SOME FACTORS WHICH INFLUENCE THE USE OF DWARF AND SEMI-DWARF APPLE TREES FOR COMMERCIAL ORCHARDS IN THE OKANAGAN VALLEY OF BRITISH COLUMBIA

by

Louis Laurent van Roechoudt
L.A.S., University of Louvain, 1930

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ABSTRACT

An investigation was carried out in order to evaluate some of the factors which influence the use of dwarf and semi-dwarf apple trees in commercial orchards in the Okanagan Valley of British Columbia.

Three determining factors were found to be of prime importance: the planting density of the trees in the orchard, the tree form as determined by the pruning and training system carried out and the nature of the rootstock used.

In the Doornberg Orchards at Okanagan Centre where the experiments were conducted, semi-dwarf trees on Malling VII rootstock trained as hedgerows and planted at a high density per acre gave the optimum earliest and total yields and returns.

The experiments were carried out from planting time up to the end of the sixth growing season. The variety of apple used in the experiment was Golden Delicious.

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INTRODUCTION

World production of apples has been rising steadily for the past 30 years, from some 400 million bushels (1926 - 1930 average) to a peak of 674 million bushels in 1950 of which about 150 million bushels may be considered as cider apples (20). It is noteworthy that the largest increase has occured in European countries, where, from a prewar level of close to 124 million bushels the production jumped to 360 million bushels in 1960. During this period Italy has increased its production six times, Denmark and Holland four times, Austria, England, Germany, Sweden and Switzerland between two and three times (20).

Production on the North American Continent (U.S.A. and Canada) on the other hand has been slowly declining from 141 million bushels (1935-1939 average) to 124.5 million bushels (1955-1959 average).

It is apparent that the competition for the world market is on the increase. The B.C. apple producer, along with others on this continent, must be prepared to meet the challenge of European competition. This could necessitate, amongst other things, changes in production techniques.

MacPhee (20) who conducted a Royal Commission inquiry into the different facets of the fruit industry in the Okanagan Valley of British Columbia during the years 1957-58 suggested some improvements which could be made in co-ordination and streamlining of certain services and some possible simplifications in organizational phases of the industry. He also laid emphasis on the fact that the final remedy for the fruit growers ills would have to be found in the orchards themselves. In many cases besides being marginal as a result of ecological factors, the land units were too small for economical and profitable operation. In some instances the crops were inadequate in nature, quality and overall tonnage.

Intensive and high density planting techniques using clonal Paradise and Doucin root stocks, particularly of the dwarfing types as developed and classified by the East-Malling Research Station in England, does not appear to have been thoroughly evaluated in North America. In contrast practically all Western European Commercial orchards have now adopted new planting concepts evolved from the use of such growth regulating rootstocks.

The object of this investigation was to experiment with similar methods and to evaluate some of the factors involved, their advantages and disadvantages, their possibilities and their economic significance with special reference to commercial fruit growing in the Okanagan Valley of British Columbia.

CHAPTER I

REVIEW OF LITERATURE

Brase and Way (2) mention that in Europe fruit trees dwarfing techniques, using growth restricting root stocks, go back many centuries. The ancient Greeks, living at the time of Theophrastos knew about dwarfing apple rootstocks, as later on did the Romans.[1] The word "paradise", according to Bunyard (2) comes from the Persian word "pairidizea", meaning a park or a garden, the word appears to have been mentioned for the first time toward the end of the XVth century. The word "doucin" has been traced as far back as 1519. In 1652 Le Gendre in France recommended that apple trees should be grown on "paradise" or "doucin" rootstock and pear trees on quince root. De la Quintinye in 1690 seems to have been the first to emphasize the importance of using the proper rootstock in relation to the form and size of tree one intends to grow.

Fey and Wirth (9) report that the French horitculturist Fanon in 1780 described a modified dwarf pyramid tree with "arched branches", (Pyramid mit Gebogenen Zweigen) which, in all probability, was the present day "spindel-bush" tree, so widely spread presently in Germany and Holland. All through the XVIIIth and XIXth century, paradise, doucin and quince were widely used over most of Western Europe as growth controlling rootstocks.

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[1]Theophrastos: Plato and Aristotels's disciple, Greek scientist and philosopher born on Lesbos around 372 B.C. Known for his learned writings on plants.

Nevertheless, only during the last 50 years have new commercial planting methods affecting tree form, size, planting distances, pruning systems, etc. come to the fore. In the beginning of this century small production units where apples, pears and peaches were grown on dwarfing stock, closely planted, often trained along walls or trellises, were common in the neighbourhood of large European cities. These "fruit-gardens" as they were called in France, Belgium and Switzerland, were conceived to supply highly particular markets with luxury fruit. They were highly intensive operations in contrast with the high-stem, standard-tree orchards, which then produced the bulk of the total apple and pear crop. These extensive, often not too well cared-for orchards were also used as pasture, where grazing was often considered of more value than the fruit crop itself (30). The large standard trees used, were planted 35 to 45 feet apart and the crown was usually carried on a 6 to 7 foot high stem. The root stock was a seedling, sometimes a wild seedling dug out of the nearby woods. Sprenger (30) states that up to 1930, most of the apple and pear orchards of Holland comprised these high-headed trees, shading grazing cattle in the pastures. Later on the pastures gave way to berry and vegetable production, and the cattle were excluded from the orchards. It then became evident that there was no necessity for such high-headed trees, and that low bush trees would simplify operations. Seedling rootstock began to be replaced by doucin, sometimes paradise rootstocks. Gradually, sometime between the old time grazed orchards of the country side and the intensive espalier-trained trees of the suburban commercial fruit gardens of prewar days, altogether different new types of orchards, more or less intensive in character, made their appearance. They were spindles or pyramid pear orchards of dwarf or semi-dwarf size, grown on quince roots; open vases, informal pyramids or simply bush-type trees for apple trees grown on doucin or paradise stock. A most significant step forward for the future of the industry, came about with the replacement of the variable doucins, paradises and quinces by the properly identified Malling type clonal rootstocks. Hatton's classification work (34) brought an end to the chronic confusion that had existed for years in the designation of apple and pear clonal rootstocks. The Malling nomenclature, with its specific Malling types, began an era of scientific experimentation, which resulted in new planting concepts in the more progressive European orchards. Each rootstock was clearly specified and identified by a roman numeral to which exactly defined morphological and physiological characteristics corresponded. The two elements of the symbiontic tree being thus both genetically defined and stable, it formed a uniform and fairly predictable unit.

Out of some seventy lots of apple rootstocks gathered from commercial establishments all over Europe were sorted some sixteen "types" which were given the Malling initial and roman numbers I to XVI. Gradually the series was increased by new productions such as M XXV and M 26, the latest addition being the woolly aphis resistant clones of the Malling-Merton series bred by Tydeman and Crane (38) (35). Although these roots have shown generally good compatibility with most of the commercial apple varieties many have nonetheless been discarded as unsuitable. Scions grown on these different clones show little vegetative difference in the nursery, but before long, in the orchard they show considerable variation in the size of tree they will grow. For all practical purpose they can be grouped in four categories of increasing vigour:

1. The very dwarfing rootstocks such as M VIII, M IX and M 26.
2. The semi dwarfing stocks such as MM 106, M VII and M IV.
3. The vigorous types producing semi-standard sized trees, more or less 2/3 of a large standard tree, such as MM 111, M 11, M I and MM 109 and MM 104.
4. The very vigorous types such as M XII, M XXV and M XVI, who will grow trees at least equal to the common standard orchard tree.

Highly skilled and imaginative horticulturists in quest for evermore efficient production ways - Fey and Wirth (9), Schmitz-Hubsch, Mac Leans, Seabrook in England; Sprenger, van Oosten and Spoor in the Netherlands; van Cauwenberghe (32) in Belgium, and many more who deserve tribute for the services they rendered, pioneered a number of new avenues during the two decades that followed the first World War. As a result, in Europe, the old standard tree orchards of the past gave way gradually to the new highly intensive dwarf tree orchards of today.

In Holland, Sprenger (30) in "Het Leerboek der Fruitteelt" did show an early awareness of the incidence of tree-form, rootstock type, variety and planting system upon the rentability of the capital investment in commercial orchards. He pointed out that this capital investment in an orchard is made:

I) of the initial establishment expenditures, plus
2) the yearly operational losses, up to the time the orchard operation becomes self-supporting.

He shows further that in the Low-Countries it takes between 12 and 20 years for a standard tree apple orchard to reach the "self-supporting" stage, whereas, for bush trees on type-rootstocks this stage may be attained between the 6th and the 11th year, depending on the nature of the rootstock, the variety and the planting system. He estimates that a permanent-temporary (filler) tree combination will reach the self-supporting stage in 6 years and if the orchard consists of a simple bush tree planting on M.I or M. II roots it will take II years. For pear trees, as standards on seedling root, the self-supporting stage will be reached between the 12th and the 15th year, while on quince roots, the same varieties, in the same environment, trained as commercial pyramids, will equate the operation costs from their 8th year on. Hedgerows, adds Professor Sprenger, would eventually shorten the waiting period to 4 to 5 years if one resorted to a permanent-filler combination grown on the appropriate rootstock. New spindle-bush planting, 4 to 6 feet in the row with 10 to 12 feet between rows, on M IV roots, could reduce even further the unbalanced-costs period, probably to 3 to 4 years. An interesting comparison of investment costs for 3 different apple planting concepts - high headed standard tree, permanent temporary bush trees on M II or M I root, and a trellised hedgerow system with "very close planting" (distances not given, but likely to be about 5 or 6 feet in the rows and 10 to 12 feet between the rows, or 871 to 605 trees per acre), is calculated in Dutch Guilders, of prewar value (1939), at the time of the initial establishment cost and at the stage they become self-supporting. This self-supporting stage was reached at 19 years for the standards, at 5 years for the semi-standard temporary filler trees combination. Final figures for the dwarf hedgerows were not yet available unfortunately.

TABLE I

Initial establishment and final investment costs for one acre of orchard (Dutch Guilders 1939)

Initial investment:		Final investment:
Standard trees	D.G. 1,526	D.G. 8,108
Semi-standard trees	" 1,844	" 2,504
Dwarf hedgerows trees ...	" 4,190	unavailable at printing time

From these figures it appears that although the standard tree orchard was initially the cheapest to establish, by the time its annual returns finally equate the yearly operational expenditures it may become the most expensive.

Van Oosten and Spoor (34) are of the opinion that too much emphasis has been put on "production per acre" while losing sight of the much more significant element, of the "labour-productivity" relationship. They estimate that in 1952 the man-hour production in a good average Dutch bush-tree orchard was approximately 20 Kg. of apples, or 50,000 Kg. per man-year. This was equivalent to twice the labour-productivity of prewar (1939) years. Their belief is that this figure would reach 25 Kg. per man-hour by 1957 and would continue to rise up to 30 Kg. They are of the opinion that although mechanisation and improved working methods have played an important part in this increase of man-hour output, it is the tree-form and the planting concept that are of major significance in the economy of the orchard operation. They emphasise that present day planting methods with small and low growing trees trained in hedgerows systems allow for maximum utilisation of orchard machinery, and that whatever hand-work there is left can be done at a much faster pace, thus cheaper than with the former large and high standard or even semi-standard type of trees. As mechanisation and labour productivity improve the number of acres that one man can handle by himself will increase, which, in turn will affect the size of the "economic unit". The economic size for a two man intensive orchard in Holland, was considered to be from 10 to 12½ acres (4-5 Ha.) in 1957. The writers express the view that it is probable that in the near future the same unit must be enlarged to 15 and eventually to 20 acres in order to remain an economic unit yielding optimum returns. Referring to the evolution of the commercial tree-form in the Low-Countries, van Oosten and Spoor believe that in the new orchards the bush tree on vigorous type rootstocks (M I - M II) is fast disappearing and is being replaced by the "free-spindle" formed trees on M VII, IV and IX roots. They add that new trends are also evident, tending to modify the round free-spindle tree to a flattened form, nearing the Belgian hedge system, which growers think will allow for a maximum of sun exposed surfaces besides other advantages that can be gained from wire support.[2] They draw a comparison between permanent x filler bush tree orchards and what they call a modern spindle-tree operation. The cost of establishment, plus the first year of upkeep was of D.G.I.1280 (post-war values) for the bush-tree semi-standard orchard against D.G.I.1880 for the spindle-bush planting, a I: 1,47 ratio. Cultural operation expenditures were covered by fruit returns at the end of the 4th year for the spindle-bush trees, but only after the 6th year for the permanent-temporary filler-bush trees, at which time the spindle orchard had already accumulated D.G. 480 of surplus, above operational expenditures, per acre. This corresponds quite closely with the earlier figures of Sprenger. Comparing semi-standard inter-planted with filler trees and spindle-bush plantings van Oosten and Spoor add that further advantages in favour of the dwarf

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[2]The Belgian hedge is a form of dwarf, closely planted loosely formed trellis, established on 3 or 4 superposed wires.

spindle trees can be expected after a six or seven year period, because at that time it will be necessary to start pulling out the temporary trees, operation which will result in a new production set-back for another two or three years. The authors conclude by doubting that there be any future for non-dwarf tree plantings in the Netherlands.

