A STUDY OF THE INFLUENCE OF SPACING WITHIN ROWS AND SEED TUBER SIZE UPON THE YIELD OF THE POTATO CROP

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C H A P T E R I

I N T R O D U C T I O N

I. INTRODUCTION

The potato is one of the main food crops grown in New Zealand, and has been established since the time of European settlement. In the early years production was concerned mainly with meeting the demands of the growing population. This resulted in a rapid and steady increase in the total acreage grown. However, in the last decade, increase has been gained largely through intensification of crop areas rather than their extensification. Consequently, a diminishing increase in acreage grown has resulted. The above pattern is clearly illustrated in the following figures (extracted from Farm Production Statistics of New Zealand 1963 - 1964);

Year	Acreage	Total Yield (ton)	Yield (ton/acr.)
1955-56	17.665	100.677	5.70
1960-61	22.334	190.438	8.53
1964-65	25.969	243.000*	9.36

Marked increases in productivity have been brought about by improvements in general crop husbandry and an increase in production efficiency. Notable progress has been made as a result of:

(1) The introduction of new varieties with high yielding capacity and resistance to certain disease;

(2) The establishment of the National Seed Certification Scheme;

(3) Better knowledge in the use of fertilizers;

(4) Specialisation of suitable areas in potato production;

(5) The use of modern technology and methods in general crop management.

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* estimated figure at the end of 1964.

In spite of these approaches there remains much to be studied. Mundy (1966) emphasised that because of rising costs in potato production, crops of at least 10 tons per acre will have to be grown if the venture is to be profitable. Undoubtedly there is a need for more intensive research on improving methods of growing potatoes.

One aspect which has a major influence on plant population is seed spacing and seed size. The project reported herein was designed to study the effect of different levels of spacing and seed size, together with their interactions, on terminal yield of potato crops.

In view of the need to study other important factors influencing yield, the investigation was extended to include the effects of seed spacing and size on growth and development of the crops.

C H A P T E R   II

R E V I E W   O F   L I T E R A T U R E

2.1. THE EFFECT OF SPACING AND SEED SIZE ON YIELD OF POTATO CROP

2.1.1. Spacing

2.1.1.1. The Effect of Spacing on Total Yield

An important aspect of plant population studies is the spacing distance between plants. Bates (1935), Singh (1952), and Toosey (1958) have suggested that each sprout on the seed tuber ultimately separates from the mother tuber and may therefore be considered as an independent plant. The stem number per unit area was considered by Reetsman & de Witt (1959) as a measure of plant population. Later, Holliday (1960) defined total population as the product of the mean number of sprouts per set and the number of sets per unit area.

Bates (1935) carried out a combination of within-row spacing and seed size trials over two seasons using two varieties: Eclipse and King Edward. The spacing ranged from 12 - 15 inches between sets and 28 inches between rows. Although the results were not statistically significant, he showed that there were differences in yield in favour of the closer spacing. Further study of this aspect was carried out by Findlay & Sykes (1938) in two seasons, which led to the conclusion that within the limits of the distance adopted (12 to 21 inches), wide spacing reduced the total yield. Singh & Wakankar (1943), with spacing treatments 6, 9, and 12 inches between seed sets supported the above results, except that between 6 and 9 inches there was no significant difference in yield. The disadvantage of planting sets wider than 12 inches apart was further emphasised by Ivins &

Montague (1955). Chandra's (1961) trial showed that total and ware yields were higher at 6 inch spacing than at 8 or 10 inches.

Singh (1952) in two contrasting seasons (a normal season and a season of summer drought) found that the total yield of King Edward spaced at 8, 12, and 16 inches increased with closer spacing in the normal season, but did not differ significantly in the drier season. Roer (1955) suggested that the yield per plant increased with wider distance, but close spacing was more favourable under good growing conditions. Taha (1961) over two seasons, using spacings of 12, 18, and 24 inches emphasised that the effect of spacing on total yield is dependent on the growing conditions and length of season. Thus, the advantage in yield per plant from the wider spacing does not compensate for fewer plants, so that the advantage in yield per unit area is with closer spacing. Bremner <u>et al</u> (1961) agreed with the above result and suggested that although the total yield per unit area increased as spacing distance decreased, a lower total yield per plant resulted, at the close spacing, mainly due to differences in bulking rate.

