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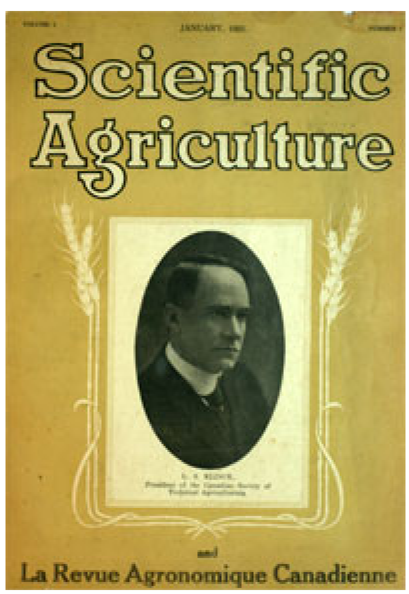

SAWDUST AS A MULCH FOR STRAWBERRIES

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Strawberries are the most important of the small fruits grown in British Columbia. They are particularly adapted to the coastal areas of southern British Columbia.

The lumber industry is very large and thriving in this area and the cut of hemlock is increasing each year, so that large quantities of hemlock sawdust are available in progressively increasing amounts.

The object of this experiment was to ascertain whether this hemlock sawdust could be used as a mulch for strawberries with beneficial effects and so prove a boon to both industries instead of a waste product.

Physical and chemical effects of mulches such as straw, hay and manure have been extensively investigated but the effects of sawdust on the soil have come under consideration only in recent years. Midgely (7) points out that woody materials when added to the soil act like other carbonaceous materials. Anderson (1) and Thom (13) have reported that the addition of straws and cellulose to the soil depress the available nitrogen. Turk and Partridge (15) state that nitrification was slower under mulched than unmulched soils. However, they agree with Anderson (1) that soil processes are not inhibited by the addition of a carbohydrate and that actually soil conditions are improved for the development of micro-organisms which utilize the available nitrogen for their growth, the nitrogen usually becoming a limiting factor.

Shatuk *et al.* (12) found that sawdust applied as a mulch to blueberries increased the soil moisture but the increase was not so great as with straw. Turk (14) considers that the effect of sawdust is largely physical. He reports better water holding capacity, decreased soil losses due to erosion, prevention of a hard crust on the soil surface and that capillary movements of water may be limited by the addition of sawdust to the soil.

Most of the humus in soil is derived from, or is lignin in a modified form (5). The end product in the wood decay process is humus and as a result of this conversion considerable amounts of nitrogen, phosphorous and potash may be deposited (2). Turk (14) states that, on an average, sawdust contains 4 pounds of nitrogen, 2 pounds of phosphorus and 4 pounds of potash per ton of dry sawdust; this is about one-third the amounts of nutrients contained in the same amounts of wheat straw. Analyses of sawdust and wood shavings used as bedding material show the following: nitrogen 0.4 per cent or 8 pounds per ton; phosphorous 0.3 per cent or 6 pounds per ton; potash 0.7 per cent or 14 pounds per ton (17). The amounts of nutrients, however, will vary with the type of wood from which the sawdust is derived.

Shatuk *et al.* (12) report that the soil pH was significantly higher under sawdust-mulched blueberry plots than under straw-mulched or clean cultivated blueberry plots. Midgely (7) states that the suggestion that sawdust produces excessive soil acidity has no basis. He states further that soft wood sawdust contains less basic materials than hardwood sawdust; yet after a complete decay, most of the organic acids are used by the micro-organisms or lost into the air, leaving an alkali or neutral residue in the soil. All plant ashes are alkaline in reaction. Midgely concludes that, while some plant residues contain certain tannins, these are destroyed by the soil organisms before they remain long in the soil.

Shatuk *et al.* (12) found that blueberry yields were significantly higher in plots mulched with sawdust than in plots mulched with manure or in clean cultivation.

MATERIALS AND METHODS

The experiment was carried out on the farm of the University of British Columbia. The soil is one of the typical soil types of coastal British Columbia. It can be described briefly as an upland glaciated sandy loam with a reaction of about pH 6.0. The organic matter content is low and, due to the leaching effect of the heavy winter rains in this area, available nutrients in general are low.

