grapes

1. Marginal and interveinal chlorosis followed by scorch.

BORON DEFICIENCY

2. Restricted shoot growth, small leaves and interveinal chlorosis.

Professor Gärtel

3. Typical "Hen and Chickens".

Professor Gärtel

4. Stunted growth with very short and thick internodes.

RECOGNITION

Leaf and Shoot Symptoms. An early and clear symptom of boron deficiency is the development of a mottled chlorosis from the leaf margin, Figure 1; as the deficiency becomes more severe the chlorotic patches coalesce and become necrotic, commencing from the leaf margin.

In very severe cases the young leaves are small and may be deformed and brittle, Figure 2; eventually the growing points die and secondary shoots develop. Shoot extension is restricted and boron deficient vines have short, thick internodes, Figure 4. Pith necrosis occurs.

Fruit Symptoms. Boron deficiency causes a marked reduction in fruit set. There is not only a considerable loss of flowers but also a poor development of seedless and shrivelled berries largely attributable to poor pollination caused by the lack of boron. The presence of berries of different sizes on the same bunch, known as "Hen and Chickens" is a characteristic symptom of boron deficiency, Figure 3. In severe cases there may be no fruit set at all.

CORRECTION

Boronated Fertilisers. Boronated fertilisers enable the grape farmer to apply boron simply and cheaply without incurring extra application costs; boronated fertilisers should be used at rates and times in accordance with manufacturers' instructions, and when so applied should give about 30-50 kg/ha (lb/ac) of borax, or its equivalent.

Borax and Fertiliser Borate 46, High Grade. When boronated fertilisers are not available boron deficiency may be prevented by applying 30-50 kg/ha borax (36.5% B_2O_3) or 25-40 kg/ha Fertiliser Borate 46, High Grade (46% B_2O_3) to the vines at the end of winter. Whenever possible the borate should be mixed on the farm with other fertiliser materials (or with sand) in order to facilitate uniform and accurate application. Annual applications are likely to be needed in most cases. When a very severe boron deficiency has been diagnosed for the first time much higher applications (e.g. 100 kg/ha of borax) may be needed; in some cases as much as 200 kg/ha borax or its equivalent is applied.

SOLUBOR

Spray application of SOLUBOR, which is a readily soluble sodium borate containing 66% B_2O_3, affords a simple and rapid method of applying boron uniformly; it is particularly useful when boron deficiency has been diagnosed for the first time or when the deficiency is very severe and it is necessary to apply boron to the foliage as well as to the soil.

It is recommended that 5-10 kg/ha SOLUBOR be applied using a concentration of 0.25% w/v. SOLUBOR is compatible with a wide range of pesticides and herbicides, a list of which is available.

APPLICATION RATES

kg/ha (lb/ac).

BORAX	FERTILISER BORATE 46	SOLUBOR
30-50	25-40	5-10

For recommendations and advice on the prevention and correction of boron deficiency and on the times and rates of application of boron fertilisers in specific localities, growers should consult their local agricultural authorities. Further details regarding the agricultural borates and boron deficiency on other crops may be obtained from the Agricultural Department, Borax Consolidated Limited.

BORAX

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BORON IN THE PHYSIOLOGY OF FRUIT TREES

RELATION WITH FRUIT QUALITY

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BORON IN THE PHYSIOLOGY OF FRUIT TREES

RELATION WITH FRUIT QUALITY

Mme. C. Huguet, Station d'Agronomie, Montfavet.

INTRODUCTION

It is not proposed, at this Conference, to consider the boron physiology of plants in detail as this has been widely studied and reported in many papers over the last 30 years.

We shall limit ourselves to a brief resume of the varied and essential roles that are played by boron, despite the fact that it is present in only very small amounts in plant tissues (*several mg per kg of dry matter*). The second part of this report will attempt to summarise the observations made in France, as well as abroad, on the influence of boron nutrition on the quality and storage properties of the fruit.

THE ROLE OF BORON IN PLANTS

When considering the many studies on boron physiology it is necessary to distinguish between those dealing with boron absorption and translocation and those dealing with the effect of boron on cell metabolism; the effects of boron on the absorption of elements such as calcium, magnesium, potassium and phosphorus has been examined in detail by several workers.

A large amount of work has been carried out on the two phenomena, namely absorption and metabolism in annual plants. As similar studies have not been made for perennial plants, we shall only quote works of general interest on the effects of boron on metabolism that can be applied to fruit trees.

According to SCHWEIGART (1961) boron is a component of enzymes and SHOK (1958) has shown that boron can accelerate the transport of growth substances.

The affinity of boron for hydroxyl groups was confirmed by SISLER (1956), and NELSON (1956) who studied the action of boron on the translocation of sugar by means of C^{14}. DUGGER (1957) considered the reaction of both starch and soluble sugar by means of a borated phosphate intermediary. Proteins also seem to need boron for their synthesis. Finally, most authors accept that boron has an indirect role in pectin formation. In brief, sugar, proteins, pectins and growth substances all need boron for their synthesis.

The principal effects of boron deficiency, which are primarily due to the biochemical roles of boron, may be mentioned; the slowing down of bud and flower formation, the stopping of root growth (BUSSLER, 1960) are all due to a reduction in cell division and to the malformation of cell membranes; the increase in the number of sterile flowers, poor pollen germination, foliar necrosis are all due to the disturbance of cell metabolism in which boron participates actively (THELLIER, 1963).