Lysten (18) commenting on the apple-tree population of Holland, reports that the standard sized trees on seedling roots accounted still for 22.6 per cent of all the commercial trees during the 1950-51 period, but that by 1957-58 a survey showed that this value had dropped to 2.3 per cent. Over the same lapse of time the percentage of M IX type roots declined slightly from 16.6 to 13.8 per cent, while apple trees on M II roots remained practically unchanged, showing a percentage of 10.5 and 10.1 respectively for 1951 and 1958 statistical surveys. For pear trees it is of interest to read, in the same report, that standards on seedling roots amounted to 58.6 per cent of the total pear tree population in 1951 and that by 1958 their proportion had dropped to 24.9 per cent, while trees on quince type roots had risen to 75.1 per cent. These figures indicate the obvious trend toward the smaller tree forms in the Low Countries in recent years.

In Germany it appears that the evolution of the planting systems has been following a similar pattern to that in the Lowlands. Schmitz-Hübsch and Fürst (29) state that the first attempt to plant a commercial orchard of bush-formed, low-stem apple trees dates back to the year 1900, being inaugurated in the Johannes Böttner orchards near Frankfurt-on-Oder and at the same time in the Schmitz-Hubsch orchards, near Merten. Soon after the first world-war, about 1920, in the same Schmitz-Hubsch orchards, improvements on the ordinary bush trees were made, which, eventually led to the spindle-bush form of tree. The authors refer to the latest tendency as leaning toward the hedge-form, with the expectation of improvement in color, quality and grade of fruit as well as a better utilisation of mechanical equipment, resulting in more efficiency and savings in spraying operations, and easier pruning of trees, thinning and harvesting of fruit; they show herewith a parallel trend of thought with van Oosten and Spoor in Holland.

Fey and Wirth (9) report that Christian Fey introduced as early as 1916, what they call the "schnurbaum mit langen Fruchtholz", later on called a spindle-bush tree, re-discovering the form Fanon had already described and recommended some 160 years earlier. The authors state that, since around 1950, the standard trees as well as the larger semi-standard bush trees are gradually being replaced in commercial orchards by dwarf forms of trees all over Western Europe, from Italy to Sweden and from France to Holland. They warn the German fruit growers that if they want to remain in a position to compete for the fruit markets they can only hope to succeed if they change over, as quickly as possible, from the standard tree orchards to the intensive dwarf-tree operations.

They mention that in many "bleiber-weicher" or "permanent-filler tree" combinations, the filler tree had often been formed as a spindle-bush tree and that over the years it became apparent that these were not short lived trees, as it had often been claimed, and when the time came to uproot them on account of over-crowding, growers often changed their minds and decided instead to remove the permanent bush trees, replacing them eventually by new spindles.

Karnatz (16) reports that during the 1930-37 period, 34.1 per cent of the apple production in Germany was grown on clonal rootstock trees. Twenty years later, for the period 1954-58, the proportion of clonal trees had risen to 67.9 per cent in West Germany (Bundesgebiet: no figures available from East Germany). The break down of the rootstock types used in West Germany between 1950 and 1958 shows the following trends:

M IX: drops from 30.1% to 21.8%
M IV: rises from 16.3% to 22.4%
M II: drops from 13.6% to 9.4%
M I: drops from 6.0% to 0.0%
M XI: rises from 29.7% to 37.1%

Commenting about these figures the author interprets them as a tendency for M IV to replace M IX on account of its better behaviour in average to poor soils and for its greater winter hardiness, rather than because of a change in planting concept. The semi-standard M I trees have practically disappeared while the M II rooted trees are losing ground in favour of the A2 and particularly to the M XI which is in demand because of its specific winter hardiness in the colder climates.[3] The quince rootstock for pear trees, states Karnatz, is unsuitable for most of West Germany, because of its lack of cold hardiness. Although Karnatz's figures are not entirely similar with the trends observed in Holland in regard to rootstock types, they nevertheless illustrate again the same trends toward more intensification and smaller tree-form plantings.

Hilkenbaumer (15) does not question the economical advantages of dwarf-tree orchards but differs merely with Schmitz-Hübsch and Fürst regarding spindle-bush trees versus trellised hedgerows. His opinion is that hedges appear to produce somewhat less per tree than the spindles. Further he seems to think that the color of the apples was slightly better on spindles but only when these had been trained with horizontal rather than with bent-down, drooping primaries. Schmitz-Hübsch (29) disputes this view claiming that fruit on large spindles is often shaded by over-hanging branches, and for this reason not so well colored than those on trellised trees where branches are supported by wire.

In England, reference has already been made to the outstanding contribution from the East Malling Research Station, Maidstone, Kent. Walker (35) reviewing forty years of work at this station and looking back at Hatton's basic root classifications, points out the important role which his nomenclature has played in the fruit industry. He

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[3] A2, a selection from Alnarp (Sweden), vigorous rootstock particularly suited to cold climates.

reviews the development of the more recently created types of clonal rootstocks, such as the Malling-Merton types, resistant to the Woolly Aphid, and the different M IX crosses. The importance of rootstock, tree-form and pruning systems and their effect on early returns is emphasized and related to economic orchard operation. Preston (25) enters into more detailed information about the new MM (Malling-Merton) and the other recently released rootstock selections and the fruit yields to be expected from them following a seven year experiment with three scion varieties. It is apparent that British fruit growers seem to have realized at an early date the economic advantages to be gained in shifting from the standard sized trees to the more intensive semi-standards, which they grew very widely on M II root. Fisher (10), as a result of a visit to England in 1955 reports that for commercial operations practically all the apple trees appear to be grown on M II stock, M VII being also used but to a more limited extent, while trees on M IX are being strictly considered as "a home-garden" proposition. A modified training and pruning system for semi-standard and semi-dwarf bush trees has been suggested by Preston (24) in 1954 and called the "Regulated pruning method". From a seven year long production experiment with apple trees on clonal rootstocks he succeeded in obtaining four times larger yields by applying the "Regulated method" of training and pruning than with the classical spur-pruning system and twice as much fruit as with the renewal pruning method.

G. Mac Lean (19), an English commercial fruit grower, proposed an imaginative and entirely new, unorthodox, training and pruning idea based on continual renewal of the primary branches as soon as they have produced a set of fruit, i.e. every third year. The tree following such treatment develops a rather columnar form. He calls his method the "Pillar system". The trees are grown preferably on a rather vigorous type of rootstock - M II or MM 104 - and planted at a fairly high rate of density, up to 605 trees per acre when planted 6 feet apart in the row and 12 feet between the rows. Mac Lean claims that his system has many advantages such as early and heavy cropping - 600 bushels per acre at full production age with the Cox's Orange variety. Such trees appear to be quite satisfactory under British conditions and produce high grade fruit because of a maximum of light exposure and because they are always obtained on young wood. They are easy to prune, spray and harvest, and have the advantage of not requiring any of the expensive posts and wire installations of the trellised systems. From experience he considers his system financially sound and remarks that "the grower who still persists in the old idea of planting the obsolete large bush-trees loses time, first while he waits for his bush-trees to come into production, and again later on when they will overcrowd, and must be thinned out. In his opinion the slightly larger initial capital investment required for a "pillar-tree" orchard is far outweighed by the subsequent savings in cultural operations, plus the added advantages of earlier and larger net returns per acre.

Marshall (21) (22), who visited European orchards in 1959, reports that he saw in England a planting of the Lord Derby apple variety trained as trellised cordons on M IX rootstock, planted in 1908 and continuing to average yields of 500 bushels per acre yearly. This led him to remark that small trees are not necessarily short lived trees. Quoting and English horticulturist he mentions that there were in 1959 approximately 5,000 acres of commercial dwarf pyramid apple and pear trees in England. In Bedfordshire the "British Wholesale Society" had apparently over 1,000 acres in close planted dwarf pyramids, consisting of nearly 2 million trees. From this report it would appear that the planting concepts in England are also undergoing characteristical changes, and that here again the trend is toward smaller trees, higher desnity per acre and more intensive methods of handling.

In Belgium, Switzerland, France and Italy the evolution in planting methods appear to follow the same direction. Marshall (21) states that he found in Belgium, M IX and M IV and quince A were the most commonly used understocks in apple and pear orchards, and that, by and large, fruit growers all over the Continent were "getting rid of the large tree as fast as possible". Fisher (10) noted that most of the pear trees in Belgium and Holland were grown on quince stock, and he examined some of them 45 years old, which appeared to be in "excellent health and still bearing fine crops".

Switzerland has a highly intensive and specialized fruit producing district situated in the Upper Rhone Valley, in the midst of the Alps, between Martigny and Sierre (Valais). The climate features of this valley appear in many ways very similar to those of the Okanagan Valley; subarid, making irrigation compulsory, with a considerable amount of sunshine during the summertime; warm days alternating with cool nights; long, cold and dangerously unpredictable winters. Property is extremely subdivided, land scarce and very expensive to acquire. High quality apples, pears, prunes and apricots are produced there by highly skilled fruit growers. Rawitscher (26) describes its fruit industry and discusses the merits of the extensive standard tree concept in contrast to the intensive densely planted dwarf-tree plantings, which he still calls "fruit gardens" - "jardins-fruitiers". He examines production records and states that providing the "dwarf-fruit-tree-garden" has properly been established, meaning by this the proper varieties on the right type of rootstock, planted at the right distances, well-trained and pruned, the production will undoubtedly start much earlier and outyield the standard-tree potential on an acre basis, as the standard-trees are very slow to come into production. He shows that trellised cordons and spindle trees produced in their eighth year from planting, from 30,000 to

40,000 Kg. per Ha., equivalent to 826 to 1,102 loose apple boxes per acre, in the Valais fruit belt. Standard tree orchards of the same variety - in this case Reinette du Canada - the main apple variety grown at the time in the valley - yielded only an average of 4,400 Kg. per Ha. or 121 loose bushel boxes per acre, for the period extending from the eighth to the twenty second year, to reach only 17,000 Kgs. or 456 loose apple boxes per acre at the thirty eighth year. It is also of interest to read in his study that the annual operation costs of an intensive dwarf tree orchard differs very little from the operational costs of a standard tree orchard. The extra work entailed in the intensive orchards being compensated by the more difficult task of caring and harvesting large and high standard trees.

Perraudin (23) states that there is presently over production of fruit in Switzerland, especially of apples and that Swiss producers, like the other fruit growers all over the world, hope that export trade will eventually act as a safeguard to maintain the industry. He forecasts that before long, number two grade of fruit will become practically unsalable. In order to remain competitive, the present day fruit grower should therefore spare no effort to lower production costs, while at the same time he must aim at producing only extra-fancy grade fruit. He states that the prerequisites considered basic for economic survival are going to be: 1) the localisation of commercial fruit growing only in the better climatic and topographic locations: 2) the technical arrangement and organization of orchards to obtain maximum use of mechanisation, maximum economy in spraying operations and optimum hand labour efficiency and output when it comes to pruning, thinning and harvesting: 3) the maximum possible shortening of the initial period of time during which orchards are costing more than they return. These basic requirements he claims, depend to a great extent on the nature of the rootstock, the variety, the nature of the tree form and the pruning system followed. Perraudin states further that fruit growing is becoming a more and more complex enterprise, requiring a high degree of technical specialization and considerably more professional knowledge and skill than was previously required for the handling of the former extensive type of orchards.