An area approximately one acre in size was selected and divided into 72 plots. Each plot was planted with certified British Sovereign plants and consisted of 5 rows of 10 plants each, or 50 plants spaced 18 inches within the row and 3 feet between rows. Guard rows were placed between all plots. The British Sovereign variety of strawberry is a local product and is used by growers almost exclusively in the lower Fraser Valley and on Vancouver Island, the two largest strawberry-producing areas in British Columbia.

Twenty-four randomized plots received an application of barnyard manure at the rate of ten tons per acre. Another 24 plots were covered with a layer of freshly cut hemlock sawdust to a depth of 2 inches, while the remaining 24 plots were left for clean cultivation. The manure was disked under before planting, but the plants were planted in the sawdust plots directly by pushing back the sawdust and inserting the planting spade deep enough to penetrate the soil to the required depth for the roots. The whole area received an application of 8-10-5 fertilizer, broadcast at the rate of 1000 pounds per acre. The planting took place on May 30, 1947. Cultivation was practised in the manured and clean cultivated plots while the few weeds which penetrated the sawdust were removed with a Dutch hoe.

On August 15, 1947, leaf samples were taken from each plot for analyses and then a further application of 8-10-5 fertilizer was made at the rate of 500 pounds per acre.

On September 4 a count was made of the number of runners on each plant.

In January, 1948, the sawdust plots received a further 2-inch application of sawdust. The original application had worked down to a considerable extent into the light soil. The ground was frozen at the time, which greatly facilitated spreading the sawdust. In March, 1948, the manure application was repeated and a 1000 pounds per acre of 8-10-5 fertilizer broadcast over the whole area. The treatments were continued as in the previous year except that the crop was harvested and all runners were kept removed from the plants.

The yield data were recorded separately from each plot and analysed statistically by the method of analysis of variance. Samples of fruit from each plot were analysed for ash, carbohydrates, acidity and vitamin C.

The whole area was again fertilized with 8-10-5 fertilizer in August, 1948, at the rate of 300 pounds per acre.

The winter of 1948-49 was very severe for the district, the temperature dropping to 10° F. Very little snow was on the ground, with the result that considerable heaving of strawberry plants was a common occurrence in the district.

In 1949 no further addition of sawdust was made; otherwise the treatments were continued the same as in previous years. The fruit was harvested and data were recorded for yield, sugars, ash, acidity and vitamin C content, together with nitrogen, phosphorous, potash, calcium and magnesium.

Soil samples were taken just prior to setting out the plants in 1947 and again in August, 1948, and 1949. They were analysed for organic matter, nitrogen, phosphorous, potash, calcium and magnesium.

The methods of analyses used were as stated below:

Soil.—Numerous difficulties beset the accurate determination of organic matter. However, as a relative index and for comparative purposes, the wet method of oxidation where the soil is digested with chromic and sulphuric acids was decided upon as being a reasonable method and because of its convenience in determining large numbers of samples. Soil samples were taken to a depth of six inches after the surface sawdust or trashy material, in the case of the manured plots, had been removed. The samples were air-dried and passed through a sieve with round holes of 0.5 mm. in diameter. Ten gram samples of the sifted soil were used for each determination which was made by the rapid titration method of Schollenberger (10, 11). All samples were run in triplicate. Nitrogen was determined by the Kjeldahl method A.O.A.C. (3). A hydrochloric acid extract was made for the determination of calcium, magnesium, potassium and phosphorous as outlined by Wright (16). Potassium was determined by the method of Peech *et al.* (8); calcium and magnesium according to Blasdale (4); phosphorous by the blue colorimetric method of Deneges as modified by McCance and Shipp (6). Soil reaction was determined with a Beckman pH meter using a glass electrode.