THE IMPORTANCE AND PATTERN OF BORON ABSORPTION AND TRANSLOCATION IN THE PEAR TREE

At the Agronomical Station of Montfavet in the Lower Rhone Valley, GOUNY & HUGUET (1964) tried to assess the importance of boron in the nutrition of the pear tree (*variety Dr. J. Guyot*) grafted on quince trees.

The variation in boron content of different plant tissues was studied during different periods in the development of the tree.

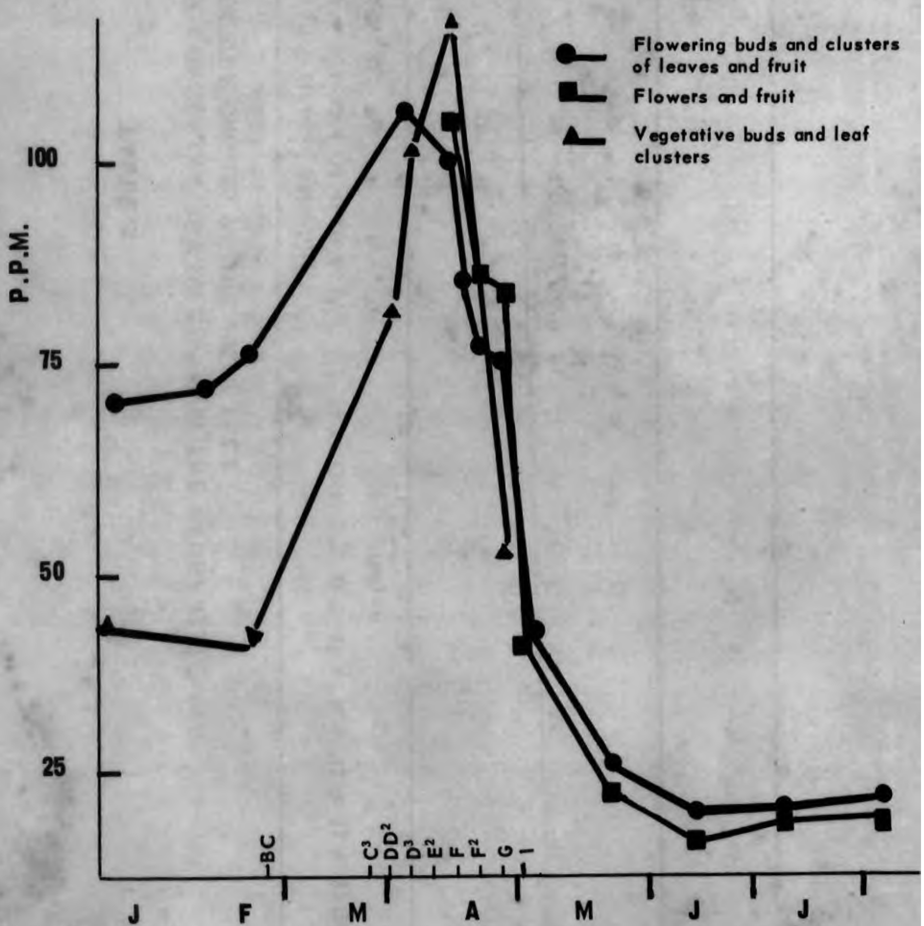

FIGURE 1

VARIATION IN BORON CONCENTRATION IN FLOWER FRUIT AND LEAVES OF THE PEAR TREE WITH TIME

TABLE I

VARIATION WITH TIME IN THE CONCENTRATION OF BORON IN THE VEGETATIVE AND REPRODUCTIVE ORGANS OF THE PEAR TREE

ppm in dry matter

	Date of Sampling																				
	27/12	18/1	12/2	22/2	30/3	3/4	6/4	13/4	16/4	20/4	27/4	4/5	24/5	13/6	4/7	31/7	17/8	30/8	13/9	15/9	27/10
Phenological Stage	A			B-C	C_3	D-D_2	D_3	E_2	F	F_2	G	I				Harvest					
Flowering buds	70	72	73	76	108	106	106												50	58	74
Flowers								106	93	86	86										
Fruit												41	23	17	20	21					
Leaves								96	77	67	62	44	32	34	39	42	53	58	57	41	
Clusters of leaves and fruit								102	87	78	73	43	26	20	21	22					
Vegetative buds	43	44	42	42	84	103		118			54										
Leaves													27	27	36	43	47	49	55	46	

