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## The Effects of Soil Management Systems on the Chemical Composition and Quality of Apples

### II. Cox's Orange Pippin and Red Jonathan Apples

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The quality of fruit of Cox's Orange Pippin and Red Jonathan from different soil management treatments was tested in 1969 and again in 1970. The range of tests included soluble solids, reducing sugar and acid contents, texture measurements and taste panel assessment. The non-cultivation treatment gave the highest yields and the quality of fruit of both cultivars from all treatments was acceptable. Grass improved the quality of Cox's Orange Pippin in 1969 but not in 1970. Cultivation gave higher soluble solids levels than non-cultivation for Red Jonathan in both seasons. There was no correlation between soluble solids content and taste panel response for either cultivar. However, solids levels of fruit from the different treatments tested were close together thus making it difficult for the panel to distinguish between samples.

Soluble solids levels increased in fruit of Cox's Orange Pippin during storage at 1 °C in 1969 but remained constant in 1970. Levels in Red Jonathan decreased in both seasons. Fruit of Cox's Orange Pippin became softer during storage in both seasons while fruit of Red Jonathan softened only in 1969.

Acid levels for fruit of both cultivars from the different soil management treatments were not significantly different in either season.

#### 1. Introduction

Fruit of Cox's Orange Pippin and Red Jonathan tested in this experiment were obtained from the non-cultivation experiment of O'Kennedy and Robinson<sup>1</sup> described in the preceding paper.<sup>2</sup> The aims and objectives of the experiment were similar to those described for Golden Delicious apples.<sup>2</sup> Tests were carried out in the 1969 and 1970 seasons at harvest time and again after a period of storage in air at 1 °C.

#### 2. Experimental

##### 2.1. Fruit source

Fruit was obtained from the soil management experiment planted in February 1965.<sup>1</sup> The different soil management treatments are listed below and abbreviations in parentheses are used throughout the text.

1. Clean cultivation (cultivated).

2. Clean cultivation followed by grassing down after 3 years (cultivation 3 year+ grass—or grassed down).
3. Non-cultivation (non-cultivated).
4. Non-cultivation followed by grassing down after 3 years (non-cultivation 3 year + grass—or grassed down).
5. Non-cultivation + straw mulch (mulched).
6. Grassing down from planting time (grass only).

Red Jonathan was planted as guard rows around plots containing Golden Delicious and Cox's Orange Pippin, each soil management treatment extending for 7.5 ft beyond the guard row.

### 2.2. Range of quality tests

In 1969 fruit of both cultivars was tested for reducing sugar, a.i.s., soluble solids (s.s.), acid, astringency and nitrogen in the skin and flesh contents. In 1970 only s.s. and acid contents were measured. Shear estimations and taste panel evaluation of flavour were done in both seasons. Fruit of Cox's Orange Pippin was tested at harvest time and after 50 and 68 days storage in air at 1 °C in the 1969 and 1970 seasons, respectively. Fruit of Red Jonathan was tested at harvest time and after 80 days storage in air at 1 °C in 1969 and 1970.

### 2.3. Chemical, physical and organoleptic tests

Preparation of fruit for testing and methods used for evaluation of chemical composition were identical with those described by Gormley, Robinson and O'Kennedy,<sup>2</sup> in the preceding paper. Taste panel methods were also the same.

## 3. Results

### 3.1. Percentage soluble solids

Values for fruit of Cox's Orange Pippin and Red Jonathan showed differences between treatments at time of harvest ( $P=0.01$ ,  $P=0.05$ , respectively) in the 1969 season (Figures 1 and 2). Grassed-down plots gave fruit with higher s.s. levels ( $P=0.001$ ) for Cox's Orange Pippin in 1969 than non-grassed plots. This effect was not found in fruit of Red Jonathan but cultivation gave a higher s.s. content ( $P=0.01$ ) than non-cultivation for this cultivar in the absence of grass (interaction,  $P=0.05$ ) (Figure 2). Storage of fruit of Cox's Orange Pippin in 1969 for 50 days at 1 °C resulted in an increase in s.s. content for all treatments but differences between treatments were not significant. In contrast s.s. levels for fruit of Red Jonathan fell markedly during storage in 1969 and differences between treatments were not significant at this stage.