Experimental orchards in the Swiss Rhone Valley of the Valais country revealed that yields obtained from Red Delicious trees during their eighth year depended on the adopted tree form, the per acre density of trees and the rootstock type. They varied all the way from 104½ loose bushel boxes for bush trees on M IV roots, planted at the density rate of 160 trees per acre (distance: 16½ x 16½ feet on the square), to 805 loose bushel boxes per acre for trees of the same variety and on the same rootstock but trained as spindle-trees and planted at the rate of

435 trees per acre (10 x 10 feet on the square). Bartlett trees on quince A rootstock, trained as commercial pyramids and planted at the rate of 257 trees per acre (13 x 13 feet on the square) produced in their eighth year 358 loose bushel boxes, while the same variety on the same rootstock but trained as Ferragutti cordons, at the rate of 726 trees per acre (6 x 10 feet in trellised hedges) produced at the same age 997 bushel boxes per acre.[4] The same author reports also that insofar as the Swiss Rhone Valley is concerned the dwarf-intensive methods of planting have rightly been adopted by the great majority of commercial fruit growers and that the former standard tree is now definitely obsolete. But, he adds, when it comes to what type of dwarf tree planting to recommend it undoubtedly remains very difficult to decide. Much more factual information is needed, particularly regarding their adaptability to local conditions.

On the American continent it appears that planting concepts did not follow the same line of thought as in Europe. Brase and Way (2) point out that the availability of relatively inexpensive land and labour in America tended toward rather extensive than intensive type of orcharding, as a result most American orchards are of the standard, seedling-root type. Nevertheless they acknowledge

[4]Ferragutti cordons: Italian method of training trellised hedgerows developed by Professor Ferragutti in the early 30's. Three to four horizontal wires on which primaries are tied by arching down.

the fact that conditions are now changing rapidly. They think that maintenance costs and mechanisation make it desirable to strive for smaller sized trees which would come into bearing at a much earlier age.

Weiss and Fisher (36) state that apple and pear trees in commercial orchards of North America have traditionally been grown on seedling roots as standard trees, often reaching over 20 feet high with a 25 to 30 foot spread. Their management leads to a rather extensive than intensive type of operation.

Zeiger and Tukey (37) in a historical review of the Malling apple rootstock in America, mention Patrick Barry, Georges Ellwanger and C.M. Hovey as the earliest proponants of dwarf apple tree culture in the U.S.A. In New York state Barry recommended, as early as in the middle of the XIXth century, the use of apple trees on paradise or doucin rootstock, for early production and as filler trees. It was reported that thirty year old apple trees on French paradise stock were producing 3 to 4 bushels of fruit per tree in the Ellwanger orchard. These observations seem to discard the common notion that dwarf trees were unproductive and short lived. Pear trees on quince roots and grown as dwarf trees comprised about 50 per cent of the pear orchards of New York state up to the end of the XIXth century. Notwithstanding such an early start dwarf apple and pear plantings did not seem to find favour in commercial orchards. The reason for this, according to Zeiger and Tuckey, are hard to make out. They suggest that cultural recommendations, mostly reprints from European articles about small garden practices mislead the American fruit growers, although they cannot understand why there was not more thought given to training these dwarf trees in ways adapted to local conditions. The Geneva Experimental Station in New York State did begin extensive experimentation with paradise and doucin rootstocks around 1897, but they claimed, without much success. Four or five years later the San Jose scale menace broke out, and as the only way to control the pest at that time was by fumigation with cyanide under canvas, it appeared obvious that it would be easier to treat small trees than large standards, hence a renewed interest in the smaller tree forms took place about 1906, with the event of the lime sulphur treatment which kept the San Jose scale fairly well under control, the dwarf tree experimental plots lost a good deal of their intended purpose and it does not appear that they were considered of any further commercial interest. Following the writers Hedrick reported that the rootstocks in the collections lacked uniformity to the point that many trees were not dwarf at all, and some not even semi-dwarf. Many had, no doubt, just scion rooted, others lacked proper anchorage, and a great many of the trees appeared to have been very poorly handled or badly neglected. It was also said that the location had been an unfortunate choice. In America as in Europe the era of rootstock confusion came only to an end around 1930 following Hatton's classification work at East Malling. The first experimental orchards to be planted on duly specified Malling types were set out in 1928 at the Massachussett's Experimental Station. The following year one was planted at the Pennsylvania State College. From these plantings the first systematic and reliable information on dwarf and semi-dwarf and semi-standard trees was obtained on the American continent.

Waugh in 1906, Thornton in 1909 and more recently Southwick (30) are amongst the few American garden Horticulturists to have devoted specialized books to dwarf fruit trees. Their writings were more directed to the home garden amateur, repeating the old European Gardeners techniques, than toward the commercial fruit grower. Nevertheless Southwick portends some valuable advantages in favor of dwarf tree culture, such as: easier handling, easier and more economical to spray or to dust, earliness of the productivity, high yields, quality fruit, ease of harvesting, etc.

As late as 1956, the U.S. Department of Agriculture published a leaflet (32) about "Dwarf fruit trees, their selection and care", in which it is stated that dwarf fruit trees are only desirable when growing space is limited and hand labour quite inexpensive. Dealing with commercial fruit growing on dwarf trees, this publication states that their main disadvantages are: 1)the high cost of dwarf trees, at least twice the cost of standard trees, combined with the need of more trees per acre to get yields that pay; 2) the impossibility of employing large power machinery for cultivation, spraying, etc: 3) the need for staking or wire support. Yet it is admitted that the use of dwarf trees may perhaps be justified as temporary filler trees between standards in order to increase the fruit production during the early years of the orchard.

Childers (6) is of the opinion that considerable research needs to be done in order to assess the reaction of the various Malling type roots under different soil and climatic conditions and that, although little used at present in commercial operations, they nevertheless show considerable promise for the future. Discussing the equipment required for harvesting operations, it is of interest to note that he writes "too much time and energy is spent climbing up and down tall ladders", and on account of this, the cost of picking tall trees is "almost double the cost of harvesting low trees". Childers states also that some commercial dwarf or semi-dwarf pear orchards on quince roots do exist in California and that these trees have been known for their earliness to come into bearing, their ease of management, their regular crops, their larger better shaped and excellent quality fruit, but that they have the following disadvantages: tendency to sucker, susceptibility to blight, and greater cost of establishment per acre. In spite of this he still considers that, insofar as California is concerned, the quince stock is to be recommended for commercial pear orchards.

Gourley and Howlett (12) express the opinion that while dwarf and semi-dwarf apple and pear trees are extensively used abroad, they have never appeared to have been successful as commercial orchards on this continent. They conclude that they are of interest only where small quantities of several varieties of fruit are wanted and for home gardens.

Gardner, Bradford and Hooker (11), although more particularly interested in physiological considerations than in orchard economics or fruit bearing performances, discuss some points of interest to the commercial fruit grower. Amongst them, the rootstock influence on tree hardiness and on fruit quality. They point out that hardiness has been shown to be in direct relationship to the water retaining capacity, which, in turn depends on maturity. The water relationship may be influenced by cultural practices, but it can also depend, to a large extent, on the rootstock effect. Mahaleb root - a dwarfing type - is reported to induce hardiness in sweet cherry tops on account of the earlier ripening of the scion's wood tissues. Discussing the possible effects of the rootstock type on fruit quality, Gardener et al mention a two year investigation by Riviere and Bailhache on the sugar content of pears grown on quince roots in comparison with the same pear variety grown on seedling roots. Doyenne d'Hiver pears showed 11.59 per cent sugar content in their juice when obtained from trees on quince root against only 9.04 per cent in the juice of fruit grown on trees with seedling roots. No sugar values are given for apples on dwarfing stock.

Harris and Woods (13) report that from their investigations at the Canada Department of Agriculture, Experimental Farm Saanichton, B.C., apple trees on M IX rootstock grow well, produce heavily with high quality fruit at an age when standard trees were far from being in a state of commercial production. They state that for commercial operations hedgerows trees on M IX planted between 4 and 7 feet in the row and 10 feet between rows, appear to be proper spacings. For small bush-trees, distances over 7½ feet were not economical. The closer the trees were planted, the higher was the yield on an acre basis and this particularly during the first ten - year period of the orchard life. The old country spindle-bush, the hedgerow, the formal cordon and espalier methods were used. On hedgerows planted at 4 x 12 feet distance, or 907 trees per acre, on M IX root, production of over 5 T or 300 loose bushel boxes for the fourth growing season was recorded, while on standard trees of the same variety and strain, in the same environment, no crop to speak of was anticipated before eight or more years. The espalier formed trees, following more or less the Kniffen training method used for grapes, trained along two wires at four years old averaged 40 lbs. of apples per tree with individual yields up to 100 lbs. per tree. Commenting on management of dwarf tree systems of orchards they suggest that planting distances should, as much as possible, be planned in accordance with the mechanical equipment which the grower has available, although, considering the very high cost of land and irrigation equipment, close planting, even if it necessitates the purchase of specially adapted equipment, may be advisable. From their experience they found the harvesting of dwarf trees a very easy task, since no ladder work was entailed, also that a minimum of grading was required as the fruit produced was uniformly of high grade and quality. Discussing the matter of longevity of dwarf tree orchards, the authors suggest that in order to keep up the vigor of the tree, a rotation of periodical tree renewal should perhaps be considered, because young trees generally produce the best grade of fruit. Estimating the cost of establishment of an acre of dwarf hedgerows, trellised on one strand of wire, planted at 7 feet in the row and 10 feet between rows, or 620 trees per acre, the land being rented, the authors estimate that the total initial outlay would amount to some $1,119.00 for trees, materials and labour included - but without irrigation installations. For the yearly maintenance costs, they allow $250.00 per acre, covering land rental, fertilizers, spray materials and labour.

Weiss and Fisher (36) consider that rising costs of labour and capital investment may induce growers to be more interested in the future in more intensive methods of orcharding. They show comparative cumulative yields obtained over a 20 year period at the Canada Department of Agriculture, Research Station of Summerland, B.C., for standard, semi-standard and dwarf tree plantings of the Red Delicious and MacIntosh varieties, the data also indicates the relative earliness of production by showing the accumulated yields every five years

TABLE II

Cumulative yields per acre in 40 lb. boxes for Delicious and MacIntosh , on 4 rootstocks.
(Research Station, Summerland, B.C.)

Rootstock	No. of trees per acre	No. of 40 lb. boxes per acre for the period:				
Red Delicious		1-5 yrs.	1-10	1-15	1-20	16-20
Seedling	48	0	368	1384	2972	1588
M XVI	48	0	456	1628	3668	2040
M II	70	6	578	1970	4293	2323
M IX	363	210	1287	3828	6984	3156
MacIntosh						
Seedling	48	20	926	2439	4618	2179
M XVI	48	20	971	2402	5056	2654
M II	70	75	1339	3741	6331	2990
M IX	363	423	1674	4797	9333	4536

It appears that in both varieties dwarf trees on M IX planted in the hedgerow system, have outproduced the semi-standards on M II roots, as well as the standards on seedling or M XVI type rootstock. Semi-standards although they were planted at only 70 trees per acre still take second place for earliness and total productivity. The standard trees on clonal rootstock outproduced (with both varieties) the standard or seedling roots.

Brase and Way (2) found that the smaller trees, because of reduced bearing area, will produce less fruit per unit when compared on that basis with the large standard tree, but as more trees can be planted per acre with the dwarfs, the acre yield can be larger, or at least as large. Further they add that even if yields were not larger, there would still be an advantage with the smaller tree because of easier cultural and harvesting operations and "most important, because of earlier production".

Roberts (27) working at the Oregon Experimental Station notes that although the dwarfing roostock induces earlier bearing in any variety, it does not eliminate the varietal tendency to early or late bearing, nor does it eliminate tendencies toward alternate bearing habits. He concluded, however, that the advantages of earlier production and the larger total production per acre is becoming increasingly evident and that this, added to the advantages of ease of management and labour saving practices will undoubtedly continue to encourage the introduction of dwarf trees in the "orchards of tomorrow". He sums up by stating that:

> "If the smaller than standard tree is to have a place in solving the problem of rising costs in the orchard, it will be on the basis of earlier and heavier production with less labour and expense. If such an approach is to be successful, orchard management must find the answer to two questions:
> (1) What unit-stock scion - or what combination of units is most productive per unit area?
> (2) How to arrange these units in the orchards for maximum efficiency in production and management."