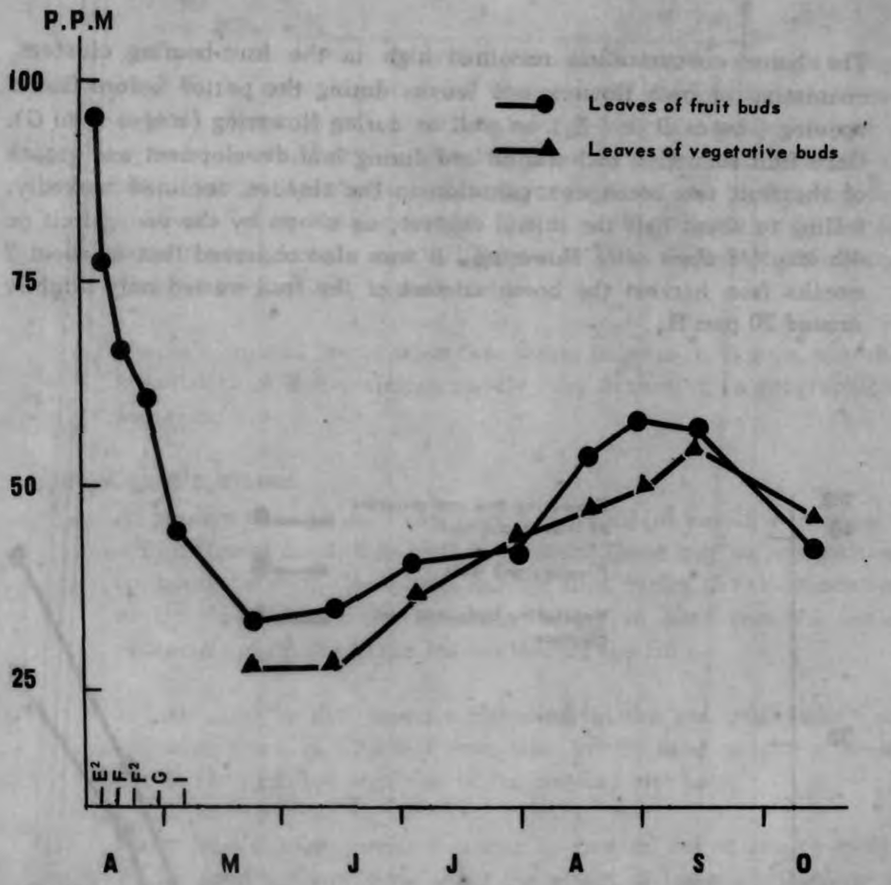

FIGURE 2

VARIATION IN THE BORON CONCENTRATION OF PEAR LEAVES WITH TIME

In three uniform plots each of 60 trees, the flowering fruit buds and ordinary vegetative buds were identified as soon as possible in the spring. Observations were then made from the summer period of shoot initiation until dormancy. Afterwards the observations were conducted by using as guides the development stages established by FLECKINGER (1945) as shown in Table 1.

The change in boron concentration of the buds (*Figure 1*) was characterized by a long phase between July and mid-February when the contents slowly increased (50-73 ppm B). It was followed by an active phase, which started on 22nd February (*about 55 days before flowering*) during which the boron concentration rose from 76 ppm to 106 ppm B, during *which the development* stages passed *from* C to C_3.

The boron concentration remained high in the fruit-bearing clusters, consisting of both flowers and leaves during the period before flower opening (*stages D and E_2*), as well as during flowering (*stages E to G*). Once fruit formation had started and during leaf development and growth of the fruit the boron concentration in the tissues declined markedly, falling to about half the initial content, as shown by the young fruit on 4th May (*18 days after flowering*). It was also observed that at about 2 months from harvest the boron content of the fruit varied only slightly around 20 ppm B.