Per cent s.s. contents of fruit of Cox's Orange Pippin were much lower in 1970 than in 1969 for all soil management treatments (Figure 1) but this effect occurred only to a very small extent in Red Jonathan (Figure 2). Differences in s.s. contents of fruit from the different soil management treatments were not significantly different for Cox's Orange Pippin in 1970 but were for Red Jonathan ( $P=0.01$ ). Fruit of Red Jonathan from cultivated plots had a higher s.s. content ( $P=0.05$ ) than that from

non-cultivated plots in the absence of grass (interaction,  $P = 0.001$ ) which is a similar result to that obtained in 1969. Per cent s.s. levels for fruit from the different soil

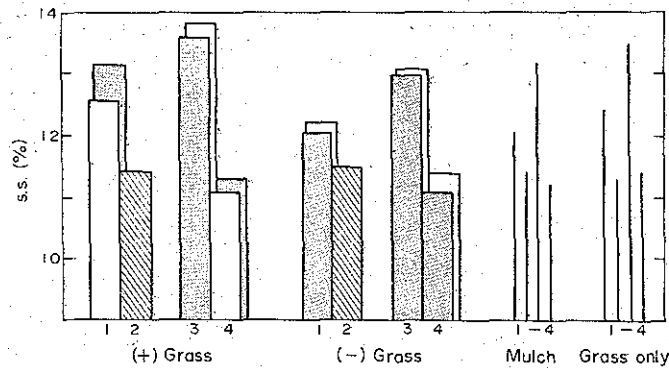


Figure 1. Per cent s.s. levels for fruit of Cox's Orange Pippin: 1. at harvest, 1969; 2. at harvest, 1970; 3. after storage for 50 days at 1 °C—1969; 4. after storage for 68 days at 1 °C—1970.

□, Clean cultivation (c); ▨, Non-cultivation (n.c.); ▩, c + n.c.

management treatments were not significantly different after storage for Cox's Orange Pippin but were different for Red Jonathan ( $P = 0.05$ ) in 1970; clean cultivation gave the highest level (Figure 2).

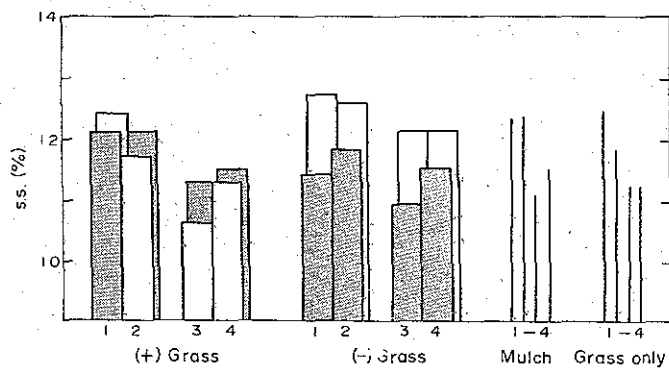


Figure 2. Per cent s.s. levels for fruit of Red Jonathan: 1. at harvest, 1969; 2. at harvest, 1970; 3. after storage for 80 days at 1 °C—1969; 4. after storage for 80 days at 1 °C—1970.

□, Clean cultivation (c); ▨, non-cultivation (n.c.).

### 3.2. Titratable acidity

Titrateable acidity levels for fruit of both cultivars from the different soil management treatments were not significantly different in 1969 or 1970 at harvest or after storage. Fruit of Red Jonathan from grassed-down plots had a lower acid content ( $P = 0.05$ ) at time of harvest in 1969. Acid content of fruit of both cultivars dropped during storage in 1969 but only that of Red Jonathan decreased during storage in 1970 (Table 1).

TABLE 1. Acidity levels (mequiv./l, grand means) for fruit of Cox's Orange Pippin and Red Jonathan at time of harvest and after storage in air at 1 °C (1969 and 1970)

Season	Cox's Orange Pippin			Red Jonathan	
	At harvest	Storage 50 days	Storage 68 days	At harvest	Storage 80 days
1969	1.46	1.38	—	1.20	0.99
1970	1.36	—	1.37	1.34	1.10

### 3.3. Other chemical tests (1969 only)

Reducing sugar content of fruit of both cultivars was measured and the results were very similar to those for s.s. (Figure 1).

Values for nitrogen (expressed on a dry-matter basis) in the skin and flesh of fruit of both cultivars were not significantly different for the six soil-management treatments. Grand mean values for fruit of Cox's Orange Pippin at harvest time were 0.82% (skin) and 0.45% (flesh) and for Red Jonathan 0.92% (skin) and 0.34% (flesh).

There were no differences in a.i.s. values of fruit of Red Jonathan from the soil management treatments but values for Cox's Orange Pippin at harvest were different ( $P = 0.05$ ). The non-cultivation 3 year + grass treatment gave the highest a.i.s. level and the non-cultivation treatment the lowest. This produced a significant interaction ( $P = 0.05$ ).

