257	289	309	287
Fir Sawdust Incorporated	257	345	291	352	311
Alder Sawdust Incorporated	252	396	350	402	350
Fir Sawdust Mulch	457	480	558	434	482
Mean	315	370	372	374	

* From 7-10-4 fertilizer
Differences for fertilizer not significant
L.S.D. for sawdust treatment means—5% = 92
1% = 132

This experiment suggests the strawberry is a crop which will respond to sawdust mulching with increased yields under some conditions. These results are in accord with those obtained by Denisen, et al. (1953) and Harris (1951), with strawberries in Iowa and British Columbia, respectively. Shutak and Christopher (1951), working with strawberries in Rhode Island, found that differences between straw mulch and clean cultivated treatments were not consistent, but plants under sawdust mulch definitely outyielded all others. This large yield from sawdust mulching was obtained with different varieties in two separate experiments.

Influence of Sawdust on Incidence of Red-Stele Disease of Strawberry

Experiment III: 1948-1952 (Strawberries)

On the basis of results obtained in preliminary experiment II, a large scale experiment was started in 1948 with the primary purpose of determining effects on strawberry production of (1) sawdust incorporated in the soil, (2) sawdust as a surface mulch at the same rate as used in soil, and (3) clean cultivation without addition of sawdust. A second objective was to determine yearly amounts of supplemental nitrogen and/or phosphorus and potassium that must be applied with and following sawdust additions to satisfy demands of the crop and organisms decomposing the sawdust.

Although effect of sawdust on fungus diseases of strawberry was not an original objective, appearance of the red-stele disease (*Phytophthora fragariae*, Hickman) in plots made consideration of this disease imperative. Repeated appearance of this disease in the plantings made it relatively impossible to obtain original objectives and the disease study was given priority.

Methods

The planting site used on the Lewis-Brown Horticultural Farm had been planted to sudangrass for two years prior to planting strawberries. In the summer of 1948 sudangrass was plowed under and soil was prepared by discing.

The experiment was designed as a rondomized split plot with four replications of each treatment. The main effects of sawdust treatment [sawdust incorporated (4 inches), sawdust mulch (4 inches), and clean cultivation] were measured in four plots consisting of nine sub-plots for fertilizer effect (see Table 4 for nine fertilizer treatments). These sub-plots were 1/166 acre in size and contained five rows of 10 plants each, set 18 inches apart in rows 42 inches apart. Guard rows of the same strawberry variety separated all plots and sub-plots.

Fresh Douglas fir sawdust, containing approximately 178% by weight of water was applied at the rate of 166 tons per acre (approximately 60 tons dry weight) to sawdust incorporated plots in the fall of 1948 and rototilled into the upper 6-8 inches of soil. In the spring of 1949 all plots were planted with Oregon Experiment Station strawberry hybrid 2001. In June, when plants were well established, the mulch plots received a 4-inch application of the same sawdust ob-

Table 4. FERTILIZER TREATMENTS USED ON STRAWBERRIES IN EXPERIMENT III, 1948-1952

Fertilizer Treatment*			
Pounds N, P_2O_5 and K_2O per acre			
1949	1950	1951	1952
0–0–0	0–0–0	0–0–0	0–0–0
0–150–100	0–150–100	0–150–100	0–150–100
200–0–0	200–0–0	200–0–0	200–0–0
100–150–100	100–150–100	100–150–100	100–150–100
100–150–100	50–150–100	25–150–100	12–150–100
200–150–100	200–150–100	200–150–100	200–150–100
200–150–100	100–150–100	50–150–100	25–150–100
400–150–100	400–150–100	400–150–100	400–150–100
400–150–100	200–150–100	100–150–100	50–150–100

* Pounds per acre of nitrogen from ammonium sulphate, P_2O_5 from treble superphosphate, and K_2O from muriate of potash. One-half of nitrogen in early spring at the same time other materials were applied, the balance in early August before bud differentiation.

tained the previous fall. These mulched plots were not cultivated after mulching. Clean cultivated plots received no special treatment.

The nine fertilizer treatments were designed to measure the effect of 3 rates (100, 200, and 400 lbs. N/acre) of nitrogen with a standard rate of phosphorus (150 lbs. P_2O_5/acre) and potassium (100 lbs. K_2O/acre) applied each of 4 years; these same rates the first year but the amount of nitrogen reduced by one-half each successive year; nitrogen only (200 lbs. N/acre); phosphorus-potassium only (150 lbs. P_2O_5 and 100 lbs. K_2O/acre); and no supplemental fertilizer on the growth and yield of the strawberry with and without sawdust as a mulch or soil amendment and clean cultivated.