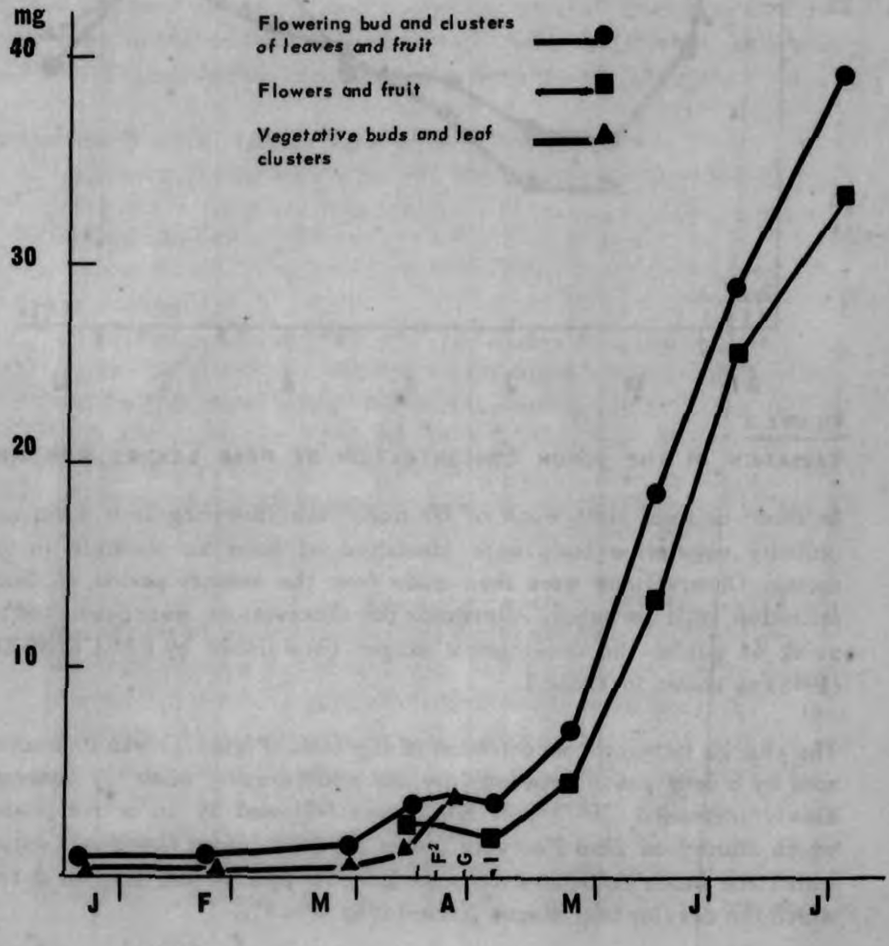

FIGURE 3

BORON ACCUMULATION IN 100 BUDS OR CLUSTERS OF PEAR

TABLE 2

BORON (mg) ACCUMULATION IN 100 BUDS OR CLUSTERS ON THE PEAR TREE

	Date of Sampling																			
	27/12	18/1	12/2	22/2	30/3	3/4	6/4	13/4	16/4	20/4	27/4	4/5	24/5	13/6	4/7	31/7	17/8	30/8	13/9	15/9	27/10
Phenological Stage	A			B-C	C_3	$D\text{-}D_2$	D_3	E_2	F	F_2	G	I				Harvest					
Flowering buds	0.3	0.3	0.4	0.4	1.0	1.5	1.8												0.1	0.2	0.3
Flowers								2.0	2.3	2.3	1.9	1.5									
Fruit													4.2	12.6	24.9	33.3					
Leaves								1.1	1.1	1.4	1.6	1.8	2.4	5.0	4.2	5.8					
Clusters of leaves and fruit								3.1	3.4	3.7	3.5	3.3	6.6	17.6	29.1	39.1					
Vegetative buds	0.07	0.06	0.06	0.06	0.1	0.2		1			3.7										
Leaves (100)													0.6	0.7	0.8	1.4	1.4	1.4	1.6	1.4	

The boron concentration of the vegetative buds (*Figure 1, Table 1*) is minimal when growth starts in the spring, but it increases rapidly during the period just before flowering, reaching a maximum of 118 ppm at flowering. During a period of two to three weeks *before flowering* the translocation of boron into the developing tissues was shown to be extremely rapid.

Two types of leaves were studied, firstly those on the flowering shoots and secondly those on the vegetative shoots; the boron concentration of both types of leaf which varied with time, showed a marked decline during April to May, i.e. one month after flowering. The changes in concentration were not measured on the vegetative shoots during the three weeks after flowering, but after harvest there were further fluctuations in concentration characterized by a maximum leaf boron content. Translocation and immobilisation of boron appear to be similar in the two types of leaves studied (*Figure 2*).

Measurements were completed by the calculation of the boron content of the buds, flowers and fruit and the leaves of pear trees. The contents are expressed on the basis of 100 shoots in Figure 3 and Table 2. About 10% of the total quantity of boron which is present in the clusters of leaves and fruit at harvest was accumulated by the flowering buds.

It was estimated that, on an average tree at harvest, 100 tree clusters, consisting of fruit and leaves, contained 39 mg boron. The number of leaves per tree was counted to determine the amount of boron accumulated; the 5,000 leaves which were present on each average tree at harvest needed 70 mg boron, i.e. nearly double the quantity needed for the growth of fruiting shoots. The orchard in question needed about 290 g boron per hectare for the growth of the fruiting shoots and the leaves alone.

In brief fruit trees show phases in their development during which the boron requirement of the buds is very intense when the boron supply must then be adequate otherwise there is a risk of deficiency.

THE QUALITY OF THE FRUIT IN RELATION TO BORON NUTRITION

Because of the many roles of boron in the metabolism of fruit trees the question arises as to whether or not boron is capable of influencing the quality of both the ripe fruit and the stored fruit; the quality of stored fruit is becoming increasingly important with the rising production of fruit.

What is understood by the quality of fruit? A distinction must be made between the commercial quality and subjective considerations based on taste and texture. Commercial qualities refer to such properties as the size of the fruit, the colour and appearance of the skin and the firmness of the flesh. The subjective considerations are related to the sugar content, the acidity and the ester content, all of which contribute to give the fruit a scent and a taste.

Very few measurements have been made to quantify the properties associated with taste. THOMAS (1960) in Australia noted that boron application increased the acidity of fruit of the apple (*variety Jonathan*), and PANKRATOVA (1960) showed that boron sprays and NPK application increased the ascorbic acid content. HALLER and BATJER (1946) showed that apples (*variety Jonathan and Golden Grimes*) which were treated with boron seemed to ripen more rapidly after harvest when they were kept at 70°F. These authors, however, did not measure the effect of boron sprays on fruit acidity or on firmness. The estimation of colour and firmness is of course a very delicate matter; PHILIPS and JOHNSTON (1942) showed that apples treated with boron were greener than untreated apples.

We shall limit ourselves here to a consideration of the effects of boron on the commercial qualities of the fruit and we shall only consider the physiological and nutritional phenomena, which might affect the appearance of the skin and flesh, excluding the disorders caused by parasites. In general it is thought that there are three main groups of non-parasitic disease conditions which can change the commercial quality and taste of the fruit. The first two groups to be dealt with here are characterised by the presence of corky tissue, consisting of suberised cells; the third group, which is more connected with storage, correspond to scald and breakdown with which we shall not concern ourselves here. We shall leave it to PATTERSON and WORKMAN (1962) in the U.S.A., and to MARCELIN (1963) in France, to assess the influence of temperature, of oxygen and carbon dioxide content during preservation on the appearance of brown and somewhat soft stains in the flesh of stored fruit in relation to the ripeness of the fruit at harvest.