Results obtained by Roberts at Corvallis, Oregon, on dwarf hedgerows on M IX, semi-dwarf bush trees on M VII, and from standard trees on M XVI for a 12 year period are shown below. The accumulated yields are added in 5 year periods for purposes of comparison with data obtained at Summerland, B.C. (cfr. Table II)

TABLE III

Calculated per acre yield of Golden and Red Delicious Apples at suggested planting distances for several Malling rootstocks. (Based on average tree yield for the past 12 years).

-GOLDEN DELICIOUS-

Planting systems:	Hedgerow	Semi-dwarf bush tree	Standard
Rootstock:	M IX	M VII	M XVI
Pl. distances:	8 x 15 ft.	18 x 24 ft.	36 x 36 ft.
No. trees per acre:	363	100	34

ANNUAL YIELD PER ACRE IN 40 LB. BOXES

1st. year	-	-	-
2nd. "	20	-	-
3rd. "	100	12	8
4th. "	254	155	77
5th. "	82	27	106
Acc. first 5 years	456	194	191
6th. year	1007	492	269
7th. "	880	95	463
8th. "	1661	1154	501
9th. "	790	165	479
10th. "	1906	1462	376
Sec. 5 yr. period	6244	3368	2088
Acc. 1st 10 yrs.	6700	3562	2279
11th.year	808	425	378
12th. "	2577	1377	478
Total Acc. prod. for 12 years	10085	5364	3135

-RED DELICIOUS-

Planting system:	Hedgerow	Semi-dwarf	Standard bush
Rootstock:	M IX	M VII	M XVI
Pl. distance:	8 x 15 ft.	18 x 24 ft.	36 x 36 ft.
No. trees per acre:	363	100	34

ANNUAL YIELD PER ACRE IN 40 LB. BOXES

1st. year	-	-	-
2nd. year	-	-	-
3rd. "	-	-	-
4th. "	272	52	1
5th. "	109	37	4
Accum. 1st 5 yrs.	381	89	5
6th. year	617	87	13
7th. "	263	77	28
8th. "	1080	577	301
9th. "	826	400	56
10th. "	1416	942	296
Sec. 5 yr. period	4202	2083	694
Acc. 1st 10 yrs.	4583	2172	699
11th.year	871	460	231
12th. "	1697	885	355
Total Acc. prod. for 12 years	7151	3517	1285

It can be seen from Table III that for the Red Delicious variety Roberts recorded greater and earlier yields than were recorded at Summerland, B.C.

MacPhee (20) referring to winter damage and the high rate of mortality of the fruit trees in the Okanagan, stresses the importance of the factor of earliness in bearing. He states that growers should be able to have trees into production as soon as possible after they have been planted. They should endeavour to obtain maximum production in the early years because statistical evidence shows that once trees are over 20 years of age they have less than 50% chance of survival. Every practice that would bring fruit trees earlier into production should be considered as of great importance in the economies of the Okanagan orchards. If trees could be induced to start to yield at 3 years of age and continue to bear for 20 years, then they could be profitable; however, if one has to wait 8 to 10 years for trees to come into production, and the chances are that 50% will only survive beyond the 20 year age, then the probability for profitable production becomes very low indeed.

The tree census, taken by the B.C. Department of Agriculture (3), shows the trend in the Okanagan Valley is towards planting more apple trees on dwarfing rootstocks. In 1951 there were no more than a few hundred trees on

Malling type rootstocks in the whole Valley. The 1955 census recorded some 37,000 trees on clonal type rootstocks. By 1960, out of a total of 479,651 trees recorded for the entire Okanagan, 231,576 were now on Malling type roots. The semi-standard trees (mostly on M II, M I, and very few on MM I09, MM III, MM I04 type roots) accounted for 70.16 per cent of them, the semi-dwarfs (on M VIII, M IV, and MM I06 roots) for 23.77 per cent, the true dwarfs (on M IX and M VIII) for 3.57 per cent and the clonal standards (on M XVI and M XXV) for 2.57 per cent of the total clonal apple tree population. It would appear that although there has been a shift in the Okanagan from the planting of large standard trees on seedling roots to the planting of smaller trees on clonal rootstock, fruit growers are still planting more semi-standard trees in preference to either the semi-dwarf or the true dwarf trees.

CHAPTER II

MATERIALS AND METHODS

The experiments were carried out at "Doornberg Orchards", which are located one mile North of Okanagan Centre, some twenty miles North of the City of Kelowna, approximately four miles above the 50 degree parallel N., in the Northern part of the Okanagan Valley. The altitude above sea level being 1,310 feet.

The soil of the lower part slope belongs to the Glenmore Clay-loam formation; the soil of the upper part belongs to the Oyama loamy-sand formation. Both are classified as dark brown soils by Kelley and Spillsbury (17). The experimental plots were situated on the Oyama loamy-sand series. In this particular case the Oyama loamy-sand formation were light, coarse and very gravelly in places, resting on irregular strata of gravel, silt or clay in the subsoil.

The local micro-climate is considered as very favourable in the Okanagan Valley, which itself is one of the mildest in Canada (17). Summers are bright, sunny and warm. Day temperatures reaching often 100 degrees F. with a maximum of 103 degrees F., while night temperatures usually contrast by their coolness. Winters are relatively mild with overcast skies and occasional cold spells, lasting from a few days to a few weeks, when temperatures hover around 0 degree F. On one occasion, however, an exceptionally low temperature of minus 22 degrees F. was reached in January 1950. Within $1\frac{1}{2}$ to 2 miles distance the deep waters of the Okanagan Lake act as temperature regulators as long as they remain free of ice, which is generally the case. Although snow-protection is by and large prevalent in the Northern half of the Valley during the coldest period of the winter, it happens occasionally that orchards remain bare and without any protective cover right through the cold season. The frost-free period for front lake benches at Okanagan Centre is of 184 days. Precipitation occurs mostly during Winter time and Spring, attaining a yearly average of 13.35 inches, corresponding to semi-arid conditions requiring irrigation practices to compensate for the natural soil and atmospheric aridity during most of the active growing season.

The orchards have a N.W. exposure and slope down close to the Eastern shore of Okanagan Lake.

EXPERIMENTAL OUTLAY

In order to evaluate the relative economic potentials of apple orchards managed under different planting and training systems and grown on different rootstocks, the following procedure was carried out:

1. Semi-standard bush trees:

In the spring of 1953 one year whips of Spartan and Jubilee varieties on Malling II rootstock were planted between 50 year old MacIntosh trees spaced 30 x 30 feet. The trees were interplanted between the old trees in both directions, giving a total of 96 trees to the acre, planted on the square $21\frac{1}{4}$ feet apart.

Once the structural primaries had been obtained in order to form a 4 to 5 leader delayed-open-centre tree, the future leaders were budded over in the Summer of 1955 and 1956 with the Golden Delicious variety. The old trees were removed during the Winter of 1955-56.

2. Spindle-bush trees:

In the Spring of 1956 one year old Golden Delicious trees on M VII rootstock were planted as filler trees between the semi-standard bush trees mentioned above, in the place where the old trees had been removed. These were staked and trained as spindle-bush trees.

The area now contained permanent bush type trees on M II rootstock with alternating filler trees as spindle-bush trees on M VII rootstock.

The planting pattern remained on the square but with trees 15 feet apart in both directions, or 192 trees per acre, with 96 trees of each type.

3. Semi-dwarf bush trees:

One year old Golden Delicious trees on M VII roots were planted in the Spring of 1956, 18 feet apart on the triangle system, giving 134 trees per acre. The area had previously been planted to peach and apricot trees.

4. Trellised hedgerow trees:

In the Spring of 1956 Golden Delicious trees on M IX, M VII and M IV roots were planted in rows 430 feet long in a N.S. direction. They were planted 6 feet apart in the rows with 11 feet between the rows, giving a planting density of 660 trees per acre.

End and intermediate posts 30 feet apart and 8½ feet high above the ground level supported a 4-wire trellis. The first wire was 30 inches above the ground, the other three wires were spaced 24 inches apart.

An overhead sprinkler system was installed.

5. Standard trees:

A block of Golden Delicious trees worked over hardy Lodi frame and on MacIntosh seedling rootstock, planted in the 30 feet square pattern in the Spring of 1952 was selected. The planting density was of 48 trees per acre. The block had never been planted with trees previously.

CULTURAL MANAGEMENT

Soil management:

For the first four year period, trees in blocks I, 2, 3, 4 and 5 were kept under clean-cultivation. During the fifth and sixth year block I, with the semi-standards and block 4 planted with the hedgerows, were maintained under clean cultivation, block 3, the semi-dwarfs and block 5, the standards being brought under grass cover, mown down three or four times during the season.

Fertilization:

Right after planting, all trees received a chicken-litter manure dressing two or three inches thick covering the root-zone. In the standard tree block this dressing was of ordinary cow manure.

All clonal-root trees received a yearly Fall application of nitrogen in the form of Ammonium nitrate, 33-0-0, scattered over the root zone, at the rate of 2 lbs. per tree for the semi-standards and the semi-dwarfs, the spindle bush trees received one lb. per tree and the hedgerow trees only one-half lb. per tree. The standard seedling root trees received a supplementary late Fall application of blood and bone meal 7-11-0 at the rate of two lbs. per tree.

Every other season boron, magnesium and zinc were supplied at the recommended rate in order to prevent mineral deficiencies.

Irrigation:

Irrigation water was supplied from the middle of May to the end of August by way of a sprinkle system. For the hedgerow block, ditch irrigation was tried out during the first three seasons but as this was found to be very impractical and irregular, on account of the excessive permeability of the soil, a semi-permanent system of over-head sprinkles was devised and set up in the Spring of 1959.

The standard tree block was ditch irrigated from 1952 till 1960 when sprinkler irrigation was installed there also.

Pruning methods:

The standard, semi-standard and semi-dwarf trees were formed as delayed open-centre trees with 4 to 5 leaders, started about 30 to 40 inches above ground level. Secondary growth was left unpruned when possible, but it was shortened or removed where in the presence of competing branches.

The spindle bush trees were trained following the classical methods in general use in Continental Europe.

The one year whips were headed back about 30 inches above soil level. Four or five primaries with wide angled crotches were selected all around the tree and forced to grow to the horizontal with the help of strings tied to the base of the stake for a few weeks. Once the first tier of branches appeared well established the central leader was allowed to grow another 24 to 30 inches where it was tipped in order to force a new tier of 3 or 4 primaries. As soon as these had grown two or three feet long they were again bent down to the horizontal by tieing or clipping to the lower branches for two or three weeks. This process will be continued until the tree reaches 10 to 12 feet high, when the central leader will finally be headed back to avoid the spindle becoming too high, ladder work not being desired. Secondary growth was shortened to 6 or 8 buds; upward growing shoots were entirely removed.

The trellised hedgerow trees, regardless of the rootstock type they were on, were headed back at planting time about 28 inches above ground level, which was about 2 inches below the first horizontal wire. Two primary laterals, as much as possible oriented in the axial direction of the row, one on each side, were allowed to grow, plus a central leader. When the lateral leaders were considered long enough - two or three feet- they were bent down and tied to the horizontal wire with the help of clothes pins or plastic ties. Once the first tier was well established the central leader was allowed to reach the next wire, at which level it was again headed back. Two primaries were selected and again trained in both directions along the second wire, the process being repeated for each wire. Primaries growing perpendicular to the wire were shortened to 8 to 10 buds or bent down to the horizontal and shortened in order to avoid the hedge becoming wider than desired. Secondary growth on both sides of the leaders was shortened to 8 - 10 buds; all vertical shoots were completely removed. The width of the hedges varied between 36 and 40 inches for the trees grown on M IV and M VII, and somewhat less for the trees on M IX.

No summer pruning has been experimented with so far, only occasionally some branches were tied to the wires or bent to the horizontal when it was felt it was time to do so.

Thinning:

Excess of fruit was removed every year by hand thinning. The operation was generally done between June 15-30. The amount of fruit removed depended on the fruit set. The general rules followed were: I) elimination of fruit showing any kind of defect such as scab, mechanical bruising, excessive russetting, deformities, etc. 2) breaking up of all clusters, leaving only one apple per fruit spur and 3) when the set still appeared to be too heavy, the smaller sized fruit was taken off leaving at least 5 to 6 inches between the apples.

Spraying:

All semi-standard, semi-dwarf and dwarf trees were submitted to the same protective sprays. The sprays were applied following a medium volume technique until 1958, and at a low volume (50 gallons per acre) from then on. The standard tree block was treated with the same materials but by the high volume (300 gallons per acre) method throughout.