The effect of row spacing on the growth and development of the potato had also been studied by Singh (1952), who measured the height and dry matter content of plants spaced at 8, 16, and 24 inches. He found that in the early stages, height decreased with increase in planting distance, and dry matter per plant increased as the spacing widened. As the season advanced, the widely spaced plants made up height and produced more leaves. The advantage in dry matter per plant was such as to equal the dry matter production of closely spaced plants on an equal area basis. Taha (1961) and Bremner & Taha (1966) concluded that wi' spacing produced a higher total dryweight than the close spacing, but the proportion of dry matter entering the tubers appeared to increase with decrease in spacing distance.

With regard to the spacing distance between rows Davidson (1925), quoted by Taha (1961), studied rows 24, 26, 28 and 30 inches apart, and found that the average yield decreased slightly from 24 to 30 inch rows. A trial carried at Staten Forsogsvirksomhed Denmark (1958) over 4 years, suggested that greater distances between rows than the normal 63 cm.* could be used without entailing much yield reduction. Svensson (1961) with twelve trials over two seasons studied the effect of distance between rows (60, 70 and 80 cms.) on three varieties, and concluded that distance between the rows had a great influence on the yield. Yield increased at the closer row spacing.

The influence of irregular planting distance on the yield of the potato crop has also been studied by many workers. Among them was Davies (1955) who used mean spacings of 6, 14, 22 or 30 inches and with irregularity for each mean spacing varied from 0 to 100%. He found that irregularity had little effect on the total yield except at the wide spacing. Similar results were found by Haugdal (1958). El Saeed (1963) with two years experiments showed that there was no significant effect of irregular spacing on total yield except for an apparent depression in yield caused by irregularity in spacing at the high seed rate in 1961 when the crops were badly damaged by frost.

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* 1 inch = 2.54 cms.

2.1.1.2. The Effect of Spacing on Tuber Size and Tuber Number

In normal agricultural practice, yield is usually divided into table, seed, and small potato.

Bates (1935) found that the ware (table potato) yield over a $1\frac{5}{8}$ inch riddle was similar from sets spaced 21, 18, 15 and 12 inches, but the yield over $2\frac{1}{4}$ inch was reduced as the spacing decreased. When the yield of ware was expressed as a percentage of the total yield, however, it showed a decline with decreased spacing. The above conclusion was supported by Findlay & Sykes (1938) with the further point that wide spacing increased the average weight of individual tubers and the number of tubers per set. Singh (1952) and Jessup (1958) similarly found an increased tuber size and number with increased spacing. Tinley & Bryant (1939) in a trial with Great Scot and King Edward varieties, found that 12 inch plantings, produced a larger total yield of ware and seed than any other planting distance. However, Taha (1961) found that during a wet season (1960) the spacing effect on tuber size and number was not significant. But during the dry season (1959) although there was no significant difference between the ware yield at 18 and 24 inch spacings, both were significantly higher than at the 12 inch spacing. Svensson (1962) with 15, 30, and 55 cm. spacings, found that tuber yield and size increased as the space between plants increased. El Saeed (1963) found that irregularity in spacing had no effect on ware yield and tuber number.

2.1.2. Seed Size

2.1.2.1. The Effect of Seed Size on Total Yield

Seed tuber is usually measured by weight although some investigators use diameter of the tuber. In New Zealand seed sizes of 2, 3, and 4 ozs. are available for normal agricultural practice (Hadfield et al, 1952).

Salaman (1922) was one of the earlier workers who investigated the effect of seed tuber size on the yield of the potato crop. He carried out experiments on the variety, Barley Bounty, using seed sizes varying from 0.6 to 5.33 ozs., and found that the total yield varied directly with the weight of the tubers planted. Bates (1935) using average seed weights of 1, 1.5, and 2.5 ozs., (King Edward) found that the yield increased with seed size. Many experiments which followed (Findlay & Sykes, 1938; Tinley & Bryant, 1939; Singh, 1952; Diaz de Mendivil, et al, 1953; Roer, 1955; Elbe, 1957; Antchev, 1959; Taha, 1961; Suri, 1963) have confirmed that with constant spacing total yield increased with large seed.