I. In the first group of diseases the symptoms appear as stains on the skin or in the flesh. PHILIPS and JOHNSTON (1942) in Canada have described the anatomical changes occurring at the cell level, distinguishing between 'internal cork', 'corky core' and 'core flush'; they mention a difference in the attachment of the endocarp to the adjoining tissues, the demarcation being more or less defined in core flush. In severe cases the fruit are deformed and have cracked skins the actual symptoms varying somewhat with variety.

   'Drought spot' belongs to this first group as it terminates with the formation of cracks in the young fruit which may include the formation of external corky tissues. The depreciation of the fruit is thus total: poor quality fruit, internal and external damage to the tissue and, as BURREL (1956) points out in the case of apples, little juice.

'Cork spot' as described by MATTUS (1962) in the Virginia and Maryland varieties can also be included. MATTUS obtained a considerable but not total reduction of 'cork spot' by boron application to the variety York.

All the Canadian, New Zealand and Australian authors who have studied the different cases agree that boron deficiency is a cause of these corky symptoms.

In France we use the general term 'cork' for these cellular anomalies and sometimes indicate the location of the symptoms in the fruit by calling them 'internal cork' and 'corky core'.

In 1963, GACHON in Auvergne, confirmed that the cracks, described by BURREL (1937) were similar to those that he had observed in the variety Reinette de Canada. The grey, corky areas in the form of stars, which appear during the summer and which coincide with breaks in the skin around the lenticels are definitely reduced by spraying with sodium pentaborate.

The same research worker showed however that the large and often deep cracks, which are localised in the middle of the fruit, do not have the same origin. This last observation agrees with those of TAVERNIER and JACQUIN (1952); in fact, these authors were not able to show that apples and pears, whose fruit were affected by large cracks, with reddening of the skin, could be healed by boron application. The injuries which have been studied particularly in stone fruit trees, are generally characterised by deformation of fruit and by gumming. LINDNER & BENSON (1954) showed a definite reduction in the quality of apricot fruit due to boron deficiency which was due to the brown colouration of the tissues and by the formation of cork and cracks in the fruit.

II. In the second group of physiological diseases, described by the general terms of 'spot' and 'pit' there are two main disorders: Bitter Pit and Jonathan spot, which are recognised by yellow and green round spots and which usually turn brown, during storage; they are accompanied by small dry spongy zones, which are situated under a superficial depression on the skin. The brown spots in the flesh appear late, while the apples are still on the trees but just before they ripen. The colour and appearance of the depressions differ from one variety and from one year to another; storage, which accentuates the browning also increases the development of spots. Drought in the summer and rain around harvest also seem to accelerate the appearance of the spots.

When the various studies that have dealt with bitter pit type diseases are considered it is seen that there are two theories and consequently two treatments. One theory attributes beneficial action to boron application and the other, more recent theory, raises the question of calcium nutrition and the cation ration. $\frac{K+Mg}{Ca}$ VAN DER BOON (1964), in the Netherlands, attempted to control bitter pit with the method of GARMAN and MATHIS (1956); after three years of spraying the leaves with calcium nitrate the number of fruit affected with bitter pit has fallen from 30% to 5% in the variety 'Cox's Orange Pippin'. In France BOUHIER DE L'ECLUSE (1962) and CORNELISSEN (1963) advised the foliar application of calcium salts, but it is too early to judge the efficacy of the treatment.

THOMPSON and RODGERS (1961) working in New Jersey have shown over 4 years that it is possible to obtain a significant reduction in bitter pit by spraying boron at flowering, followed by two other spray applications at 10 day intervals. DUNLOP & THOMPSON (1959) reduced bitter pit and cracks in the skin in Maryland in the same way. BRAMLAGE and THOMPSON (1962) described the effect of early sprays on the varieties, Golden, Stayman and Jonathan. On Jonathan the boron treatment delayed the appearance of the symptom known as 'Jonathan spot' the spots of which are associated with the lenticels on the fruit. On the other hand, the phenomena of internal scald in the Stayman variety and of vitreous core increased after five borate treatments applied at five day intervals. In this same work it was stressed that boron did not significantly reduce the russetting of the Golden variety. It is thus apparent that the results obtained by the different authors are somewhat contradictory. Is this due to a confusion in the names of different symptoms or could it be that the two elements boron and calcium are both relevant, which could explain the difficulties encountered by the research workers and the experts to find a solution to the problem?

A systematic and precise classification of the different types of internal injury and external spots of physiological origin has, as far as we know, not yet been made in France. Apart from the corky injuries mentioned previously, which responded to boron applications, there are, it seems, several types of symptoms which are generally and perhaps wrongly called 'bitter pit'. We shall mention here the interesting work carried out by the Service de la Protection des

Vegetaux de Rennes (1960) of which M. Viel has made a very complete report covering the varieties Winter Banana, Belle de Boskoop, Reinette de Caux and Ontario. After two sprayings with sodium borate (*at 0.25% w/v*) carried out on 12th May and 16th June (*i.e. after fruit formation*) the fruit were inspected for corky spots at harvest and also after one and two months storage. The varieties were classified according to sensitivity to the condition after inspection of the stored fruit. Reinette de Caux was the most sensitive followed by Winter Banana, Belle de Boskoop and by Ontario in that order. The improvement brought about by the boron treatment itself varied with variety; there was only an 11% improvement on Ontario whereas there was a 42% improvement on Reinette de Caux.