Harvesting:

All apples from the trees under investigation were picked simultaneously. Fruit below 2 inches in diameter was considered as non commercial and eliminated; there were very few of them. Windfalls were included in the records providing they were without large marks of decay and within the size limit. Recording entries were taken on the individual tree basis, from rows chosen at random. The apples were collected in standard wooden bushel apple boxes.

CHAPTER III

RESULTS

Semi-standard bush trees:

The individual production per tree, the total yield per acre for each year, in loose bushel boxes together with the accumulated yields are shown in Table IV.

TABLE IV

Yields for 9 consecutive years of Golden Delicious apples from trees grown on M II rootstock and with hardy intermediate frame, pruned to a delayed open-centre form.

Growing Season	No. of trees rec.	Yield bu.	Prod. per tree	Prod. per acre	Acc. prod. per acre
First to Fourth	15	0	0	0	0
Fifth	15	6.00	0.40	38.40	38.40
Sixth	15	29.00	1.93	185.60	224.00
Seventh	15	27.00	1.80	174.60	398.60
Eighth	10	63.50	6.35	609.60	1,008.20
Ninth	10	42.00	4.20	403.20	1,411.40

It would appear that the semi-standard tree, double worked, came into bearing on the fifth year but did not approach a commercial crop until the eighth year after planting, from then on the yield appears to be satisfactory.

Spindle-bush as filler trees:

Individual yields per tree, total production per acre and accumulated yields in loose bushel boxes are given in Table V.

TABLE V

Yields for 6 consecutive years of Golden Delicious trees, directly on M VII rootstock, trained as spindle-bush trees and used as filler trees in the semi-standard block.

Growing Season	No. of trees rec.	Yield in Bu.	Prod. per tree	Prod. per acre	Acc. prod. per acre
First & Sec. inc.	23	0	0	0	0
Third	23	3.00	0.13	12.52	12.52
Fourth	20	11.25	0.56	53.95	66.47
Fifth	20	22.00	1.10	105.60	172.07
Sixth	20	51.50	2.57	242.20	419.27

These trees started bearing in their third growing season but their crop did not become of commercial importance before the sixth year. It should be remembered that the planting density was of only 96 trees per acre, as they were used as fillers between the semi-standards.

Semi-standards as permanent trees combined with spindle-bush trees as filler trees.

Aggregate yields per acre of the combined production of semi-standard and spindle-bush trees, projected as for trees planted during the same season. In order to show the production potential over the first six growing seasons from a permanent filler type of orchard.

TABLE VI

Yields in bushel boxes per acre and accumulated from a permanent temporary tree combination. The permanents being semi-standards on M II rootstocks double-worked, the fillers being spindle-bush trees directly on M VII root. Record for the first six growing seasons.

Growing Season	Semi-standard on M II bu. per acre	Spindle-bush on M VII bu. per acre	Permanent filler com. bu. per acre	Acc. aggreg. bu.-acre
First & Sec. incl.	0	0	0	0
Third	0	12.52	12.52	12.52
Fourth	0	53.95	53.95	66.47
Fifth	38.40	105.60	144.00	210.47
Sixth	185.60	247.20	432.80	643.27
Totals Bu.	224.00	419.27	643.27	-

Commercial production started at the end of the fifth growing season; the largest part - 105.6 Bu. - being produced from the spindle-bush filler trees. At the end of the sixth growing season out of the accumulated combined production of 643.27 bushel boxes, 419.27 came from filler trees against 224.00 bushel boxes from the semi-standards. The part played by the temporary spindles appears to justify the additional expenses they caused.

Semi-dwarf bush trees

Yields in bushel boxes per tree per acre and accumulated up to the sixth growing season inclusive, are shown in Table VII.

TABLE VII

Yield in bushel boxes for the first 6 growing seasons of Golden Delicious trees trained as delayed open-centre bush-trees and grown on M VII rootstock. Planting density: 134 trees per acre.

Growing Season	No. of trees rec.	Yield Bu.	Prod. per tree	Prod. per acre	Acc. prod. per acre
First & Sec. inc.	46				
Third	46	2.50	0.05	7.28	7.28
Fourth	46	32.00	0.70	93.22	100.50
Fifth	26	53.00	2.04	273.15	373.65
Sixth	26	88.50	3.41	456.15	829.80

Production in this block started the third season and reached a commercial level the fifth year.

The hedgerows

Average yields for individual trees, their projected yield per acre and the accumulated yields are shown in bushel boxes for Golden Delicious A) on M IX, B) on M VII, C) on M IV rootstock for the first 6 growing seasons, in Table VIII-A, VIII-B and VIII-C.

TABLE VIII-A

Yields in bushel boxes per tree, per acre, and accumulated over the first six growing seasons for Golden Delicious trees on M IX rootstock, planted at the density of 660 trees per acre and formed as trellised hedgerow.

Growing Season	No. of trees rec.	Yield Bu. bxs.	Prod. per tree	Prod. per acre	Acc. prod. per acre
First & Sec. inc.	143	0	0	0	0
Third	143	26	0.18	120.00	120.00
Fourth	40	13.50	0.34	222.75	342.75
Fifth	10	7.50	0.75	495.00	837.75
Sixth	10	9.00	0.90	594.00	1,431.75

TABLE VIII-B

Same as for Table VII-A except for the rootstock which was M VII.

Growing Season	No. of trees rec.	Yield Bu. bxs.	Prod. per tree	Prod. per acre	Acc. prod. per acre
First & Sec. inc.	145	0	0	0	0
Third	145	19.00	0.13	86.51	86.51
Fourth	70	47.25	0.67	445.70	532.21
Fifth	70	81.50	1.16	768.43	1,300.64
Sixth	70	107.00	1.53	1,008.86	2,309.50

TABLE VIII-C

Cfr. the introduction to Table VII-A, except for the rootstock type which is M IV in this case.

Growing Season	No. of trees rec.	Yield Bu. bxs.	Prod. per tree	Prod. per acre	Acc. prod. per acre
First & Sec. inc.	0	0	0	0	0
Third	71	2.00	0.03	18.59	18.59
Fourth	71	22.75	0.32	211.48	230.07
Fifth	70	89.00	1.29	839.14	1,069.00
Sixth	68	89.50	1.32	868.68	1,937.89

Tables VII-A and VII-C show that production for the three different rootstocks started during the third growing season. The trees on M IX, the less vigorous type of the three, showed the earliest production but were soon passed by the M VII trees - in the fourth growing season and by the trees on M IV during the fifth growing year. Earliness of production was in verse ratio to the vigour of the adopted rootstock. At the end of the sixth growing season the accumulated yields show wide differences which appear directly related with the nature of the rootstock type. The trees on M VII are leading to date but they are closely followed by the trees on M IV.

Yields of 1,008.86 or even of 868.68 Bu. boxes per acre obtained respectively by trees on M VII and M IV which have hardly attained half their expected development, are very promising. Cfr. Fig. 2

Standard trees

Yields in Bu. boxes, per acre and accumulated up to the tenth growing season are recorded in Table IX.

TABLE IX

Yields from double-worked Golden Delicious trees grown on seedling rootstocks during the first ten year period - trained as delayed open centre trees and planted at the rate of 48 trees per acre.

Season	No. of trees rec.	Yield Bu. bxs.	Prod. per tree	Prod. per acre	Acc. prod. per acre
First - Fifth inc.	0	0	0	0	0
Sixth	27	50	1.85	88.88	88.88
Seventh	27	121	4.48	215.11	303.99
Eighth	27	171	6.33	304.00	607.99
Ninth	27	314	11.63	558.22	1,166.21
Tenth	27	136	5.04	241.77	1,407.98

Although in this study the crop figures are only compared up to the sixth year inclusive, which in the case of the standard trees corresponds with their first fruit returns, records are nevertheless given up to the tenth growing season as a matter of general interest in comparison with the yields shown for the semi-standards on M II which are given up to the ninth growing season in Table IV. The relatively low crop of the tenth-growing season suggests an alternate-bearing effect. The semi-standards on M II appear to have been affecting also but to a much lesser degree. The trees on less vigorous rootstocks, those on M IX and M VII do not indicate any alternate bearing effect, but those on M IV may have been somewhat affected in the sixth year as the increase in production was lower than anticipated.

Cfr. Fig. 4

Spindle-bush trees as a permanent planting.

Although widespread in European plantings, Doornberg Orchards has at present no block made up entirely of spindle-bush trees. However, potential yields of such a planting can be projected, based on the records of the spindle-bush trees used as filler trees in the semi-standard block, as shown in Table IV. Under prevailing conditions and for the Golden Delicious variety on M VII root, the planting distances would have to be ten feet by fifteen feet, giving a density of 290 trees per acre.

TABLE X

Yields in Bu. boxes per tree, and projected yields per acre and accumulated per acre, up to the sixth year for a Golden Delicious spindle-bush planting on M VII rootstock at a density of 290 trees per acre.

Season	No. of trees rec.	Yield Bu. bxs.	Prod. per tree	Prod. per acre	Acc. prod. per acre
First & Sec. inc.	0	0	0	0	0
Third	23		0.13	37.82	37.82
Fourth	20	11.25	0.56	163.12	200.94
Fifth	20	22.00	1.10	319.00	519.94
Sixth	20	51.50	2.57	746.75	1,266.69

The importance of the optimum planting distance and the planting density is apparent. At 96 trees per acre, the accumulative yield of 419.27 boxes was obtained in six years, whereas, if a density of 290 trees per acre had been used the yield would have been 1,266.99 boxes.

A solid planting of spindle-bush trees on M VII rootstock would have been more advantageous than using them merely as filler trees between the semi-standards.

The actual production per tree in loose bushel boxes up to the end of the sixth growing season, is shown in Table XI, and the total yield for the period compared as a ratio with that of the standard trees on seedling roots. The data in this table does not take into account the planting density per acre, which, as seen in Table IX is a very important factor.

TABLE XI

Yield in loose Bu. boxes per tree up to the end of the sixth growing season in relation to rootstock type and tree form.

Season	Standard Seedling	Semi Standard M II	Bush Semi-dwarf M VII	Spindle M VII	Hedgerows M IX	MVII	M IV
First & Sec. Yr.	0	0	0	0	0	0	0
Third	0	0	0.05	0.13	0.18	0.13	0.03
Fourth	0	0	0.70	0.56	0.34	0.67	0.32
Fifth	0	0.40	2.04	1.10	0.75	1.16	1.29
Sixth	1.85	1.93	3.41	2.57	0.90	1.53	1.32
Total Bu.	1.85	2.33	6.20	4.36	2.17	3.49	2.96
Ratio	1:1	1.25	3.35	2.35	1.17	1.83	1.60

Trees planted as hedgerows on M IX (dwarfs) gave the highest early production per tree but soon lost their advantage because of their relatively small bearing surface.

Trees on M VII (semi-dwarf), regardless of the training system used, were second in earliness of production. During the fourth year they took the lead and maintained it until the end of the experiment.

Trees planted as hedgerows on M IV (semi-dwarf) did not bear as well as those on M VII up to the end of the fourth season, but during the fifth and sixth season there was little difference in their yield. There was, however, a slight tendency toward alternate bearing with the trees on M IV rootstock.

There was little difference at the end of the sixth year in yield per tree between the semi-standard trees on M II and the standard trees on seedling roots. However, as mentioned previously, the density of planting comes into the picture. Standard trees are planted at 48 trees per acre whereas semi-standard trees can be planted at a density of 96 trees per acre.

Of the three tree forms on M VII rootstock-bush, spindle-bush and hedgerow - it would appear that the least pruned trees (bush) produced the highest yield, the moderately pruned trees (spindle-bush) produced a medium yield and the most severely pruned trees (trellised) produced the lowest yield.