Fertilizer treatments were applied as side dressings on both sides of rows. The annual amount of phosphorus and potassium was applied a month after planting the first year and during April in years thereafter. Nitrogen applications were split—half being applied with the phosphorus and potassium and half in early August or about a month or more prior to flower bud differentiation.

During the 1949 season runners were counted periodically and removed. The following season the first fruit crop was harvested. Incidence of red-stele disease in plots made runner production and yield data unreliable, and they are not presented for consideration.

All plants were removed from plots at the end of the 1950 harvest season. Sawdust mulch was carefully removed from the soil and stored for reuse. Plots were then plowed and disced. In April 1951, plots were again planted, using the Marshall variety. Fertilizer rates and methods of application were continued as originally planned in the experiment. Sawdust was returned to the mulched plots with sufficient new sawdust to provide a 4-inch mulch. A record was made of runner production in 1951 and yield of fruit the following season.

Results and Discussion

Prevalence of red-stele during the 1952 season again indicated advisability of abandoning the original objective of obtaining reliable yield data. Valuable information on influence of Douglas fir sawdust and certain fertilizer elements on incidence of this disease was obtained in 1950 and 1952. These data for sawdust treatment are summarized in Table 5 and for fertilizer in Tables 6 and 7. [For a complete report see Vaughan et al. (1954).] Both fertilizer and sawdust had a marked effect on development of red-stele. Vaughan's data indicate, however, that each factor acted independently.

Applications of large amounts of nitrogen fertilizer increased development of red-stele disease. Therefore, in soils where this fungus is known to be present, and in poorly drained soils where the disease is most likely to develop, excessive nitrogen fertilization should be avoided. Although a sawdust mulch improved growth and appearance of strawberry plants during first season of growth and under normal conditions will increase yields in following years, the mulch should be avoided on soils where red-stele is present, since this disease causes much greater damage in mulched than clean-cultivated soils.

Caution must be used in applying sawdust in or on soil to aid in restoring organic matter to strawberry soils depleted by continuous row crop cultivation. Though previous studies have indicated sawdust may have considerable value in supplying organic matter and increasing crop yields, and this experiment shows it may be used safely if mixed well with soil, its use as a mulch on some soils may be extremely hazardous and should be avoided unless the grower is certain red-stele fungus is not present. Increased development of red-stele in soils mulched with sawdust appears to be brought about by a decrease in soil temperature and an increase in moisture content of soil beneath protective mulch.

As in experiment II, these data indicate that factors other than soil nutrient-element availability are likely to limit strawberry production under Willamette Valley conditions.

Table 5. INFLUENCE OF DOUGLAS FIR SAWDUST ON THE INCIDENCE OF RED-STELE DISEASE OF STRAWBERRY.

Sawdust treatment	Percentage of plants affected by red-stele	
	1950[1]	*1952*[2]
Sawdust incorporated with soil....	8.67	16.61
Mulched	12.72	35.89
Clean cultivated	7.89	8.00
L.S.D. 1%	Not Sig.	10.82

[1] Variety OE 2001
[2] Variety Marshall

Table 6. INFLUENCE OF NITROGEN FERTILIZER ON INCIDENCE OF RED-STELE DISEASE OF STRAWBERRY SELECTION OE 2001*

Treatment No.	Treatment**		Percentage of plants affected by red-stele June, 1950
	1949	1950	
1	0–0–0	0–0–0	4.33
2	0–150–100	0–150–100	9.33
3	200–0–0	200–0–0	13.67
4	100–150–100	100–150–100	7.67
5	100–150–100	50–150–100	5.00
6	200–150–100	200–150–100	10.50
7	200–150–100	100–150–100	9.67
8	400–150–100	400–150–100	9.67
9	400–150–100	200–150–100	18.33
		L.S.D. .01	10.74

* From Vaughan et al. (1954).
** Pounds per acre of nitrogen from ammonium sulfate, P_2O_5 from treble superphosphate, and K_2O from muriate of potash.

Table 7. INFLUENCE OF NITROGEN FERTILIZER ON INCIDENCE OF RED-STELE OF MARSHALL STRAWBERRY.*

Treatment No.	Treatment**		Percentage of plants affected by red-stele June, 1952
	1951	1952	
1	0–0–0	0–0–0	7.83
2	0–150–100	0–150–100	7.83
3	200–0–0	200–0–0	28.33
4	100–150–100	100–150–100	13.00
5	25–150–100	12–150–100	15.33
6	200–150–100	200–150–100	30.17
7	50–150–100	25–150–100	11.50
8	400–150–100	400–150–100	42.83
9	100–150–100	50–150–100	24.67
		L.S.D. .01	13.88

* From Vaughan et al. (1954).
** Pounds per acre of nitrogen from ammonium sulfate, P_2O_5 from treble superphosphate and K_2O from muriate of potash.