In brief it appears that it is not always possible to establish a definite distinction between the groups of diseases, namely the cork and pit disorders which are characterised by the existence of suberised cells, if only the visual symptoms are considered. To base a classification of the different types of the diseases, as some authors have done on the time when the symptoms appear, is a test that is difficult to apply at a level of agricultural practice. The cellular changes can appear on very young fruit, several weeks after the fruit has started to form (*which is often the case in the first group of disorders*) or during the later periods of growth on the fruit that has reached more than half of its final size (*as is often the case with the second group of disorders*). However the variation in symptoms between varieties and the effect of climatic conditions (*alternation of drought and rain*), which influence the time of the appearance of symptoms on the fruit make it very difficult to interpretate and classify the various disorders distinguished by the presence of suberised cells.

WORK CARRIED OUT AT THE AGRICULTURAL STATION

The Agricultural Station at Montfavet tested the effect of boron treatment in the orchard, with the technical co-operation of G. DUCAILAR and I. MEYNADIER in order to try and analyse just one of the many cases reported by growers in the region.

TABLE 3

% Dry Soil

DEPTH	0-15 cm	20-40 cm	60-80 cm
Clay	240	205	90
Silt	445	505	250
Coarse silt	259	281	361
Fine sand	33	12	294
Coarse sand	10	1	7
Total calcium	375		
Active calcium	105		
Organic matter	25.5	18.1	12.7
P_2O_5 soluble in acetic acid/ammonium acetate (ppm)	2	5	2
Exchangeable potassium (ppm)	234	134	46
Exchangeable magnesium (ppm)	215	290	222
Boron (ppm)	0.5	0.3	0.2

A test was carried out on four blocks of apple trees, all of the Red variety, mainly Starking Delicious, growing on a calcareous soil in the Lower Rhone Valley, the physical and chemical characteristics of which are given in Table 3. Six sprays of sodium pentaborate all at 0.2% w/v were given as follows: 29th March (*17 days before flowering*), 15th May (*one month after flowering*), 22nd May, 16th August, 23rd August and 9th September so as to provide the trees with sufficient boron during the important period before flowering, and then during the development of the fruit.

Fruit samples, each of 20 kg, were picked from the eight groups of trees in the experiment on two occasions, the first on 11th September and the second on 23rd September; they were placed immediately in a cold room (*temperature* + 4°C) for storage. Periodic checks of the state of the skin of the fruit were made in November, January and March. The cumulative percentage of affected fruit, judged after storage by the appearance of brown spots on the skin is recorded in Table 4.

TABLE 4

Percentage of affected fruit

TREATMENT	DATE OF HARVEST	
	11.9.63	23.9.63
Control	30.8	28.1
Trees sprayed with boron	22.8	8.6

Two conclusions can be drawn from these observations:

(i) Boron sprays have reduced the incidence of spots by about 30% for the first harvest, and by about 70% for the second harvest, but they did not eliminate the symptoms completely.

(ii) The date of harvest had a marked influence on the appearance of brown spots during the storage of the Starking variety. This observation therefore raises the important problem of the choice of date of harvest.

The mineral composition of the apples used in the test was determined in order to study further the role played by boron. The ratios between potassium, magnesium and calcium as well as those between boron and nitrogen and between boron and calcium have been calculated (*Table 5*).

The ratio $\frac{K+Mg}{Ca}$ was definitely reduced in the healthy fruit by the boron treatment. There was also a reduction in the $\frac{\text{nitrogen}}{\text{boron}}$ ratio in the fruit treated with boron, which was especially marked in the fruit devoid of skin symptoms.

How can these results be interpreted? Should the conclusion be drawn that there is a boron deficiency in this orchard where the boron content of the untreated fruit is in the region of 20-26 ppm B?. Two hypotheses are possible: the boron treatment, which was carried out at intervals during the experiment placed 'mobile boron' at the disposal of the plants. This element was introduced into the vascular system of the plant via the leaves, but whilst as shown by THELLIER (1963), there is only very little movement of boron away from the leaves to other parts of the plants, there may nevertheless have been a small amount available for the fruit. BURREL (1958) also showed a positive effect of late boron sprays (*applied in July*) on McIntosh apples which increased the boron content of the fruit. When an adequate supply of boron is not available from the soil during alternating dry and wet periods, as was the case in the spring and summer of 1963, it has been shown that a number of foliar sprays can provide the tree with adequate boron supply.

TABLE 5

COMPOSITION OF THE FRUIT (values in mg %)

TREATMENT	DATE OF HARVEST					
	11.9.63			23.9.63		
	$\frac{K+Mg}{Ca}$	$\frac{N}{B}$	$\frac{Ca}{B}$	$\frac{K+Mg}{Ca}$	$\frac{N}{B}$	$\frac{Ca}{B}$
Control trees						
Healthy fruit	22	81	15	21	114	17
Affected fruit	19	96	13	28	142	15
Trees sprayed with boron						
Healthy fruit	16	62	16	20	88	13
Affected fruit	25	72	10	27	119	12

The analytical results show that boron was able to affect the cationic balance in the fruit, particularly calcium: the movement of calcium to the fruit was improved relative to that of potassium and magnesium. The calcium balance between the leaves and the fruit became re-established and is associated with improvement in fruit metabolism.