RECAPITULATION

In order to bring all the data from the preceding tables more closely into focus, the accumulated yields per acre of Golden Delicious apples up to the end of the sixth growing season are shown in Table XII. These data take into consideration the five different types of root-stocks used in connection with the several planting concepts involved. The yields are arranged in ascending order. The yields ratio shown is obtained by taking the yield of the standard trees as unity. Cfr. Fig. 5

TABLE XII

Planting Concept	Accum. Prod. per acre	Ratio
1. Standard trees, hardy intermediate, seedling root, 48 trees per acre...	Bu. 88.88	I : I
2. Semi-standard trees, hardy intermediate, M II root: 96 trees p.a...	Bu. 224.00	I : 2.52
3. Spindle-bush on M VII root, as fillers, 96 trees per acre	Bu. 419.27	I : 4.76
4. Combination of semi-standard permanent trees on M II and spindle b. fillers on M VII Total trees combined - 192 per acre	Bu. 643.27	I : 7.28
5. Semi-dwarf trees on M VII root, 134 trees per acre	Bu. 829.80	I : 9.33
6. Spindle-bush trees on M VII root, 290 trees per acre	Bu. 1,266.69	I : 14.25
7. Hedgerow trees on M IX 660 trees per acre	Bu. 1,431.75	I : 16.33
8. Hedgerow trees on M IV root, 660 trees per acre	Bu. 1,937.89	I : 21.75
9. Hedgerow trees on M VII root, 660 trees per acre	Bu. 2,309.50	I : 25.59

At the end of the sixth growing season, on an acre basis, there was a wide variation in yields from each of the different planting concepts. The trees planted as hedgerows on M VII rootstock at the density used had produced 25.9 times more fruit than the standard trees. The yield was related to the planting concept, the number of trees per acre, the system of pruning and training followed and the type of rootstock used.

The data in the table indicate that six years after planting one can expect a healthy return from either dwarf or semi-dwarf trees, whereas, little or no return can be expected from standard or semi-standard trees. Furthermore, the solid planting of dwarf or semi-dwarf trees should produce a more substantial return than a combination planting of standard or semi-standard trees as permanent trees and dwarf or semi-dwarf trees as filler trees.

<u>To Follow:</u>

1. Photographical illustrations of tree forms and planting systems: Figs. I to 12
2. Production charts: Figs. I to 5

Fig. 1

Double worked Golden Delicious standard tree on seedling stock in its 10th growing season. Crop: 7 bu. loose
Per acre yield the 6th growing season; 89 bu.
Per acre yield the 8th growing season; 304 bu.[1]
Accumulated production end of 8th growing year; 608 bu.
Planting density - 48 trees per acre.

Fig. 2

Double worked Golden Delicious semi-standard on M II stock in its 8th growing season.
Crop: 10½ bu. loose.
Per acre yield the 6th growing season; 224 bu.
Per acre yield the 8th growing season; 609½ bu.
Accumulated production end of 8th growing year[1]; 1,008¼ bu.
Planting density; 96 trees per acre.

Fig. 3

Semi-dwarf Golden Delicious bush-formed tree on M VII rootstock in its 6th growing season. Crop 6½ bu. loose.
Per acre yield the 6th growing season; 456¼ bu.
Accumulated production end of 6th growing season; 829.3/4 bu.
No. of trees per acre: 134.

[1]Acre yield and per acre accumulated production for the 8th growing season are given for the Double worked trees as they should be compared with the 6th growing season for ordinary grown trees.

Fig. 4
Semi-dwarf Golden Delicious bush-tree orchard on M VII rootstock in its 6th growing season; 134 bu. per acre

Cfr. Fig. 3 for yields

Fig. 5
Golden Delicious on M VII as staked spindle-bush tree in its 6th growing season.
Crop: 4 bu. loose.
96 trees per acre, as filler-trees between semi-standards on M II.
Yield per acre of the fillers, the 6th growing season; 242½ bu.
Accumulated production end of the 6th growing season; 419½ bu.
290 trees per acre, as permanents in full spindle-bush orch
Calculated yield the 6th growing season; 746. 3/4 bu.
Acc. prod. end of 6th growing season; 1,266. 3/4 bu.

Fig. 6
Trellised hedgerow orchard of Golden Delicious trees on M VII stock in its 3rd growing season. Irrigation by overhead sprinklers.
Crop - the 3rd growing season; 86½ bu.
Planting distances: 11 by 6 ft.
No. of trees per acre; 660

Fig. 7
Trellised hedgerow of Golden Delicious on M IX in their 6th growing season.
Crop per acre; 594 bu.
Accumulated production at the end of 6th growing season; 1,431. 3/4 bu.
No. of trees per acre; 660

Fig. 8
Trellised hedgerow Golden Delicious trees on M VII root in its 6th growing season.
Crop; 3 bu. loose.
Yield per acre in its 6th year; 1,008. 3/4 bu.
Accumulated production per acre - end of 6th growing season; 2,309½ bu.
No. of trees per acre; 660

Fig. 9
Trellised hedgerow of Golden Delicious trees on M IV stock in their 6th growing season.
Yield per acre in the 6th growing year; 868. 3/4 bu.
Accumulated production per acre - end of 6th year; 1,938 bu.
No. of trees per acre; 660

Fig. 10

Defoliated Golden Delicious trees on M IV stock in their 4th growing season.
Crop; respectively $1\frac{1}{2}$ and 3 bu. for 1st and 2nd trees in the row, counted from the right.

Fig. 11

Trellised hedgerow of Red Delicious (Shotwell) on M IX root in their 9th growing season.
Calculted yield for 9th year; 816 bu. per acre.
Four feet in the rows; 12 feet between the rows.
907 trees per acre.

Fig. 12

Red Delicious (Starking) on M IV stock as a spindle-bush tree in its 6th growing season.
Crop 3. 3/4 bu. loose.
Average individual production this 6th year was 2. 3/4 bu.
Planted at 290 trees per acre; $797\frac{1}{2}$ bu. during the 6th growing season.

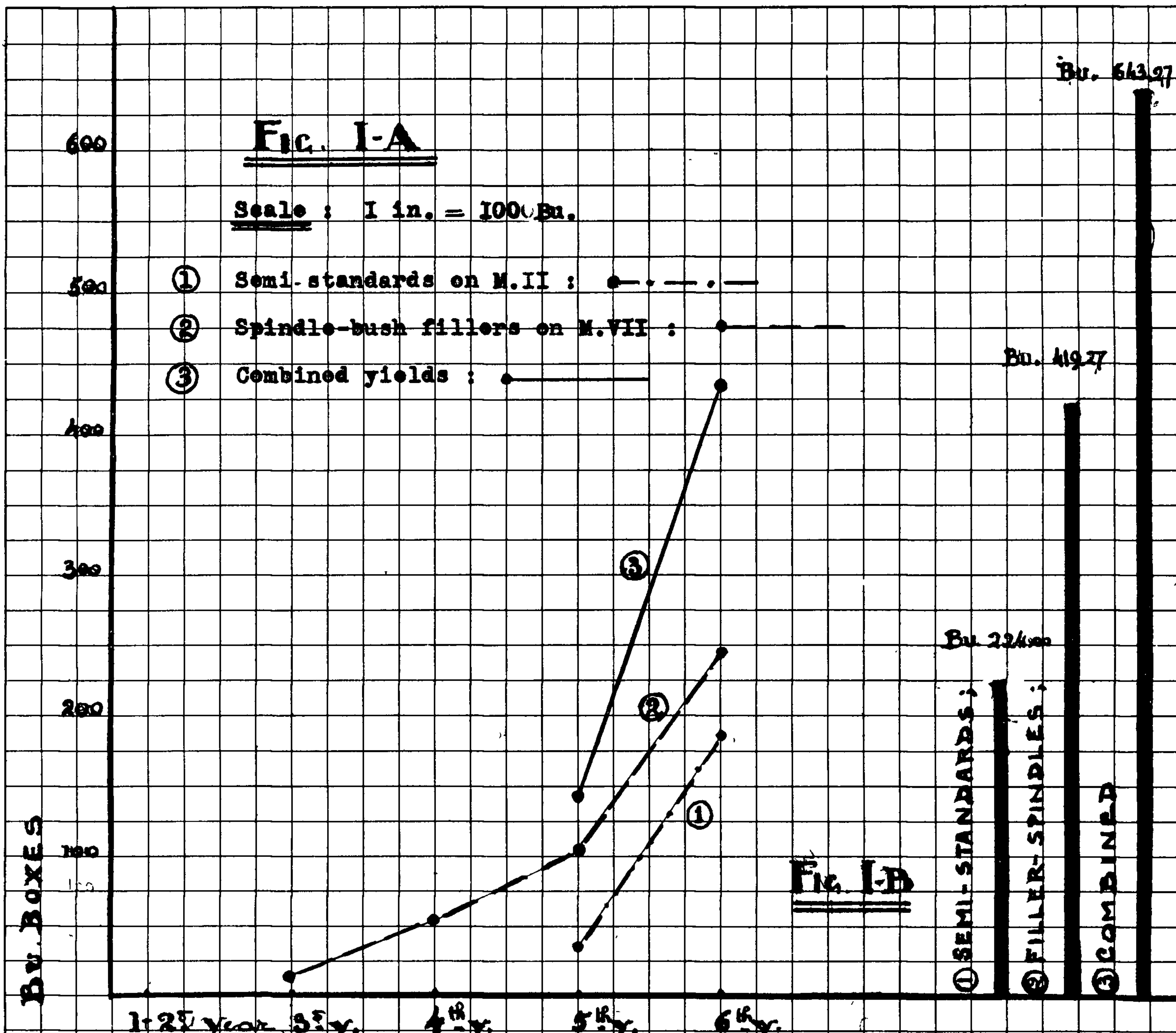

Fig. I_A. Yields in Bu.per acre for the first six growing seasons for Golden Delicious on 1) Semi-standard double-worked bush-trees on M.II rootstock @ 96 trees per acre. 2) spindle-bush filler trees on M.VII,interplanted @ 96 trees per acre. 3) both combined.

B- Accumulated yields in Bu.per acre at the end of the sixth growing season for 1), 2) and 3).

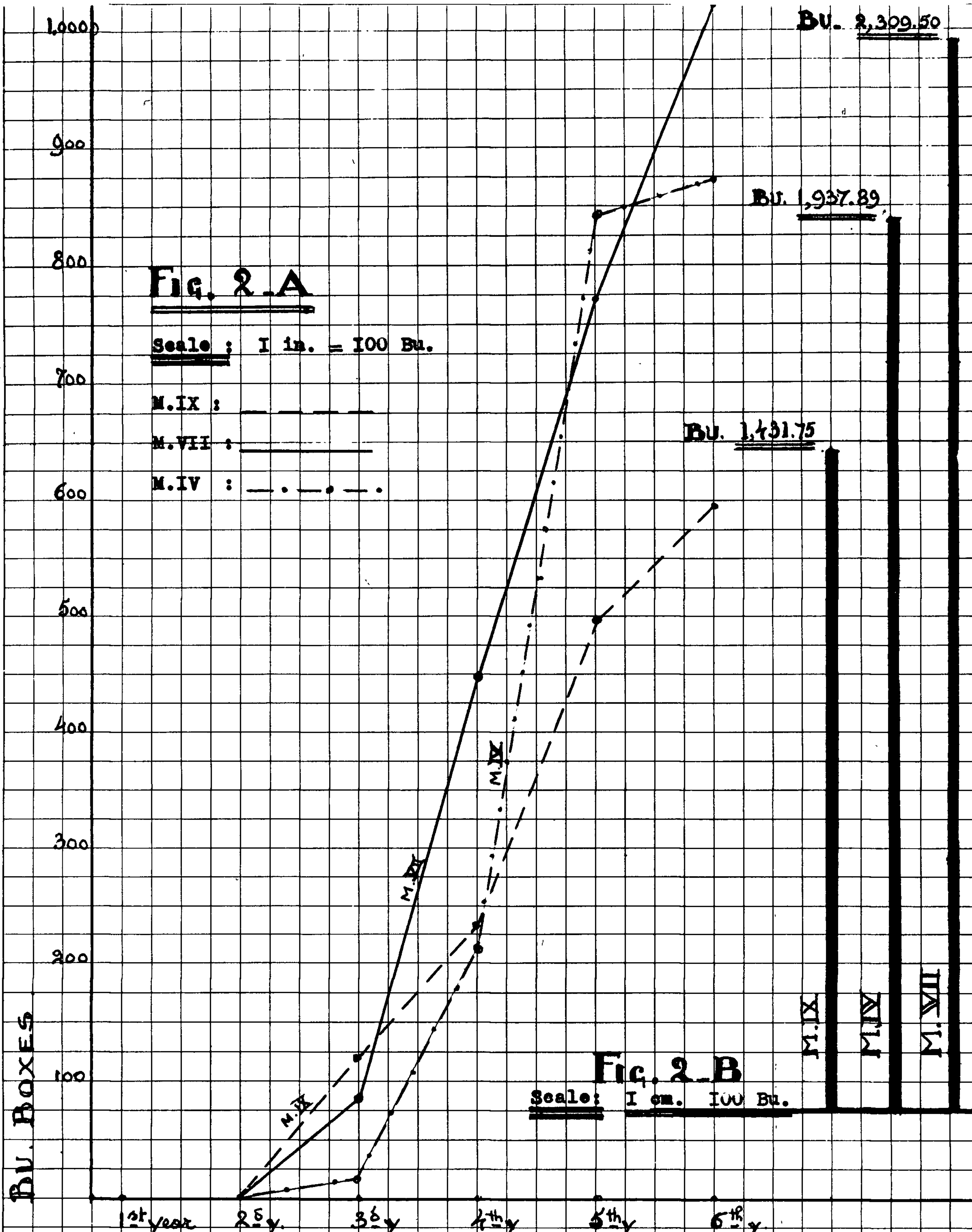

FIG. 2 A Yilds in Bu.per acre for the first six growing seasons, for Golden Delicious, formed as trellised hedgerows of 660 trees per acre, on M.IX, M.VII and M.IV rootstocks.