Fruit and Leaves.—Ashing was done at 600° C. in an electrical muffle furnace. The dry-weight of leaves was determined by drying in an electric oven at 70° C. and that of the fruit at 60° C. Carbohydrates were determined by the method of Lane and Enynon (3) and vitamin C by the Indophenol-Xylene extraction method of Robinson and Stotz, using a photoelectric colorimeter (9).

RESULTS

Soil

The results of the effect of the treatments as determined by the analyses of the soil samples taken initially when the plants were set out in May, 1947, and in August, 1948, and in August, 1949, are shown in Table 1.

This table shows that the results of the pH determinations are in accord with those of Shatuk *et al.* (12). The pH was significantly higher under the sawdust mulch, in the final analysis, than under the other treatments.

The first year after the treatments only the manured plots showed an increase in organic matter. By the second year, however, the organic matter in the sawdust-treated plots equalled that in the manured plots and finally surpassed them.

The mineral content (ash) of the soil progressively increased as a result of the fertilizer treatments with the exception of that in the sawdust plots. As will be discussed later, the larger plants and crop produced could be responsible for this lack of increase in minerals in these plots.

Nitrogen as nitrates in the sawdust plots did not increase as a result of the treatments the first year. This is in accord with other workers (5, 15, 2, 14). The final values determined for total nitrogen showed a depressing effect of the sawdust but again, as will be seen later, this did not have any deleterious effect on the crop. Either the larger plants used more nitrogen from these plots, or there was ample nitrogen for the crop even with the reduced amount available.

TABLE 1.—THE EFFECTS OF TREATMENTS ON SOIL

Factor	Treatment									L.S.D., 5 per cent
	Manure			Clean cultivation			Sawdust			
	May, 1947	Aug., 1948	Aug., 1949	May, 1947	Aug., 1948	Aug., 1949	May, 1947	Aug., 1948	Aug., 1949	
pH	5.68	5.70	5.70	5.66	5.77	5.70	5.70	5.90	6.02	0.086
O.M., per cent	1.50	2.17	5.20	1.70	1.90	1.75	1.70	1.90	5.80	0.288
Ash, per cent	0.340	0.410	0.450	0.340	0.370	0.450	0.350	0.370	0.384	0.058
NO 3*	28.00	45.50	—	29.00	42.50	—	29.00	29.00	—	3.33
Total N, per cent	—	—	0.139	—	—	0.09	—	—	0.017	0.008
P.*	10.00	33.20	—	5.50	22.10	—	6.00	20.80	—	1.580
Total P., per cent	—	—	0.128	—	—	0.120	—	—	0.082	0.009
K.*	48.00	98.40	48.40	48.00	74.00	47.20	48.00	31.42	83.40	8.82
Ca.*	—	—	256.00	—	—	246.00	—	—	236.00	18.07
Mg.*	—	—	35.00	—	—	30.00	—	—	47.00	3.90
B. p.p.m.	—	—	2.81	—	—	3.10	—	—	6.33	0.326

* Pounds per acre (2 million).

Phosphorous was depressed under the sawdust; potash was less for the first year but eventually it increased markedly.

Calcium appeared to be depressed under sawdust in contrast to the manured plots, whereas magnesium was increased.

Boron increased under the sawdust treatments.

During a period in July, after a prolonged dry spell, soil samples were taken under the various plots to ascertain the effect of the mulch on the water-holding capacity of the soil. The results shown in Table 2 indicate the amount of moisture present in the soil at the time of sampling.

TABLE 2.—THE EFFECT OF SAWDUST MULCH ON WATER HOLDING CAPACITY OF THE SOIL

Treatment			S.D. 5 per cent
Manure	Clean cultivation	Sawdust	
%	%	%	
7.80	8.10	11.7	1.02

It can be seen that the sawdust mulch was effective in increasing the water-holding capacity of the soil.

Plants

It was thought that runner production should be some index of vigour in the plant. Consequently, from the time of planting, runners were counted until September. Owing to the late planting, runner production had by no means ceased at this time, but, from this period on, they were removed without counting. Table 3 shows the counts obtained during the period mentioned.