The astringency levels for fruit of Cox's Orange Pippin from the soil management treatments were not significantly different.

### 3.4. Texture measurements

Shear values of fruit of both cultivars from the different soil management treatments were not significantly different at time of harvest or after storage in either season. Fruit of Cox's Orange Pippin from cultivated plots was significantly firmer than that from non-cultivated plots after 50 days storage at 1 °C in the 1969 season. Grand mean values for shear for the two cultivars in 1969 and 1970 at harvest and after storage are presented in Table 2. The values for Red Jonathan in 1970 were unusually low at harvest, but did not fall during the storage period which contrasts with results obtained in 1969. In 1970 shear values for Cox's Orange Pippin were also lower than in 1969 and the fruit did not soften to the same extent during storage.

TABLE 2. Shear levels (lb, grand means) for fruit of Cox's Orange Pippin and Red Jonathan at time of harvest and after storage in air at 1 °C in the seasons of 1969 and 1970

Season	Cox's Orange Pippin			Red Jonathan	
	At harvest	Storage 50 days	Storage 68 days	At harvest	Storage 80 days
1969	390	170	—	515	207
1970	364	—	197	201	220

### 3.5. Flavour evaluation

Taste panel tests were carried out on fruit of both cultivars in each season at harvest time and after storage. Two field replicates were tested each time giving a total of 16 sets of panels (assessments were made in the morning and were repeated in the afternoon, giving a total of 32 individual panels). Flavour responses for the different treatments from each of the 16 panels were correlated with s.s. values for fruit from the same field replicates on which the panels were carried out. Only three of the 16 correlation coefficients were greater than 0.77 indicating that s.s. had little influence on flavour for these cultivars. However, the s.s. values for the different soil management treatments were close together and the panel was probably unable to distinguish accurately between samples. Coefficients of variability were calculated for s.s. values of fruit from the different soil management treatments for each of the 16 panels concerned (8 for Cox's Orange Pippin and 8 for Red Jonathan). In the case of Cox's Orange Pippin the mean c.v. for s.s. was 3.35 (mean of 8 coefficients of variability) and the highest and lowest values were 5.9 and 1.8, respectively. Similarly, for Red Jonathan the mean was 4.2 and the highest and lowest values were 5.1 and 3.4. Panel flavour response was also correlated with acid sugar ratios, acid/sugar/astringency ratios and also with yield but coefficients were mostly small and no pattern was obtained.

The tasters did not find significant differences between fruit from the soil management treatments in any of the tests done on fruit from storage. However, significant flavour differences were found in three out of four panels done on fruit at time of harvest in 1970. Samples from field replicate 2 (Cox's Orange Pippin) were different ( $P = 0.01$ ) and fruit from the cultivation only treatment was rated best; samples from field replicates 2 and 4 (Red Jonathan) were also different ( $P = 0.05$  for both) and the cultivation only treatment again gave the best flavoured fruit. The correlation coefficients between panel flavour response and s.s. for the three panels were +0.89, zero and +0.27. However, in each case the best flavoured samples as determined by the panel also had the highest s.s. value which confirms that although the overall correlation was poor, a high s.s. value is associated with good flavour.

### 3.6. Yield

Yields were much higher in 1970 than in 1969 for both cultivars. Yield of Cox's Orange Pippin was affected to a much greater extent by soil management treatments than that of Red Jonathan. In all cases the non-cultivation treatment gave the highest yields (Figure 3).

## 4. Discussion

In general, differences in chemical composition of Cox's Orange Pippin and Red Jonathan apples from the soil management treatments were not as great as those found in Golden Delicious.<sup>2</sup> Fruit quality of Cox's Orange Pippin was affected to a greater extent than that of Red Jonathan by the presence of grass and yield also varied more considerably for the former (Figures 1, 2 and 3).

Correlations between taste panel flavour rating and various compositional levels and ratios were generally small and no pattern existed. Smock and Neubert<sup>3</sup> showed