That plant growth from large seed is more vigorous than that from small seed has been emphasised by many workers. Singh (1952) determined dry matter, number of leaves, and height; and Taha (1961) studied leaf area and axillary branches from different seed sizes. Both found that large seed had an advantage with regard to all these attributes during the early stages of growth, but the differences lessened as the season progressed. Emergence from large seed is earlier than from small seed as was emphasised by Singh (1952), Roer, (1955), Ivins & Montague (1955). Elbe-

(1957), Toosey (1959), Bremner et al (1961), and El Saeed (1963).

The greater vigour of plants from large seed has been explained on the basis that large seed has more reserves, greater initial meristematic capital, and higher relative growth rate (Bremner & El Saeed, 1963). Denny (1929) using seed of 28 grams, examined the dependence of shoots on the mother tuber by amputating them at different stages of plant growth. He concluded that the potato plant was dependent on the mother tuber from sprouting, emergence and up to the stage when the leaves of young plants about 2" in height were fully expanded. Thereafter it became independent of the mother tuber.

The number of sprouts developing on a seed tuber has been shown to vary with the size. Bates (1935) counted the sprouts developing from King Edward seed weighing 1, 1.5 and 2.5 ozs. The mean number of sprouts developed by these tubers were 2.82, 3.37, and 4.55 respectively. Other workers (Singh, 1952; Roer, 1955; Toosey, 1959; Reetsman & de Witt, 1959) have reported similar results. Toosey (1959) with varieties, King Edward and Stormont 480, found that the number of sprouts per set increased in proportion to the weight of seed.

2.1.2.2 The Effect of Seed Size on Tuber Size and Number

Salaman (1922) suggested that large sets tend to produce a heavier yield than small sets, but that the crop produced by small sets is made up of larger tubers. Bates (1935), Finlay & Sykes (1938) and Tinley & Bryant (1939) found that the yields of ware (greater than $1\frac{5}{8}$") and of seed ($1\frac{1}{4}$ - $1\frac{5}{8}$") were high from large tubers. Bremner <u>et al</u> (1961) concluded that a greater proportion of the production from small seed fell into the ware category. They suggested that within the range of seed rates normally used for ware production, small seed would have a greater advantage in ware and total yield over large seed, at the same seed rate. This is in variance to the results of Taha (1961) who found that in 1960 (a normal season) the large seed was significantly superior to the small seed, but in 1959 (a dry season) the difference between seed sizes was not significant.

A great deal of evidence indicates that tuber number increases with increasing seed size (Bates, 1935; Findlay & Sykes, 1938; Ivins & Montague, 1955; McCubbin, 1955; Taha, 1961; El Saeed, 1963).

The effect of stem number on yield and size of tubers has been studied by Toosey (1958, 1959). He found that the number of tubers increases in proportion to the number of sprouts per set with a consequent reduction in the individual size of tubers. Roer (1955) showed an interaction between variety and seed size, and indicated that a variety with a very low number of stems and of tubers (Arran Consul) reacted more favourably to an increase in seed size than one with more normal tuber and stem development (Kerrs Pink). Birecki & Roztropowicz (1963) suggested that larger seed tubers provide a larger number of eyes and therefore produce more stems. Consequently a greater foliage area is produced and this in turn, results in a higher yield. Kapoor (1954) and Haugdal (1957), attributed this higher yield to a greater number of tubers produced despite the fact that the proportion of large tubers in the yield decreases. El Saeed (1963), later explained that this was due to increasing intensity of inter-tuber competition.