Influence of Sawdust on Fertilizer Requirement, Particularly Nitrogen, as Measured by Crop Response

Since a temporary depression of available nitrogen had been established as the principal problem involved in utilizing sawdust in soil management, 2 experiments were used to determine how long this depression persists under Oregon conditions. Residual effects of sawdust and fertilizer additions on soil fertility were studied. By measuring response of certain annual horticultural crops to such treatments over a period of several years, additional evidence was gathered as to feasibility of using a so-called "critical nitrogen percentage" with sawdust. As used with straw and other crop residues, it is the level required to bring about satisfactory nitrogen conditions for decomposition without decreases in crop yield.

Since the experiments used to gather this information involved different crops and methods, they will be discussed separately. These experiments were also conducted at the Lewis-Brown Horticultural Farm near Corvallis on a Chehalis silty clay loam soil using irrigation to supplement normal rainfall.

Experiment IV: 1947-1950 (Tomatoes and Potatoes)

This experiment was designed to determine the amount of supplemental fertilizer, particularly nitrogen, required for satisfactory growth and production of tomatoes and potatoes following incorporation of large amounts of fir and alder sawdust. Progressive changes in fertilizer requirement were measured over a 4-year period.

Methods

Randomized plots, 1/240 acre in size, were laid out in 2 ranges with walks on each side and a guard strip between each plot in the range. In fall 1946, fresh Douglas fir sawdust, containing approximately 178% by weight of water, was applied at the rate of 166 tons per acre (approximately 4 inches in depth and equivalent to 60 tons dry weight) to one-third of the plots. These plots were selected at random and sawdust was rototilled into the upper 6-8 inches of soil. A like number of plots were treated in the same manner with alder sawdust. The remaining third of the plots received no sawdust treatment.

During each of the four growing seasons (1947-1950), 8 Stokesdale tomato plants, spaced 3 feet apart in rows 3 feet apart, and 2 rows of Netted Gem potatoes in hills one foot apart with rows 3 feet apart, were planted on each plot. Guard rows were planted to the same crop they bordered.

Fertilizer treatments, consisting of five levels of nitrogen (0, 100, 200, 400, and 500 or 590 lbs./acre of N) in form of ammonium sulfate or a commercial 7-10-4 fertilizer, were made each spring soon after planting. The two forms of fertilizer were used in amounts to supply the same rates of nitrogen in each series. A comparison of N-only, as against NPK at each nitrogen rate was thus possible. Amounts of phosphorus and potassium applied increased with increasing amounts of nitrogen applied in the commercial 7-10-4 fertilizer. Fertilizers were applied to the plots each spring by broadcasting materials over the entire plot surface.

These fertilizer treatments were terminated after three seasons (no fertilizer spring 1950) to determine whether or not a nutrient balance satisfactory for biological activity and crop growth had been reestablished in the soil-sawdust mixture.

Total production of ripe tomatoes and their average weight was recorded each year. Amount of green fruit remaining at the end of the picking season was also recorded.

Since little information could be gained from either fruit size or green fruit data in interpreting influence of sawdust treatments, only total production of ripe fruit was used in the following discussion.

Response to sawdust or fertilizer treatment of potatoes paralleled tomatoes and data are not included in this report.

Results and Discussion

Tomato yields from these plots for 1947-1950, expressed as average pounds of ripe fruit per plant, and their statistical interpretation, are given in Tables 8 and 9. Figures in Table 8 are average yields for sawdust treatments without regard for fertilizer effects, while Table 9 gives average yields of fertilizer treatment without regard for sawdust effects. Although the experimental design does not allow a statistical evaluation of sawdust-fertilizer interaction, graphic presentation of data in Figure 2 indicates interactions are in effect.

Table 8. YIELD OF STOKESDALE TOMATO FOLLOWING INCORPORATION OF DOUGLAS FIR AND ALDER SAWDUST IN THE SOIL, 1947-1950

Sawdust treatment	Average lbs. of ripe fruit per plant 1947	1948	1949	1950*
No sawdust added	11.61	13.02	15.43	13.18
Alder sawdust incorporated	7.96	12.30	16.74	16.29
Fir sawdust incorporated	8.71	11.41	14.31	9.01
L.S.D. 5%	2.90	Diff. not significant	Diff. not significant	2.06

* No fertilizer treatments were applied in 1950.
Influence of N and NPK treatments applied in 1947, 48 and 49 are shown in Table 9.