As a certain number of details such as the period over which boron was applied, the frequency and rates of application could not be individually studied in this work, we feel it would be premature to use the method described such as it is.

Too hasty a generalisation of this technique to embrace all orchards under varying conditions and containing other varieties than those studied should be avoided. The opportunity for and the choice of treatment for orchards of apples affected by brown spots on the skin will be specified in the future by establishing precise diagnosis based on soil and fruit analysis and on the basis of cell anatomy. It should be remembered that the incautious and repeated use of boron could lead to toxicity symptoms in the fruit which are as damaging to the quality of the fruit as the symptoms dealt with here. CHITTENDEN and THOMSON (1939) in New Zealand showed that the application of 2 lb borax per tree to the soil caused a very serious reduction in the quality of stored Jonathan apples due to internal russeting. The use of boron should therefore be controlled if such accidents are to be avoided during storing.

CONCLUSIONS

Attempts have been made here to stress the role of boron in the nutrition of fruit trees, especially its early action in the metabolic processes of the plant during the period before flowering as well as during the later development and growth of the fruit.

The diagnosis of boron deficiency, based on symptoms only, is generally somewhat difficult. It seems however that boron applications could be extended when this element is known to be involved in determining the quality of stored fruit.

During this work one of the main factors which condition the storage of apples of the variety Red Delicious, namely the exact timing of the harvest, has been emphasised; the timing of the harvest appears to be closely related to climate, soil conditions and to nutrition. In brief it appears essential to establish precise tests over many orchards, for different regions and for different varieties, so as to be able to judge the efficacy of the various treatments in order that the physiological damage to the fruit during storage may be reduced.

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DISCUSSION

M. Dauguet . Esso Standard, 6 Avenue Gambetta, a Courbevoie.

(i) Up to now bitter pit and boron deficiency have been considered to be two separate phenomena. The work recently carried out has shown that this is not true. How can it then be explained that bitter pit is much more frequent in young trees or those having little fruit than on old and heavily laden trees?

(ii) What is the frequency and timing of the spray treatments for the important boron application during the three weeks before flowering? Is the normal spray concentration of 0.20% w/v SOLUBOR correct according to the research workers? Is there a risk of excess boron by repeated sprays?

(iii) What is the reason for the increased sensitivity of the Red variety to skin disorders from the south to the north of France? Is the Golden variety as sensitive in spite of the absence of branch canker?

M. Decau's answer

The most frequently used treatment for apples suffering from boron deficiency is as follows:

A first treatment at bud opening, at Stage D, with 200-250 g of sodium pentaborate per hectolitre then a second spray application, during flowering, at Stage F_2, with a dose of 150 g/hl.

These sprays are sufficient to ensure a good fertilisation but are not always enough for normal subsequent growth. In the case of a definite deficiency a third treatment of 250 g/hl should be given when the fruit starts to form, at Stage I.

Do repeated sprayings present a danger for the tree and their production? Although spraying with sodium pentaborate with a dose of 250 g/hl on trees which are already well nourished cannot have a toxic effect, a rash repetition of the treatment could in such a case be a risk. It would therefore be wise to proceed carefully in the absence of definite deficiency symptoms and to compare the behaviour of treated trees with that of control trees that have not been treated and to check, before and after treatment, the boron level in the soil and in the plant.

We have not had any studies that would help us to explain why the sensitivity of Red varieties should vary according to geographical location.

Mme. Huguet's answer

(i) At present one can only postulate why bitter pit varies in incidence with different conditions in the orchards. There may be competition for boron between the leaves and the fruit during the translocation of the elements in the summer, bearing in mind that the boron contents are higher in the leaves than in the fruit.

It may also be that boron metabolism in the not very laden and vigorous trees is different from that in the aged or laden trees, due to the complex interplay of the mineral element.

(ii) Apart from the treatments that can be carried out at stages D and F_2 we need to know more about the effect of later applications to the fruit whilst they are growing.

(iii) An answer to the third question can only be based on a nationwide and detailed investigation.

M. Levy . Montpellier

Regarding the harvest on 11th and 23rd December - were the fruit of one part or another of the orchard taken first at random or were the ripest fruit taken first and then the others?

Mme. Huguet's reply

There was no systematic selection of fruit according to their geographical location in the orchard. The fruit harvested was dictated only by commercial considerations and there was no systematic classification of the fruit according to their degree of ripeness.

M. Schwartz. Mulhouse

Were any observations made on the relation between magnesium deficiency and boron deficiency?

Mme. Huguet's answer

In the orchard understudy we did not specially look for magnesium deficiency but it is not impossible that boron and magnesium deficiency could exist together in the same orchard.

M. Decau's answer

Boron deficiency and magnesium deficiency can occur together, the conditions that lead to the impoverishment of soil boron also lead to an impoverishment of soil magnesium. In some very acid vineyard soils, which are also stony and permeable and where the boron concentration is very low and bordering on deficiency, due to leaching, we have observed a low magnesium content which limited growth and fruiting of the vines considerably and, apart from dwarfing, caused characteristic foliar symptoms. Mineral fertilisers do not include magnesium so that the magnesium balance in the soil as well as that of boron is definitely deficient. This is another common feature between the two elements.