2.1.3. Seed Rate

Spacing and seed size are the components of seed rate. The former determined the proximity of plants to each other, and the latter is one factor governing size of plants (El Saeed, 1963). Boyd & Lessels (1954) attempted to treat the problem of assessing seed rate (the net weight of seed planted per acre), as distinct from the specific effects of spacing and seed size. The results of a survey of main potato-growing areas in England and Wales, Boyd & Lessels (loc.cit.), suggest that: "provided the optimum seed rate is attained, then the precise combination of seed size and spacing distance appears to be of minor importance." This implies, that, within fairly wide limits, the differences in yield (total and ware) from various seed size and spacing combinations at the same seed rate, are practically negligible. At lower seed rates small seed is superior, on the other hand, at higher seed rate large seed is desirable. Holliday (1960) and Taha (1961) consider this superiority of small seed at low and moderate seed rates to be due to more even shoot distribution.

Holliday (1960) suggested that the number of developing tubers is closely related to the number of shoots. Shoot numbers are to a greater extent increased by closer spacing rather than by increasing size of seed. This conclusion seems to be in agreement with Reetsman & de Witt (1959). Bremner et al (1961) found that shoot number per unit area is a better basis for expression of plant population than seed weight per unit area, being largely, though not wholly, independent of seed size. Further more, Reetsman & de Witt (loc.cit.) suggested that since a linear relationship exists between the number of shoots and the total surface area of tubers, it should be used to express seed rate rather than the total weight planted per unit area.

Boyd & Lessells (1954) related seed rate to yield with the following regression equation:

$$Ys = Yo + b_1 (\log S_1 - \log So)$$

where S = Seed rate in tons per acre, Ys = total yield in tons per acre at seed rate S_1, Yo = total yield in tons per acre at a standard seed rate So, b_1 = a constant. Using this equation, by varying either seed size or spacing, the difference in result was too small to be of much practical significance within the normal range of seed rates used. Holliday (1960) confirmed the above result.

2.2. GROWTH AND DEVELOPMENT

2.2.1. The Leaf Area

2.2.1.1. Leaf Area Measurement

Several direct methods for measuring leaf area of potato plants have been used. Bald (1943), developed a series of standards of known leaf area for estimating the area of individual potato leaves. Broadbent *et al* (1957) estimated total leaf area of potato plants from determination of leaf area of a small number of leaves per plant. Procedures involving use of a photoelectric cell were carried out by Maggs (1956) and a modified technique was developed by Voisey & Kloek (1964). An air flow planimeter was used by Jenkins (1959). Recently a rapid method for determining leaf area of potato plants by measuring the width and the length of the leaf blade was introduced by Epstein & Robinson (1965).

However, indirect methods have been widely used in dealing with large numbers of plants.

A "Punch method" was first developed by Watson & Watson (1953) for measuring leaf area of sugar beet. The original method involved by pressing a punch (a steel pipe) of known diameter (1¼ inch) through a layer of leaves, the area of which are measured. From this the leaf area of the sample is estimated simply by area/fresh weight ratio multiply by the total fresh weight of lamina. This technique, however, was modified by Taha (1961) where a punch of 2.27 cms. cross-sectional area was used for measuring leaf area in the potato plant.

2.2.1.2. <u>Leaf Area and Leaf Area Index</u>

Although several parts of the plant may be involved in photosynthesis and contribute substantially to dry matter accumulation, the leaf is by far the major organ concerned with this process. Gregory (1921) has emphasised that the total dry weight of a plant, excluding reserves of material in the seed, results almost entirely from the assimilatory activity of the leaf surface. Hence the development of the leaf surface must, to a large extent, determine the rate of increase in dryweight of a plant.

The development of the leaf surface depends on factors controlling leaf growth. Studies on the influence of light, (Gregory, 1921 and Watson, 1947) found that the relative leaf growth rate increased with increasing light intensity and duration. Temperature also influences the leaf development. Gregory (1928, 1956), Milthorpe (1956, 1959), and Blackman (1956) have suggested that the rate of leaf production increased with temperature up to an optimum, and remains constant thereafter. Leaf area is also greatly dependent on nutrition and water level. Nitrogenous and phosphate fertiliser were found to increase leaf area per plant, while potassium had little effect on leaf area of various crops studied by Watson (1952, 1963). Although different crops react differently to restriction of water supply, in general, drought reduces the leaf area as reported by Milthorpe (1945) and Watson (1952).