Table 9. INFLUENCE OF N AND NPK FERTILIZERS ON THE YIELD OF STOKESDALE TOMATO PLANTS GROWN IN SAWDUST TREATED CHEHALIS SILTY CLAY LOAM SOIL, 1947-1950

	Average lbs. of ripe fruit per plant							
	1947		1948		1949		1950*	
Fertilizer Treatment	Am. Sul.	7-10-4	Am. Sul.	7-10-4	Am. Sul.	7-10-4	0	0
Lbs./N added yearly								
None	5.2	5.2	5.1	5.1	10.5	10.5	9.9	9.9
100	6.1	8.0	11.8	10.2	14.6	17.3	12.1	14.5
200	8.1	8.8	14.7	13.6	14.2	17.9	9.5	13.4
400	10.9	12.5	12.8	16.3	13.4	18.8	11.4	14.8
500 or 590[1]	13.5	11.8	10.8	14.9	12.4	20.3	13.6	16.3
L.S.D. 5%	5.1		5.1		4.9		3.6	

* No fertilizers were applied in 1950.
[1] 500 lbs. in case of $(NH_4)_2SO_4$ and 590 in case of 7-10-4. (Difference in rate of nitrogen applied accidental.)

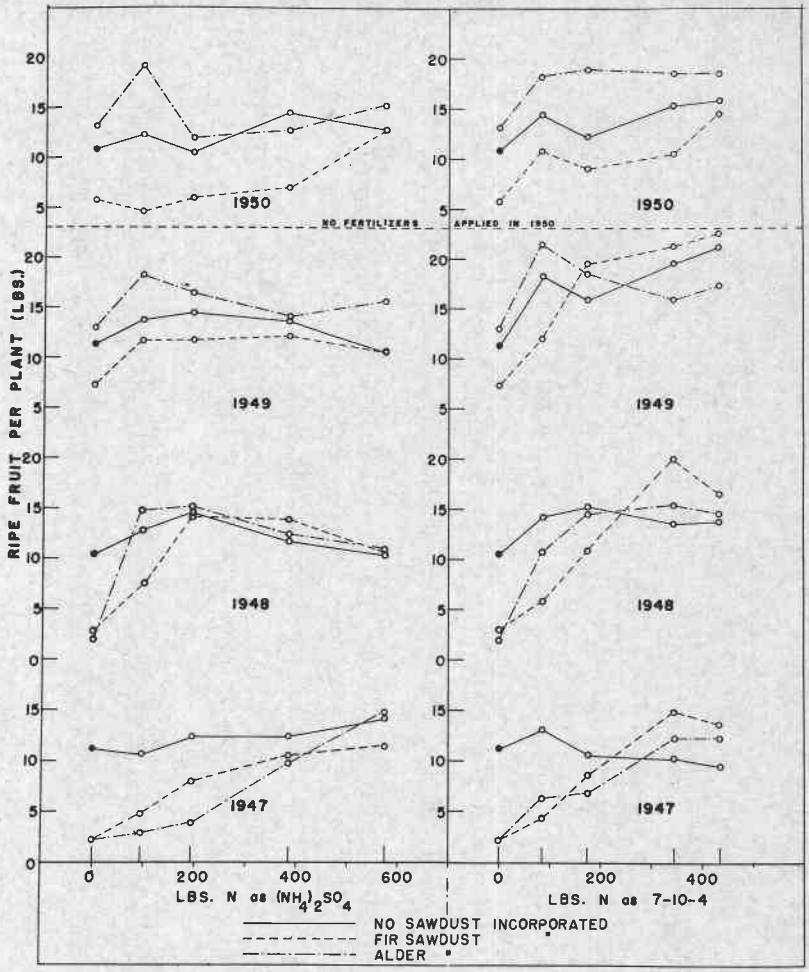

FIGURE 2. Effect of sawdust incorporations and supplemental nitrogen on the yield of Stokesdale tomato plants—1947-50.

Ignoring these interactions, alder sawdust depressed crop yields the first season (1947) after it was incorporated with the soil (60 tons per acre). No depression existed the second and third seasons and yields the fourth and final year (1950) show substantial increases as a result of alder sawdust additions (Table 8). Fir sawdust did not appear to give significant reductions in yield until the fourth season, although in general these plots did not make as much total growth as the control plots (no sawdust treatment) and had less green fruit remaining on the plants at end of the season.