-B Accumulated yield in Bu.per acre after the sixth growing season for Golden Delicious, formed as trellised hedgerows of 660 trees per acre, on M.IX, M.IV and M.VII rootstocks.

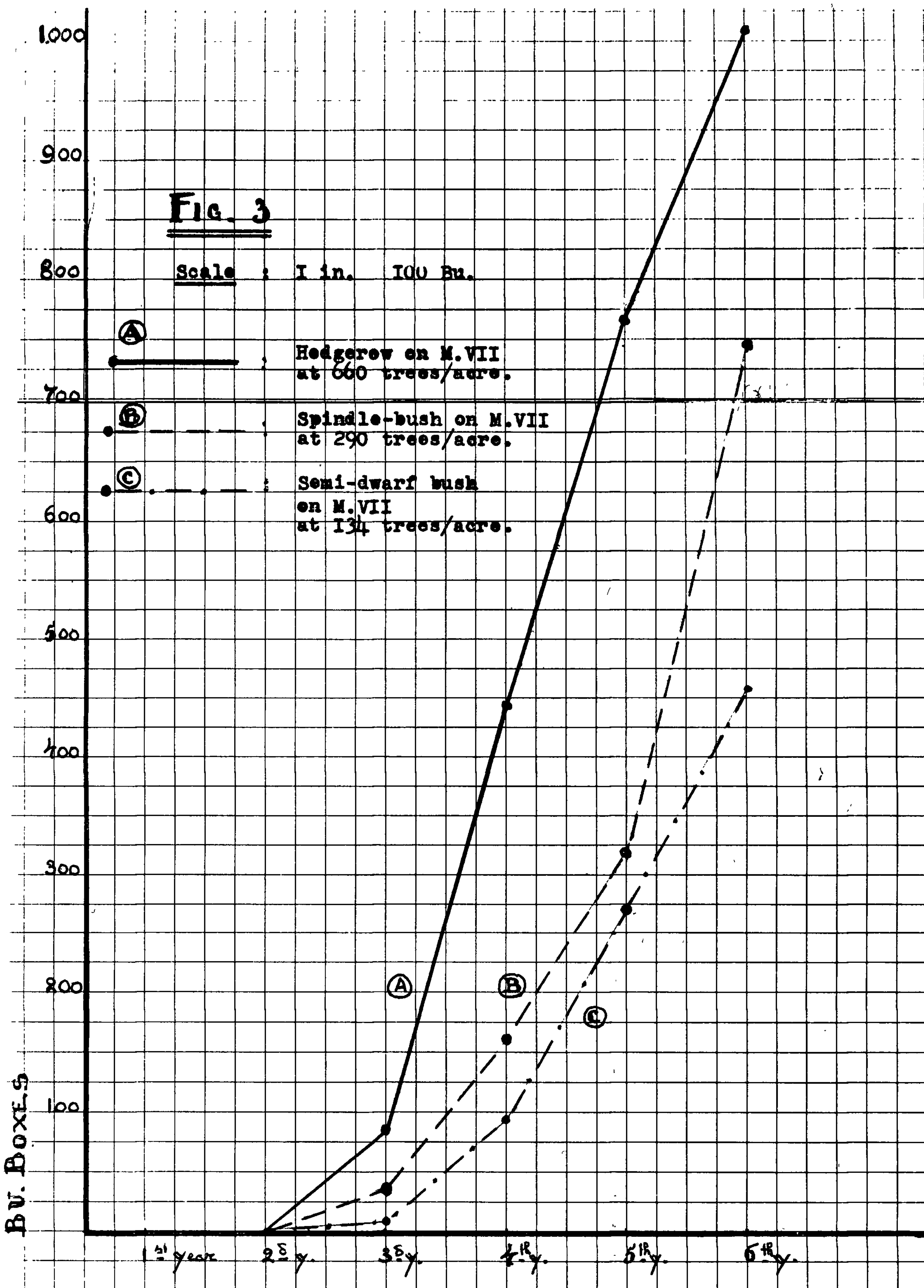

Fig. 3 . Yields in Bu.per acre up to the sixth growing season from Golden Delicious on M.VII related to tree-form (hedgerow, spindle-bush and semi-dwarf bush tree) and planting density (660, 290 and I34 trees/acre).

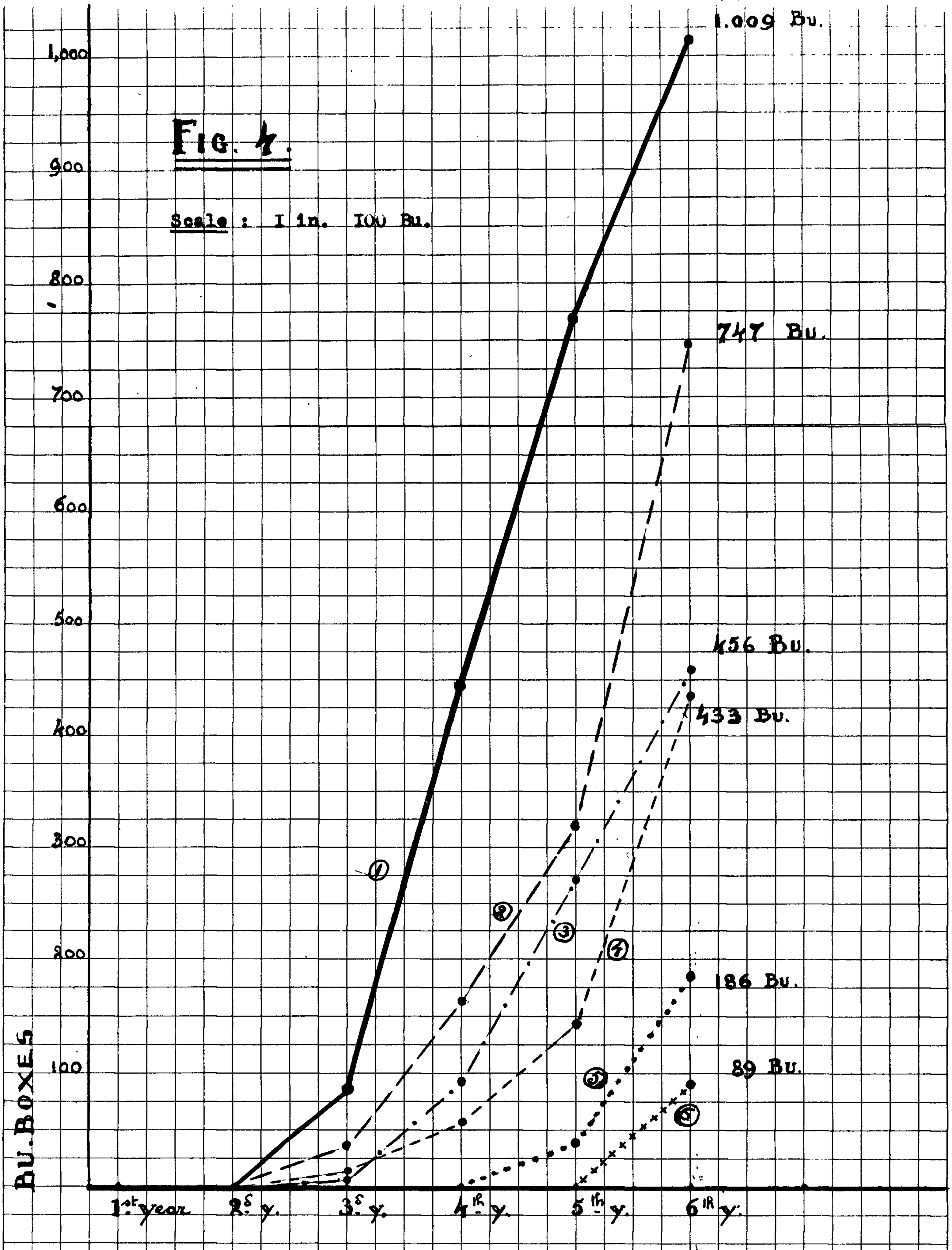

FIG. 4. Yields in loose Bu. boxes per acre for Golden Delicious during the first six growing seasons for :

1. - trellised hedgerows @ 660 trees per acre, on M.VII rootstock;
2. - spindle bush trees @ 290 trees per acre, on M.VII rootstock;
3. - semi-dwarf bush trees @ 134 trees per acre, on M.VII rootstock;
4. - combined semi-standard bush trees @ 96 trees per acre, on M.II rootstock interplanted with spindle-bush filler trees on M.VII root @ 96 trees per acre;
5. - semi-standard bush trees @ 96 trees per acre, on M.II rootstock;
6. - standard bush trees @ 48 trees per acre, on seedling root.

Fig. 5

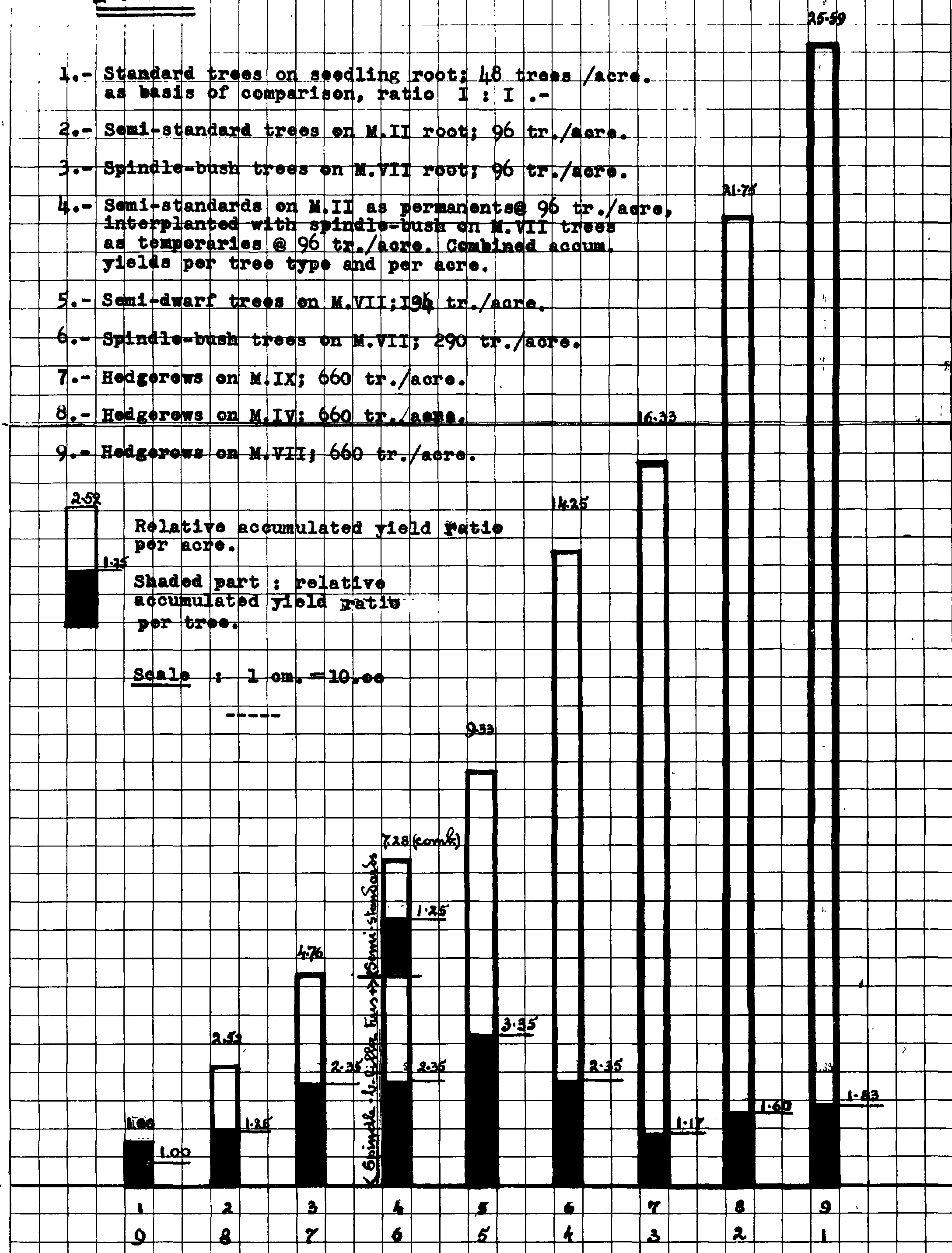

Fig. 5 Relative per tree and per acre accumulated yield ratio at the end of the sixth growing season, for Golden Delicious, trees managed following nine different planting concepts.