Superiority in leaf area of one plant or species over another must be the result of superiority of one or both of the components of leaf growth, i.e., leaf size and leaf number. In experiments with wheat, barley, sugar beet and potatoes, Watson (1947, 1952) showed that variation in leaf size was a more important cause of differences in leaf area per plant than variation in leaf number. This was supported by Radley (1963) where the late sown potato variety Ulster Torch, gave greater leaf size and therefore ultimately higher maximum leaf area indices. Taha (1961) however, studied two varieties of potatoes, and found that varying leaf numbers were responsible for leaf area index differences.

Bald (1943. 1946) suggested that if emergence date was the same, various potato varieties would grow at the same rate in the early stages of development. Differences in the rate of expansion of leaf area would appear at a later stage when the leaf area of late varieties continued to increase after the onset of flowering. Total leaf area of late varieties will therefore be greater in the end than that of the early varieties. Also, greater total leaf area may be contributed by a higher production of axillary branches (Taha, 1961).

As agricultural yield is usually measured in terms of weight of crop per unit area of land, leaf area per plant has a limited value. Watson (1947) first suggested that the leaf area per unit area of land (leaf area index - L.A.I) was a measure of leaf area which more closely related to the usual expression of agricultural yield. The L.A.I. depends on the leaf area per plant and the plant population. Watson (1952) concluded from a study of a large number of field crops that the L.A.I. of most crops rises slowly from zero to a peak and then starts to decline with senescence of leaves. In some crops the decline is slower than in others. In cereals, the beginning of a slow decline is marked by the onset of flowering, whereas in potato the onset of blight frequently results in a steep decline of the L.A.I. The L.A.I. is also influenced by plant population, seed size, and nutrient status as shown by Watson (1947, 1963) and Harper (1963). The peak L.A.I. varies between species (Watson, 1952; Donald, 1963), and between spacing and seed size treatments (Taha, 1961, and El Saeed, 1963).

2.2.2. Net Assimilation Rate (N.A.R.)

Net assimilation rate is a measure of the efficiency of the photosynthetic tissues and may be defined as the rate of increase of dry matter per unit area of assimilating material. This concept was first introduced by Gregory (1917), (quoted by Taha, 1961).

Different measures of assimilating material have been used in the past, such as leaf weight, leaf protein and leaf area. In view of the fact that the leaf is the main organ concerned with photosynthesis, Watson (1947, 1952, 1958) and William (1946) suggested that leaf area is a more logical basis for the estimation of N.A.R. Milthorpe (1963) has critically reviewed this concept and suggested:

$$\text{N.A.R.} = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{\ln L_2 - \ln L_1}{L_2 - L_1}$$

where $W_2 - W_1$ = dryweight change, $L_2 - L_1$ = change in leaf area at time $t_2 - t_1$, is the usual expression by which N.A.R. is calculated.

Net assimilation rate varies with environmental factors such as light, temperature, nutrients, and water supply, age, and variety.

Blackman et al (1948, 1951) showed a linear relationship between logarithm of light intensity and N.A.R. of many plants. The relationship of N.A.R. to temperature varied with the species, not only in magnitude but also in sign (Watson, 1947). A positive relationship between N.A.R. and maximum day temperature exists in potato, but in sugar beet it is negative. The effect of nutrients on N.A.R. was summarised by Watson (1963). N.A.R. increased with an increased nutrient supply at low rates, but became independent of nutrient supply at higher rates. Similarly, Watson (1952) found drought temporarily reduced N.A.R. but had no cumulative effects.

However, early assumptions that the N.A.R. is mainly dependent on external factors and remains independent of internal ones at least during vegetative growth (Gregory, 1926; Heath & Gregory, 1938; Watson, 1952) were refuted by Milthorpe (1963). Based on the results from many workers, he suggested that in a constant environment the N.A.R.'s of sugar beet, barley, and cucumber, fall with age. This change with age arose in part from an increasing proportion of respiring to photosynthetic tissue, from the decreasing capacity for photosynthesis per unit leaf area and from shading of the less efficient lower leaves by the upper leaves. In the case of a potato crop, Milthorpe (loc.cit.) found that there was a seasonal variation in the N.A.R. High rates soon after emergence and subsequent decreases were associated with transfer of materials from the seed and with decreasing rates of photosynthesis per unit of leaf surface as the number of leaves increased and reach maturity. Then an increase in N.A.R. occurs towards the end of the season, when a high proportion of photosynthate is transferred to the tubers rather than used in production of new leaves.