Data in Table 9 reflects need for additional soil nitrogen in the plots the first year (1947) for maximum yields. There was a trend of increasing crop yields with increasing amounts to 400 lbs. N/acre. The second year 200 lbs. N/acre produced maximum yields. Addition of phosphorus and potassium to the fertilizer the first two years did not increase yield over that of nitrogen alone. However, additional nitrogen failed to increase yield the third year unless supplemented by phosphorus and/or potassium, in which case 100 lbs. N/acre rate gave maximum yields. This response to phosphorus and potassium was also evident again in 1950, even after fertilizer treatments were terminated. Such response the third and fourth seasons is interesting in light of possible interactions between sawdust and phosphorus availability as decomposition processes proceed.

These observations must be considered in light of interactions between sawdust and applied fertilizer indicated in Figure 2, otherwise the data in Tables 8 and 9 may be misleading. It appears that approximately 400 lbs. (6.6 lbs./ton sawdust) of supplemental nitrogen was required the first year (1947) to bring about satisfactory nitrogen relations in the soil. One-half of this amount or 200 lbs. of actual nitrogen was sufficient the second year and only 100 lbs. the third year. Yields obtained in 1950 without supplemental nitrogen indicate a definite shortage of available nitrogen still existed in those plots three years after incorporation of fir sawdust. This was not the case with alder sawdust, and after the second year of decomposition, significant increases in yield over that of the controls were evident in these plots whether supplemented with nitrogen or not. These graphs also substantiate increased response to phosphorus and/or potassium obtained with additions of fir or alder sawdust.

On basis of these data, approximately 8 lbs. of nitrogen per ton of alder sawdust was required over a 2-year period to bring about satisfactory nitrogen relations in soil for decomposition of sawdust without depleting supply of available nitrogen to a crop. Need for approximately 12 lbs. of nitrogen per ton of fir sawdust over a 3-year period was indicated, and even then supply of available nitrogen the fourth year was not above the critical level for satisfactory decomposition and crop demands. Data indicate small additions of nitrogen after the third year should be sufficient for normal crop yields.

While increased yields may be obtained after the second year with alder sawdust additions to the soil, little or no increase in yield can be expected from added fir sawdust, unless supplemented with large amounts of available nitrogen for at least four years. Data obtained in this experiment indicate that on this particular soil type, at least, use of phosphorus and possible potassium in a soil management program may enhance crop response to sawdust additions.

Experiment V: 1952-1953 (Sweet Corn Following Strawberries)

Plots used in experiment III (strawberries) and described in detail in the first section were used to provide additional information on residual effects of sawdust and its influence on fertilizer requirement. These plots, planted to strawberries for four years (1948-1952), were designed to show effects of Douglas fir sawdust, with and without fertilizers, and applied both as a mulch and incorporated with surface soil, on plant growth and yield. A summary of the yearly fertilizer treatments is given in Table 4 and their cumulative totals in Table 10.

Methods

Plots mentioned above were terminated in 1952 by discing under the strawberry plants. The mulched plots thus became incorporated for the 1953 season and constituted the only plot change as far as sawdust or fertilizer treatment was concerned. No additional N, P_2O_5, or K_2O was applied at time of planting a sweet corn crop in spring of 1953. It was thus possible to measure the residual effects of (1) four years of sawdust decomposition (incorporated 1949), (2) one year of fir sawdust decomposition (incorporated in 1952) and no sawdust treatment, with and without various rates of nitrogen and standard applications of phosphorus and potassium, on plant growth and yield.

Yield of Golden Cross Bantam sweet corn was used as a measure of soil fertility. Five rows of corn 3½ feet apart were planted across each plot and thinned uniformly to 1 foot in the row. The crop was irrigated regularly on basis of soil moisture content as determined by moisture blocks.

Average silking date was used as an index of maturity and all plots were harvested accordingly. The harvested corn was separated arbitrarily into good and poor ears. Average weight of good ears was determined after husking, while poor ears were weighed without husking.

Analysis of variance was used in making statistical interpretation of data presented in Tables 10 and 11. Figure 3 shows graphically interactions between sawdust and fertilizer treatments presented in Table 11.

A study of effects of these soil management practices on soil physical and chemical properties was made by Kirsch (1959), using soil and leaf tissue analyses.