Standard trees on seedling root at 48 tr./acre = 1.oo

CHAPTER IV

DISCUSSION

It could be inferred that the earliness of production, as well as the relatively high yields, obtained in these experiments were unduly influenced because of the variety used. Golden Delicious is a naturally early bearing and fertile variety. However, shy and late bearing varieties, as a consequence of varietal behavior, show the same natural tendency regardless of tree form or root-type. Rootstock effect does not alter the genotypical characteristics of the epibiote. Parallel observations in the Doornberg orchards on the Red Delicious (Starking) variety, a late and shy bearing tree, have shown consistently similar trends. They came into bearing a little later than Golden Delicious but the same relative differences were observed between tree form and root-type.

Trellised hedgerows on M IX, M IV and M VII rootstock; 660 trees per acre:

The trellised hedgerow trees planted at high density, regardless of rootstock type, on an acre basis outyielded all other tree forms and combinations of planting at the end of the sixth growing season.

The hedges on M IX had accumulated 1,431.75 bushels per acre in spite of the low per tree average accumulated yield of only 2.17 bushels. This placed them in the third position for yield in the experiment (16.33 greater yield than the standard trees). These trees were also the earliest to come into bearing, yielding 120 boxes per acre by their third year.

It is believed that this lead was not maintained due to the soil inadequacy to support them. Preston (25) suggested that the lighter soils are not suitable for trees on M IX rootstock. They need the 'stronger' soils. It is not the intention here to discount the value of M IX hedgerows as these experiments do not reflect the specific value of this rootstock type. It merely indicates that under the prevailing conditions in the Doornberg orchards and with Golden Delicious as epibiote the M IX type root lacked the necessary strength to allow for sufficient vegetative growth and fruit production at the same time. Under similar conditions in these orchards and on the same M IX rootstock, Red Delicious grew larger and outperformed the Golden Delicious, by the end of the sixth year.

It is pertinent, at this point, to mention that in the irrigated loams of the Columbia Basin at Quincy, Washington, Golden Delicious hedges on M IX rootstock, planted at a density of 605 trees per acre, and following the same directive as in the Doornberg orchards, produced yields of 907 bushels per acre in their third year, 665 bushels per acre in their fourth year and 1,343 bushels per acre in their fifth year. (14)

At the end of the fourth year the trellised hedgerows on M VII took the lead in yield, although the M IV hedges remained ahead of all other combinations for another year. The M VII hedges showed the highest accumulated yield per acre of all groups in the experiment with a total of 2,309.5 bushels at the end of the sixth year, or 25.59 times that of the standard trees.

Hedgerows on M IV rootstock gave a good performance, finishing up, at the end of the sixth year, with the second highest yield in the experiment reaching a total accumulated yield of 1,937.8 bushels per acre or 19 times that of the standard trees.

To illustrate the relative size of the trees on these three different rootstocks, by the end of the sixth year, the trees on M IX covered the first horizontal wire of the trellis. Those on M VII were well established along the first and second wires and were proceeding towards the third wire. While those on M IV had covered the first three wires and were approaching the fourth wire.

Technical handling of the trellised row blocks proved both convenient and economical with two reservations:

1) the hand hoeing in the rows during the first part of the growing period was costly. 2) the eleven foot inter-row spacing proved to be too narrow for the standard orchard equipment; tractor, sprayers, and bulk bins for harvesting.

It is anticipated that mechanical hoeing however, or chemical weeding will soon obviate the necessity of this hand hoeing and by increasing somewhat the width between the rows, from eleven to twelve and a half feet or thirteen feet, the second problem could be overcome. On the other hand, the large equipment for standard orchards with which the Doornberg orchards are equipped, is not necessary for handling a dwarf tree enterprise. For such an operation, smaller and probably cheaper equipment would be adviseable.

The spacing of six feet between trees in the row appeared to be wider than necessary for trees on the M IX rootstock. By reducing this space more trees could have been planted per acre with a corresponding increase in yield. On the other hand, the same six foot spacing appeared to be just right for the trees on M VII rootstock but at least one foot too close for trees on M IV rootstock.

Pruning to date has been done from the ground level, but the trees on M VII and M IV may require the use of a short step ladder, or a mobile low platform in the future years.

Hand thinning of fruit was done easily on the semi-dwarf and dwarf trees as compared with the standard trees and spot picking, difficult and costly with large trees, presented no problem.

Spraying was performed with a maximum of technical efficiency and with a minimum of physical strain or waste of materials.

Because of the trellis wire support, propping was not required during the summer and windfalls were reduced. In the case of a salvage operation there is a minimum of bruising on windfalls due to only a short drop to the ground.

On one occasion the lower branches of the hedgerows at a lower edge of the orchard were slightly affected by frost damage (1959). The closer to the ground level the blossoms, the more they are exposed to damage from radiation frosts in the Spring. Therefore the planting of Dwarf trees should only be recommended in frost free locations.

The cost of establishing such an acre of trellised hedgerows may appear prohibitive at first glance. In the present case, the initial investment cost - materials and labour, excluding the owner's supervision but including the operational deficits of the three first growing seasons, arrived in round figures, close to three thousand dollars.

Such high initial capital investment may deter many from this intensive planting method. Nevertheless it was considered that potential yields, the anticipated high quality of the fruit, the earliness of returns, plus all the other technical advantages derived from the form would justify the initial expenses. The experience gained following the first six growing seasons is encouraging and it could well be that the trellised hedgerows system will prove to be one of the more economical and rewarding of the planting concepts under trial.

The semi-dwarf bush trees on M VII rootstock; 134 trees per acre:

The semi-dwarf bush trees on M VII rootstock yielded 829.8 bushels to the acre as against 2,309.5 for the hedgerows on the same rootstock, although for individual tree performance they were the highest in the experiment. One tree in the sixth year produced a crop of 6 3/4 bushels.

It is possible that by narrowing the distance from 18 to 12 feet in the row, the width of the working row remaining the same, the number of trees could have been increased to a 201 tree density, and, when full grown, the planting would become a close hedgerow orchard. This would have raised the yield to 1246 bushels per acre, without any major inconvenience.

The Spindle-bush tree on M VII rootstock;
290 trees per acre:

The projected yield of the spindle-bush trees planted at a distance of 10 x 15 feet was 1,267 bushels per acre. On the basis of these yields, this planting arrangement came second to that of the hedgerows.

Such a planting is cheaper to establish and to maintain, at least during the earlier years, than a hedgerow. It could be considered as intermediate in intensity between the trellised hedgerow and the bush tree hedgerows. Here, adequate spacing is provided for mechanical operations, including bulk-handling of fruit.

The Semi-standard trees on M II rootstock:
96 trees per acre:

The semi-standard trees on M II rootstock, with hardy intermediate, are those which appear to be finding favour with the Okanagan growers for their new plantings. Up to the end of the sixth year, these trees only bore 224 bushels but this was only their second bearing year. The accumulated yield at the eighth year was 1,008.20 bushels per acre, reaching 1,411.4 bushels by the end of ninth year. This yield still falls below that of the semi-dwarfs and dwarf hedgerows, and only approximates that of the spindle-bush trees on M VII, at the end of their sixth year.

<u>The standard trees on seedling rootstocks;</u>
<u>48 trees per acre</u>:

The standard trees on seedling roots started to bear in their sixth year but only produced a yield of 88.88 bushels per acre. At the end of the eighth year, they had produced and accumulated a yield of 607.99 bushels per acre; at the end of ninth year they had reached a yield of 1,166.21 bushels and by the tenth year approximated the yield of the M II trees in the ninth year, namely - 1,407.98 bushels. Here again the yield, even in the tenth year did not equal that of the semi-dwarf and dwarf trees at the end of their sixth year.

The planting costs of classical standard apple tree orchards following the usual 48 trees per acre pattern are unquestionably the lowest. But if the operational losses accumulated during the deficit years have to be added, being actually an integral part of the initial capital investment as mentioned by Spenger (31), this deficit period for a standard tree orchard can last from eight to twelve years in the Okanagan, depending on the variety. It will readily appear that the initial advantage is going to be considerably diminished.

The permanent semi-standard bush trees on M II rootstock combined with temporary spindle-bush trees on M VII rootstock.

At the end of the sixth growing season the accumulated yields of the semi-standard trees and the semi-dwarf spindle trees, combined was 643.27 bushels per acre. Of this total, only 224 bushels had been produced by the semi-standard trees as against 419 bushels by the semi-dwarf spindles. Judging by the performance of the trees on M VII rootstock, it is felt that they might better have been used as the permanent trees. In any case, eventually a grower would be faced with a difficult decision as to which trees to remove. The data obtained in this experiment indicate that a solid planting of spindles on M VII rootstock would have been a better concept than the combination planting.

CHAPTER V

CONCLUSION

The B.C. Department of Agriculture's most recent survey of the Okanagan orchards (3) shows that it is the semi-standard trees on M II rootstock that are becoming rapidly the most poular in the new plantings at present, and that the more intensive types, although increasing in numbers, do not appear to have been accepted to any great extent to date.

Speculating as to why this is so, the following views are expressed. In the first place, there is a psychological reason. The Okanagan fruitgrowers are used to large trees; to suddenly change to dwarf trees may appear to them as 'too big a jump'. It may seem less disturbing and more reasonable to them to change over, gradually, from the very large standard trees they were used to handling in the traditional manner, to the somewhat smaller semi-standards. Technically, the shape of the M II trees differs little from what they were used to and their large orchard equipment remains usable throughout, without serious alterations. Financially, the advances required for rejuvenating their orchards appears as a much lesser burden than with the rather costly intensive high-density plantings. Semi-standards on M II are known as reliable trees and may well remain for some time a sound economical proposition, particularly where orchard units are of fair size, meaning by this - at least 15 acres, under present production conjuncture. In itself, the change from the large standard tree on seedling roots to a semi-standard tree on clonal root-stock can be interpreted as a first step towards more intensification and as the beginning of a trend toward the smaller tree, which trend could continue to the point where the semi-dwarf or even the dwarf tree forms may eventually shape the orchards of the future.

The evidence, as a result of the experiments carried over the last twelve year period in the 'Doornberg Orchards', has shown that optimum results were obtained from the more intensive planting concepts, i.e. the semi-dwarf hedgerow planting on M VII, the spindle-bush, and above all by the trellised hedgerow on M VII or M IV.

If, as stated by Mac Phee (20), it is desirable for the fruitgrower to get his orchard into full production as early as possible and within ten years, the experiments show also that the most feasible method of effecting this is by the use of dwarf or semi-dwarf type trees.

Hence it appears that intensive planting concepts, with all the flexibility they offer, could be of major interest, particularly for the Okanagan where the smaller acreages are in the majority[1]. To manage small orchard

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[1]It is stated in the Report of the Royal Commission on the Fruit Industry in B.C. (20) that 70% of the Okanagan Valley orchards are 10 acres or less in area.

units - ten acres or less - by extensive cultural practices does not allow for maximum labour productivity. Economically this means only part capacity efficiency, with as a result only incomplete earnings for the operator and all it socially implies, not only for the living standard of the fruitgrower and his family but to the whole economy of the valley.

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