There is evidence that both varietal and specific differences exist in N.A.R. as suggested by Watson (1947) and Blackman et al (1951).

With regard to the potato crop, Taha (1961) and Bremner & Taha (1966) found that N.A.R. did not show any consistent differences as a result of spacing and seed size treatments.

Watson (1952) emphasised that in the determination of N.A.R. in field crops there were inherent limitations and sources of error. The dry matter of the plant does not result purely from photosynthesis but includes mineral substances absorbed from the soil. There is also the difficulty of complete recovery of the root system.

2.2.3. Relation to Leaf Area and Net Assimilation Rate to Yield

Heath & Gregory (1938) hypothesised that "mean N.A.R. during the vegetative phase is constant for a wide range of species and environments." Its implication is that, since dry matter increase is determined by N.A.R. and leaf area, differences in dry matter accumulation must, therefore, arise mainly from variation in leaf area. Although this hypothesis has been refuted by many workers, notably Watson (1947) and Blackman et al (1951), later evidence of an increase in dry matter yield associated with an increase in mean leaf area was found by Watson (1952). Thus, Watson subsequently agreed with the general conclusion of Heath & Gregory.

Although leaf area may determine the total production of dry matter, the relationship between leaf area and rate of tuber bulking has attracted much attention to its importance in determining the tuber yield. Taylor (1955) reported that low yield in early potato varieties associated with early bulking and small leaf area. But in late varieties, tuber formation is delayed while a rapid growth of axillary shoots give large total leaf area for assimilation. This results in a higher total yield of tubers. Radley et al (1961) appeared to be in agreement with the above relationships between the two parameters, in so far as higher bulking-rates are associated with greater leaf area. But in the same paper they suggested that: "the bulking rate of tubers in the potato crop is, within fairly wide limits, independent of leaf area."

Any assessment of the relative importance of leaf area and N.A.R. as determinants of the difference in dry matter yield between species should take account of the leaf area duration, i.e., a measure of its ability to produce and maintain leaf area on unit area of land throughout a plant's life, and hence of its whole opportunity for assimilation (Watson, 1952). Watson (1947) found that mean yields of dry matter for wheat, barley, sugarbeet, and the potato were approximately proportional to mean leaf duration. However, Bremner & Taha (1966) conclude from results using two varieties of potato that yield is a function of the length of time for which an adequate leaf cover is maintained, rather than of the absolute leaf area duration.

2.2.4. Development of Potato Tubers.

Taha (1961) suggested that the main features of tuber growth which determine the final yield are: "the time from emergence to tuber initiation, the number of tubers initiated and the length of time over which initiation occurs; the rate of increase in weight of tubers; and the duration of the period of tuber growth."

Mechanisms which bring about tuber initiation, are still under study. Schreven (1956) has suggested that tuber initiation depends on the C/N ratio, and that it is encouraged whenever there is a surplus of carbohydrate, due to such factors as low temperature or low nitrogen supply. Borah & Milthorpe (1959) and Headford (1962) support this hypothesis in that high concentrations of carbohydrate in the stolon tip stimulates tuber initiation. Chapman (1958), Gregory (1956), and Okazawa & Chapman (1962), however, believed that tuber initiation is caused by some specific tuber-forming hormone which is produced under short day conditions. Slater (1963) reported that changes in both quantity and proportion of substrate, and growth substance at the stolon tip are likely to be involved in the formation of tubers, but at present the nature of these changes remains unknown. Later, Madec (1963) proposed a term "tuberization hormone" which stimulates tuber initiation, but its nature is unknown. This hormonal action is supported by many workers who believe that the active constituent is synthesised in the leaves. But Madec & Perenec (1959) found that tuberization may occur before the emergence of the foliage, in which case the mother tuber alone seems responsible. This evidence suggests that tuberization is induced by both the leaves and the mother tuber.