Table 10. Yield of Sweet Corn as an Indication of Cumulative Effects of Sawdust and Supplemental Fertilizer on Soil Fertility During a 4-year Period 1949-1953 (Data composited[1])

Fertilizer Treatment		Days to mature (silking to harvest)	Average of 12 plots				
			Good Ears (Husked)			Poor Ears (Unhusked)	
Total pounds N-P_2O_5, K_2O added during 4-year period prior to planting*	Applied yr. prior to planting 1952		Number /plot	Total wt. Lbs./Plot	Average ear weight lbs.	Number	Total weight Lbs./Plot
0–0–0	0–0–0	31.0	32.8	12.6	.362	9.2	2.25
0–600–400	0–150–100	31.0	35.3	12.9	.350	7.9	1.90
187–600–400	12–150–100	31.6	38.5	14.8	.372	8.2	1.83
375–600–400	25–150–100	31.4	35.8	13.7	.369	9.7	2.08
400–600–400	100–150–100	31.3	39.5	15.8	.395	7.8	1.90
750–600–400	50–150–100	31.6	43.0	16.8	.383	6.8	1.67
800–600–400	200–150–100	31.5	40.0	15.7	.382	7.3	1.64
800–0–0	200–0–0	31.2	42.7	16.6	.376	9.5	2.23
1600–600–400	400–150–100	32.5	47.2	19.2	.402	8.8	2.07
L.S.D. 5%		Not	6.0	2.6	.027	Not	Not
1%		Signif.	7.9	3.4	.036	Signif.	Signif.
Sawdust Treatment			Average of 36 plots				
Sawdust incorp. (Current Season)		33.0	20.7	7.7	.351	10.3	2.09
Sawdust incorp. 4-years previous		31.7	41.7	15.9	.378	5.7	1.31
No sawdust		29.6	55.9	22.4	.402	9.0	2.46
L.S.D. 5%		Not	10.2	4.9	Not	Not	Not
1%		Signif.	15.4	7.4	Signif.	Signif.	Signif.

* No fertilizer applied the year planted.
[1] Average of 12 plots for fertilizer treatment and average of 36 plots for sawdust treatment.

Results and Discussion

The reduction in corn yields (Table 10) obtained on plots where old fir mulches (4 years) had been incorporated just prior to planting, as well as where sawdust had been added to soil four years earlier, are indicative of severe and long lasting depression of available nutrients which follows sawdust additions to soil. Analyses of soil samples by Kirsch (1959) showed both water-soluble nitrates and available soil phosphorus were decreased by sawdust treatment in these plots. These data obtained from plots receiving no supplemental nitrogen the year the corn crop was grown show clearly that reduction in crop yield was more severe on those plots which received recent sawdust additions than on those in which sawdust had been incorporated four years previously.

Increased corn yields obtained where earlier applications of nitrogen (Table 10) had been applied indicate some reserve nitrogen had accumulated during the 4-year fertilizer program and was available to the crop. This was substantiated by Kirsch in his soil studies.

Even though certain plots received substantial amounts of phosphorus and potassium fertilizer during the four years, these additions did not increase subsequent crop yields. Whether these earlier additions had been made unavailable or the level of phosphorus and potassium in the unfertilized soil was ample is not known. The latter seems probable, as increased yields from fertilizer phosphorus and potassium on this soil is relatively uncommon.

The corn yields recorded in Table 11 show interactions between sawdust and added fertilizer and again point up the importance of supplemental nitrogen in establishing satisfactory conditions for decomposition without reducing available nutrients to a crop. Incorporation of 60 tons/acre of fir sawdust the year of planting severely reduced crop yield, regardless of amount of nitrogen and/or phosphorus added previously. This emphasizes the need for yearly applications of adequate amounts of nitrogen and phosphorus during process of decomposition. Adding sufficient nitrogen and phosphorus to sawdust at time of its incorporation to bring it to a critical nitrogen percentage [Allison and Anderson, (1951)] is not sufficient, but rather must be maintained during the five to six years of decomposition. Plots receiving a cumulative total of 1,600 lbs. of actual nitrogen per acre during the four years prior to adding sawdust did not have sufficient available nitrogen to produce a corn crop equivalent to that of unfertilized controls without sawdust. Kirsch (1959) was able to recover only 220 lbs. of total nitrogen from such plots and attributes this loss of available nitrogen to microbial activity associated with sawdust, leaching and/or excessive moisture accompanied by denitrification.

Table 11. YIELD OF SWEET CORN AS AN INDICATION OF CUMULATIVE EFFECTS OF SAWDUST AND SUPPLEMENTAL FERTILIZER ON SOIL FERTILITY DURING A 4-YEAR PERIOD, 1949-1953

Total pounds N-P_2O_5, K_2O added during 4-year period prior to planting[1]	Applied year prior to planting 1952	Weight of good husked ears: No sawdust used	Sawdust (60 T/acre) incorporated same year crop planted (1953)	Sawdust (60 T/acre) incorporated 4-years prior to planting (1949)
		lbs./plot Average of 4 plots	*lbs./plot Average of 4 plots*	*lbs./plot Average of 4 plots*
0-0-0	0-0-0	20.1	5.8	11.8
0-600-400	0-150-100	21.3	6.4	11.0
187-600-400	12-150-100	22.9	6.3	15.4*
375-600-400	25-150-100	20.7	7.2	13.1
400-600-400	100-150-100	21.1	8.8	17.5*
750-600-400	50-150-100	24.9	8.5	17.2*
800-600-400	200-150-100	21.8	7.1	18.2*
800-0-0	200-0-0	22.6	8.3	18.9*
1600-600-400	400-150-100	26.7	10.5	20.4*

(T x F) L.S.D. 5% = 4.5
1% = 5.9

* Plots equal to the unfertilized checks without sawdust.
[1] No additional fertilizer treatment the year (1953) the corn crop was planted.