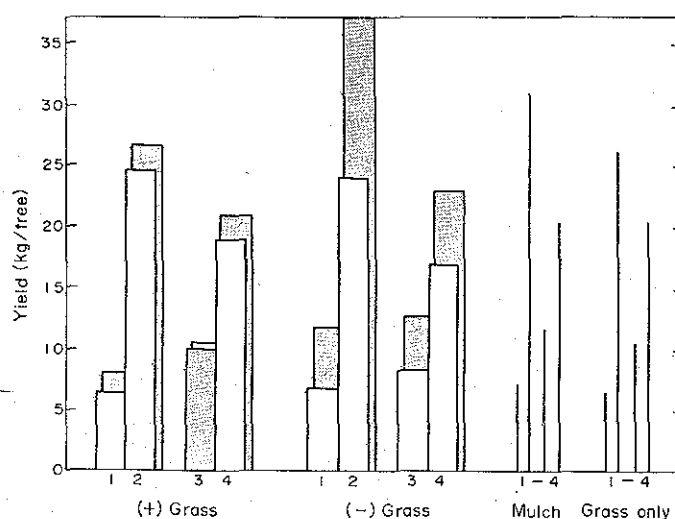


Figure 3. Yield data for Cox's Orange Pippin and Red Jonathan 1969-70: 1. Cox O.P. 1969; 2. Cox O.P. 1970; 3. Red Jonathan 1969; 4. Red Jonathan 1970.  
□, Clean cultivation (c); ▨, non-cultivation (n.c.).

that the acid/astringency/sugar ratio was a good index of flavour for many cultivars. However, in these tests only one reasonable correlation coefficient ( $-0.74$ ) was found between panel rating and the acid/astringency/sugar ratio for fruit of Cox's Orange Pippin. As already pointed out in the Results section high levels of s.s. are desirable for good flavour, however, the lack of good correlations between flavour rating for these cultivars may be due to negligible differences between solids values for fruit from the different treatments presented to the panel as indicated by the small c.v. values (see Results).

In 1969 the clean cultivation 3 year + grass and non-cultivation 3 year + grass treatments gave fruit with a higher s.s. level than the grass-only treatment of Cox's Orange Pippin indicating that treatment prior to grassing down in 1967 was still having an effect on fruit quality. In 1970, s.s. values for the three treatments were similar which suggests that the effect of treatment prior to grassing down was not now having an effect. The effect of earlier soil management treatment prior to grassing down was however, still evident in Golden Delicious after 3 years.<sup>2</sup> In 1970 the s.s. levels for Cox's Orange Pippin were all low indicating a poor season and the results from all treatments were practically identical. This indicates that 1970 was an unsuitable year for grass treatments for Cox's Orange Pippin since previous experience suggests that these treatments would have given a higher s.s. value. This result agrees with that found for Golden Delicious.<sup>2</sup>

The two cultivars contrast sharply in the way they were affected by the different treatments. The presence of grass had enhancing effects on s.s. in Cox's Orange Pippin (in 1969) and a slight lowering effect on s.s. in Red Jonathan (Figures 1 and 2). In addition, the cultivation and non-cultivation treatments had little effect on s.s. levels in

fruit of Cox's Orange Pippin but had a considerable effect on those of Red Jonathan especially in the absence of grass.

The increase in s.s. values found during storage of Cox's Orange Pippin for 50 days at 1 °C is surprising in view of results obtained for Golden Delicious.<sup>2, 3</sup> In 1970 when s.s. values were much lower a very slight decrease in s.s. values occurred over a 68-day storage period. The decrease was much less than would be expected especially as the initial levels of solids was low. These data suggest that the rate of formation of sugar by breakdown of polymeric materials must have been greater or about equal to the use of sugar in respiration while the apples were in storage. In the case of Red Jonathan, s.s. levels dropped during storage but to a greater extent in 1969 than 1970.

The unusually soft texture found for Golden Delicious<sup>2</sup> in 1970 also occurred in Red Jonathan apples in the same season. In addition, shear values remained constant for Red Jonathan while in cold store and a similar result was obtained for Golden Delicious in the 1970 season. This indicates that there was little or no breakdown of protopectin which is contrary to expectations.<sup>3</sup> However, it should be pointed out that the texture of Red Jonathan at harvest time was very soft and a considerable breakdown of protopectin may have already occurred. This could partly explain the lack of further softening during storage. In contrast, fruit of Cox's Orange Pippin did soften during storage in 1970 and its texture at harvest time was of the same order as in 1969.

### 5. Conclusions

Fruit quality of Cox's Orange Pippin and Red Jonathan was affected by soil management treatment. Differences between treatments were less marked than with Golden Delicious and there was no correlation between s.s. content and taste panel response for either Cox's Orange Pippin or Jonathan.

The use of a system of soil management based on herbicides alone reduced the quality of Red Jonathan compared with cultivation. There was little difference in fruit quality of Cox's Orange Pippin between cultivated and non-cultivated plots but quality was enhanced by grassing down. The results confirm the importance of detailed studies on the effect of systems of management involving herbicides on fruit quality of all important cultivars as well as on yield before changes are made in standard methods of soil management. The results suggest that both cultivars can give acceptable quality under a system of non-cultivation using herbicides alone.

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