It should be stated that in the reasonably sheltered experimental area used the runners rooted readily in the compacted sawdust. However, it is conceivable that in very windy areas a pegging-down of runners might be desirable. In this particular experiment, after the initial counting of runners mentioned above, the Hill system of growing was adhered to. The Hill system is used almost exclusively in growing the British Sovereign variety in British Columbia.

TABLE 3.—THE EFFECT OF TREATMENTS ON RUNNER PRODUCTION

	Treatment		
	Manure	Clean cultivation	Sawdust
Average number of runners per plant	7.98 ± 1.03	9.52 ± 1.03	12.6 ± 1.03

TABLE 4.—THE EFFECT OF TREATMENTS ON LEAF COMPOSITION (1947)

Factor	Treatment			L.S.D., 5 per cent
	Manure	Clean cultivation	Sawdust	
	%	%	%	%
Dry weight	28.00	28.85	27.92	2.24
Carbohydrate, d.w.	30.39	28.09	30.85	2.89
Nitrogen, d.w.	2.317	2.145	2.2975	0.171
Ash, f.w.	0.647	0.646	0.634	0.045
Phosphorous, d.w.	0.313	0.330	0.290	0.021
Potash, d.w.	1.50	0.96	1.35	0.112

It will be observed that the plants in the sawdust-treated plots produced the most runners.

An analysis of leaves taken from the plants in August, 1947, is shown in Table 4.

Carbohydrates, nitrogen and potash were lowest under clean cultivation, while phosphorous was so in the sawdust-treated plots.

Fruit

The effect of the treatments on the mineral composition of the fruit from the 1949 crop is shown in Table 5.

TABLE 5.—THE EFFECT OF TREATMENTS ON THE COMPOSITION OF THE FRUIT (1949 CROP)

Factor	Treatment			L.S.D., 5 per cent
	Manure	Clean cultivation	Sawdust	
	%	%	%	%
Dry weight	14.89	13.96	14.34	1.04
Ash, f.w.	0.544	0.483	0.505	0.035
Nitrogen, f.w.	0.162	0.148	0.150	0.018
Phosphorous, f.w.	0.032	0.036	0.031	0.003
Potash, f.w.	0.785	0.670	0.765	0.068
Calcium, f.w.	0.048	0.047	0.039	0.006
Magnesium, f.w.	0.016	0.015	0.021	0.004

TABLE 6.—EFFECT OF TREATMENTS ON YIELD AND COMPOSITION OF FRUIT FOR EACH CROP YEAR 1948 AND 1949

Factor	Year	Treatment			L.S.D., 5 per cent
		Manure	Clean cultivation	Sawdust	
Yield, lb. per plot	1948	30.03	27.38	27.07	4.90
	1949	58.00	52.00	120.00	14.60
	Av.	44.00	39.69	73.50	6.22
Ash, f.w., per cent	1948	0.5520	0.5435	0.5932	0.0394
	1949	0.5440	0.4821	0.5048	0.0408
	Av.	0.5480	0.5128	0.5490	0.0320
Sugars, f.w., per cent	1948	9.47	9.63	9.16	0.6094
	1949	9.45	8.80	8.27	0.5188
	Av.	9.46	9.21	8.74	0.450
pH	1948	3.28	3.29	3.29	0.020
	1949	3.28	3.28	3.33	0.035
	Av.	3.28	3.29	3.31	0.019
Vitamin C, mgm./100 gm., f.w.	1948	95.50	94.16	92.11	5.48
	1949	82.00	90.00	98.00	6.30
	Av.	88.75	92.08	95.05	4.32

From the foregoing results it would appear that the mineral (ash) content of the fruit was the highest in that from the manured plots, phosphorous was highest in fruit from the clean cultivated plots, potash was lowest in fruit from the clean cultivated plots, calcium was lowest in fruit from the sawdust-treated plots and magnesium was highest in fruit from the sawdust-treated plots.

Table 6 shows the data which were obtained on yield of fruit and from the chemical analyses of the same, for each crop year 1948 and 1949.