Plots receiving sawdust treatment four years prior to planting corn showed reduced yields in six out of nine fertilizer treatments. While these reductions in yield were confined in general to plots receiving less than an average of 100 lbs. N/acre per year, it is significant that no plots receiving sawdust produced more corn than those not receiving sawdust, regardless of fertilizer history. This indicates soil fertility had not been improved, even after four years, where such large amounts of fir sawdust had been added. It also means that for many crops supplemental nitrogen and possibly phosphorus will be necessary even in the fifth and sixth year if better than average yields are to be obtained.

Plots receiving a total of 400 or more lbs. of actual nitrogen during the 4-year period prior to sowing corn produced as much as did the average of the unfertilized control plots receiving no sawdust or supplemental nitrogen (Table 11). This means a total of 400 lbs. of actual nitrogen over a 4-year period was sufficient to bring 60 tons/acre of fir sawdust (approximately a 4-inch application) mixed with soil into satisfactory balance for decomposition without depleting the supply of available nutrients to the crop.

These results are similar to those obtained with tomatoes in experiment IV. Differences noted are expected when working with

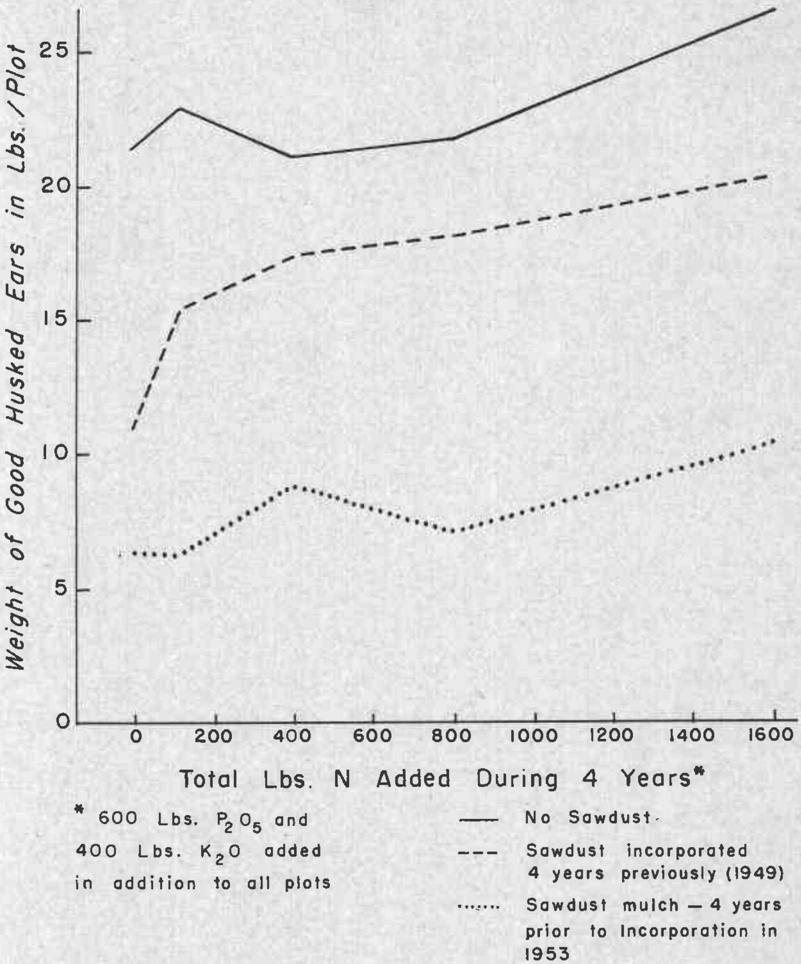

FIGURE 3. Effect of sawdust incorporations and nitrogen additions over a 4-year period to a Chehalis silty clay loam on the subsequent yield of sweet corn, 1949-52. (Crop grown in 1953 without fertilizer.)

different crops in different seasons. Where approximately 12 lbs. of nitrogen per ton of fir sawdust was sufficient over a 3-year period to bring about satisfactory soil relations for a tomato plant, only 8-10 lbs. were necessary with sweet corn. These figures compare favorably and suggest that 10-15 lbs. of actual nitrogen per ton of fir sawdust, applied over a 4- or 5-year period of decomposition should be adequate.