M. Soubies, O.N.I.A. Service Agronomique, Toulouse

Can the spraying with 0.2% w/v SOLUBOR be recommended: How many times per year? Has toxicity been seen on chalky soils and to what extent?

M. Decau's answer

SOLUBOR sprays of 0.2% w/v can always be used when there is reason to believe that there is insufficient boron for normal growth and fruiting of the trees. The visual symptoms and the analysis of soil and plant should permit such a diagnosis. Experience has shown that two or three spray applications per year, four at the maximum, if the deficiency is very serious, will correct the boron nutrition of the crop.

The number of years for which the treatment will be needed and the number of treatments required during the year will vary between different species and according to soil boron level and its nature. For the apple tree (*a perennial which is not at all sensitive to the excess of boron*) growing in a soil poor in boron and with strong adsorption capacity, about ten boron treatments over three years might be possible, but only the examination of the tree and the checking of the boron content of the leaves after a series of treatments will permit a decision to be made as to how long to continue the boron application in order to avoid giving too much.

Boron toxicity has not been reported to my knowledge in calcareous soils, at least not on fruit trees. The research workers were more concerned with determining the borderline between sufficiency and boron deficiency than they were with the question of the borderline between sufficiency and toxicity.

It has been shown that the borderline between sufficiency and boron deficiency is higher in calcareous soils than in acid soils: it is therefore probable that the same applies to borderline between sufficiency and toxicity, but the latter is certainly very variable, according to the species involved. Unfortunately we do not have precise information on this subject.

Mme Huguet's answer

The results obtained with the Red varieties reported here under specific conditions of soil and climate do not permit a systematic generalisation of sodium pentaborate sprays for all varieties and orchards. It is advisable that the effects of such sprays should be checked more thoroughly in the future and that the variety and the environment be taken into account.

Analysis of the soils, leaves and fruit can provide a guide for horticulturists who wish to obtain more detailed information.

M. Quillon, Saint-Germain

Whatever the diseases of the branches are called - these are semantics, the actual symptoms and their designations can differ according to the stage. The early stage of development of the symptom known as Peau de Crapaud consists of blisters similar to furonculosis. Later these blisters turn brown and the effective parts become necrotic and peel off in a cankerous manner.

Mme Huguet's answer

The disease that attacks the wood of the fruit trees does not belong to the present study on the quality of the fruit. The damage to the wood concerns another study, the results of which could be conveyed at another Congress.

M. Chaffard

Following her test for the control of bitter pit, Mme. Huguet concludes that boron application has had a beneficial effect, although the orchard used could not be accused of being markedly deficient in this element as the analysis showed 26 ppm B in the fruit of the Starking control trees. The boron must then have played a role in the migration of calcium and has improved the ratio $\frac{K+Mg}{Ca}$

Although boron plays an important role in the absorption and utilisation of nitrogen (*this element also has something to do with bitter pit*) and as a regulator of the $\frac{K}{Ca}$ ratio it could be that in these present tests boron could have played a more direct role in curing a slight deficiency.

In fact, one cannot be absolutely certain that 26 ppm B can be considered as a normal value for the variety Starking Delicious.

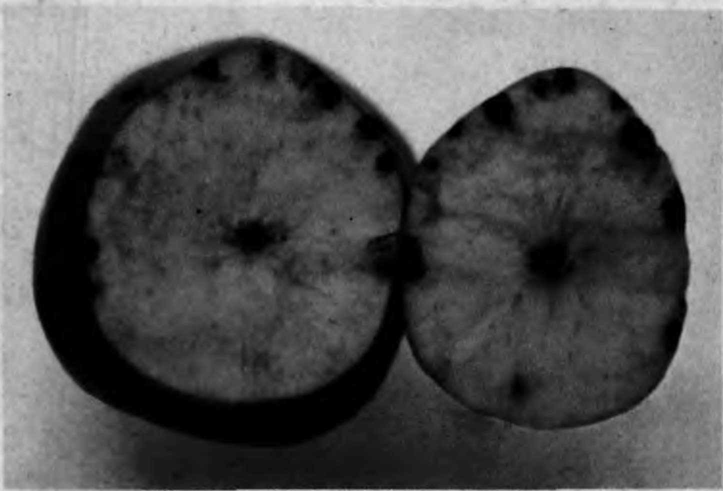
Certain Japanese authors (*see publication by Tavernier & Jacquin)* Annales Agronomique 1952, have shown variations in boron values of up to 100% according to the quantities of material submitted for analysis. In view of the observations made in the field, it seems that Delicious, Red, Starking, Richared Red varieties definitely have greater boron requirements than Golden Delicious.

Finally M. Chabannes of the Station Central d'Agronomie de Versailles has carried out a large number of boron analyses of the fruit of Golden, Red and Starking Delicious varieties in orchards where deficiency symptoms were seen. He found the following results:

Golden	...	30 ppm B
Red	...	30-40 ppm B
Starking	...	40-50 ppm B

This seems to confirm my opinion that the level of 26 ppm B given by Mme Huguet is probably rather lower than the value that should be considered normal, especially in the southern regions with their hot and dry summers, where the boron requirements should be greater. I regret that M. Chabannes is not here but I do not think that he would contradict me or reproach me for having made use of his figures.

I.N.R.A. Mme. C. Huguet



Typical bitter pit in the variety *Starking*

S.P.I.E.A. M. Mourenas

Bitter pit in the variety *Golden Delicious*