Yield

In 1948 the yield of fruit from the manured plots tended to be the highest, although the results were not significant at the 5 per cent level. In 1949, however, the sawdust plots greatly outyielded both the manured and clean cultivated plots. The combined results of the two years showed that the sawdust plots outyielded the manured and clean cultivated plots.

Ash.—The sawdust plots produced berries with the highest mineral content in 1948. In 1949 a reversal took place and the manured plots produced berries with the highest mineral content. In the combined results the manured and sawdust-treated plots both produced berries of a higher mineral content than did the clean cultivated plots.

Sugars.—The 1948 results show a trend towards the highest sugar content in the berries from the clean cultivated plots. In 1949 the berries from the manured plots showed the highest sugar content. The combined results show that the sawdust had depressed the sugar content of the fruit.

Acidity.—The acidity of the fruit from the sawdust plots showed a tendency to decrease in 1948 and a definite decrease was apparent in 1949. The combined results for both years show a significant decrease in acidity as a result of the sawdust treatment.

Vitamin C.—In 1949 the fruit from the sawdust plots showed the highest vitamin C content and that from the manured plots the least. The combined results show that the sawdust plots produced berries of higher vitamin C content than did the manured plots.

DISCUSSION

It was obvious throughout the experiment that no harmful effect was derived from the application of the sawdust. In fact, everything pointed towards its beneficial nature. There was evidence that nitrification was slower under the sawdust than in the clean cultivated or manured plots, but the soil processes were not inhibited by its addition. This is in agreement with the workers previously mentioned (1, 15). The physical improvement of the soil was noteworthy and, after the first year, breakdown of cellulose and hemicellulose was apparent by the large increase in organic matter in the soil shown in the 1949 analyses, Table 1. The decrease in acidity of the soil under the sawdust is in accord with Shatuk *et al.* (12).

The effect of the sawdust mulch in preventing heaving of strawberry plants was very pronounced as evidenced by the effect of the hard winter of 1947-48. This could account in part but not altogether for the higher yields from the sawdust plots in 1949.

The depressing effect on nitrogen and phosphorous in the soil by the sawdust was not reflected in the fruit when compared with that from the clean cultivated plots. In view of the larger crop from the sawdust plots and hence the greater drain on the soil for nutrients it could either be interpreted that the sawdust made more nutrients available to the plant or that the greater crop reduced the soil nutrient content in a degree proportionate to the increased amount used by the larger crop. On the other hand, all plots were well and adequately fertilized so that the minerals and nitrogen were not limiting factors in this experiment. The soil under the sawdust plots did have a lower calcium content and a higher magnesium content than that of the other plots. This was reflected in the fruit, whereas there seemed to be no similar relationship between fruit and soil with the other minerals and nitrogen. Possibly calcium and magnesium were nearer to limiting values in the soil than the other constituents determined.

The depressing effect of sawdust on sugars in the fruit seems to be a factor to be considered in sawdust mulching. However, associated with this lowering of sugar was the increased vitamin C content and tendency towards a higher pH of the berry. The inverse relationship here shown between sugars and vitamin C is difficult to explain, unless the higher pH in some way affected the factors concerned in the more effective metabolism of the ascorbic acid and proportionally more of the sugars were used in the process.

SUMMARY

Sawdust mulching did not appear to be harmful to strawberries; in fact, taking all factors into consideration, it was beneficial. Besides improving the physical condition of the soil it prevented heaving of the plants during a severe winter and its after-effects.

While sawdust did reduce the nitrogen content of the soil, this condition was not reflected in the fruit. Nitrogen, however, under the conditions of this experiment was adequately supplied.

Yields of fruit were increased markedly by the use of the sawdust mulch the second year after its application, and while there was reduction in the sugar content of the fruit there was an increase in vitamin C content.

Hemlock sawdust would appear to have possibilities of becoming very beneficial to the strawberry industry and to agriculture in general as a soil amendment and mulching material. No harmful effect on the soil by its use was noted. This should create an outlet for increasing quantities of hemlock sawdust which might otherwise be considered a waste product, thereby benefiting the lumber industry as well as agriculture.

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