Data obtained in these experiments emphasize that a "critical nitrogen percentage" as suggested by many investigators for straw and other rapidly decomposing organic residues, is not applicable to sawdust and other residues high in lignin. Rate of decomposition is so slow in the latter case as to require supplemental nitrogen and to lesser extent, phosphorus over a long period (five-six years) of time. While the requirements for supplemental nitrogen can be calculated on the basis of long term experiments such as these, a single application of nitrogen to bring the content of the soil-sawdust mixture to 1.2 or 1.5%, as is often done with straw, is not feasible.

Summary

As part of an over-all study of effects of sawdust and other organic residues on physical, chemical, and biological properties of soil and crop response thereto, a series of experiments were designed to measure effects of such soil management on (1) yield of certain horticultural crops, (2) incidence of red-stele disease of strawberry, and (3) fertilizer requirement, particularly nitrogen, as measured by crop response. These experiments, using Douglas fir sawdust, alder sawdust, oak leaves and grain straw as mulches and soil amendments, were conducted over an 8-year period at the Lewis-Brown Horticultural Farm near Corvallis on a Chehalis silty clay loam soil with supplemental irrigation. Blueberries, raspberries, azaleas, roses, tomatoes, potatoes, and sweet corn were used in five different experiments to measure immediate and residual effects of sawdust additions when supplemented by various rates of fertilizer nitrogen with and without a standard rate of phosphorus and potassium.

Data obtained from these experiments and their interpretation indicated that crop response to sawdust additions will depend on a number of factors including: type and quantity of sawdust used, method of use (mulch or incorporated), how long it has been used prior to planting, and the type of crop planted.

Based on crop responses, the following observations were made on the use of sawdust in soil management practice for horticultural crops:

The growth of perennial horticultural crops. Sawdust was superior to either straw or oak leaves as a mulch for blueberries and azaleas, and mulching superior to clean cultivation.

Yield of raspberries was not increased by mulching practice regardless of materials used (straw, fir sawdust, oak leaves) over that of clean cultivation.

Rather large amounts of fir or alder sawdust could be incorporated in some soils without depressing yields of strawberry.

The strawberry responded to sawdust mulching with increased yields under disease free conditions.

Incidence of red-stele disease of strawberry. Applications of large amounts of nitrogen fertilizer and/or sawdust as a mulch increased development of red-stele disease in strawberry.

Fertilizer requirement, particularly nitrogen, as measured by crop response. Fir and alder sawdust used as a surface mulch did not increase fertilizer requirement of strawberries.

Douglas fir sawdust mixed with surface soil at the rate of 60 tons/acre (dry weight) required approximately 400 lbs. of supplemental nitrogen per acre (6.6 lbs. actual N/ton sawdust) the first year, 200 lbs. the second, and 100 lbs. the third and fourth years to supply sufficient available nitrogen for a tomato or potato crop during decomposition of sawdust.

Alder sawdust incorporated at the same rate required the same amount of nitrogen (6.6 lbs.) per ton of sawdust during the first year but only 100 lbs. N/acre the second and none thereafter for satisfactory decomposition without depressing yield of tomatoes and potatoes.

Alder sawdust mixed with soil increased yield of tomatoes and potatoes after the second year and apparently increased crop response to applied phosphorus and potassium.

Fir sawdust additions did not increase crop yield of tomatoes and potatoes during a 5-year period, and in most cases reduced yields unless supplemented annually with relatively high rates of nitrogen and phosphorus fertilizer.

Conclusions

Supplemental nitrogen and possibly phosphorus will be required as long as the fifth and sixth years after fir sawdust additions, if better than average yields are to be obtained with most crops.

A total of approximately 10-15 lbs. of actual nitrogen per ton of dry fir sawdust applied over a 4-5 year period in decreasing amounts appears adequate for horticultural crops during progressive decomposition of sawdust incorporated at rate of 60 tons-acre dry weight.

Sawdust mulching requires little if any supplemental nitrogen for satisfactory growth of most crops, until root development extends into the mulch or the sawdust becomes intimately mixed with soil and decomposition commences.

A "critical nitrogen percentage" as applied to straw and similar organic residues which decompose rapidly is not applicable to sawdust which decomposes slowly. Annual losses of nitrogen through leaching, crop, and organism use must be replaced regularly.

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