The time of tuber initiation appears to be dependent on the physiological age of the mother tuber. The greater the physiological age of the seed tuber and the sprout length at the time of planting, the earlier tuber initiation takes place(Schreven, 1956; Madec & Perenec, 1959; Toosey, 1963).

Initial development of tubers is generally completed within two or three weeks (Krijth, 1955). Then enlargement is primarily dependent on available carbohydrates (Madec, 1963). Thereafter, tubers continue to grow as long as induction is sustained (Plaisted, 1957). The differentiation of tubers into various size groups is mainly due to the difference in partition of metabolites between physiologically active growing tubers. Krijth (1955) and Taha (1961) suggested that differences in tuber size may be attributed to unequal rates of growth rather than the differences in age of the tubers. Edelman (1963), however, proposed a "push" hypothesis for the inflow of assimilates into the tubers.

With regard to the increase in weight of tubers with time, Borah & Milthorpe (1959) showed three distinct phases "(1) a period of about 10 - 14 days after tuber initiation, when tuber weight increased exponentially with time; (2) a long period of 6 to 8 weeks when it increased linearly with time; and (3) a final phase of decreasing growth rate associated with senescence of leaves. The slope of the line during the linear phase giving the rate of increase in tuber fresh weight per plant per unit time, is generally referred to as the "bulking rate." The apparent time of tuber initiation is given by extrapolation of the line to the time when the weight was zero. The occurrence of a linear phase of growth was also reported by Taylor (1953) and a sigmoid curve of tuber bulking was suggested by Ivins & Bremner (1965). During this growth period, Taha (1961) found that unfavourable growing conditions or artificial defoliation can cause a departure from linearity. Radley (1963) calculated a linear regression, and showed that differences between varieties in the duration of the linear phase largely accounted for the differences in yield. This has been supported by Bremner & Taha (1966).

Factors influencing the rate of tuber increase, have been summarised by Taha (1961) : "Most of the evidence points to the fact that the total yield of tubers depends on the maintenance of a large leaf surface for a long period." Therefore, the limiting factor in tuber growth may be the quantity of photosynthetic material formed. Taylor (1953, 1955) found that some varieties produce a larger haulm, which provides a larger area for assimilation and consequently results in a higher yield of tubers. This finding is not supported by Radley (1963), who suggested that leaf persistence was responsible for major differences in final yield.

Differences between varieties with regard to the balance of foliage and tuber growrh were reported by Ivins & Bremner (1965). These were due mainly to differences in duration of dormancy, which in turn, affected the time of plant emergence and the balance of growth. They concluded that these factors together with differences in the time of tuber initiation, were mainly responsible for varietal differences in yield.

CHAPTER III

METHODS AND MATERIALS

3.1. GENERAL

The trial involving spacing and seed size experiments was undertaken in the 1965/66 season. The area of 18,400 sq.ft. was selected for uniformity of grade and soil type and was located in paddock No. 5, Massey University No. 1 Dairy Unit. The soil is Karapoti Silt Loam classified as "recent soil," formed on the third low terrace of the Manawatu River. It has the outstanding feature of being well supplied with humus, and a free draining fine sandy loam sub-soil, Pollok (1966). For many years this area has been under intensive dairy farming. The record of farm practice is given in Appendix I. The programme of soil preparation for the trial crops is shown in Appendix II.

Weather conditions during the growing period were obtained daily from the Plant Physiology Division, D.S.I.R., which is situated approximately fifty yards from the trial area. The meteorological record on a weekly basis is given in Appendix III.

Throughout the growing period the crops were under regular observation. Weed and disease control were undertaken in an appropriate manner as the need arose. The detailed management between planting and harvesting is given in Appendix IV.

3.2. EXPERIMENTAL DESIGN

The field study was divided into two experiments - viz; Experiment-I, terminal yield, and Experiment-II, successional lifting. Lay-out of the area is given in Fig. 1.

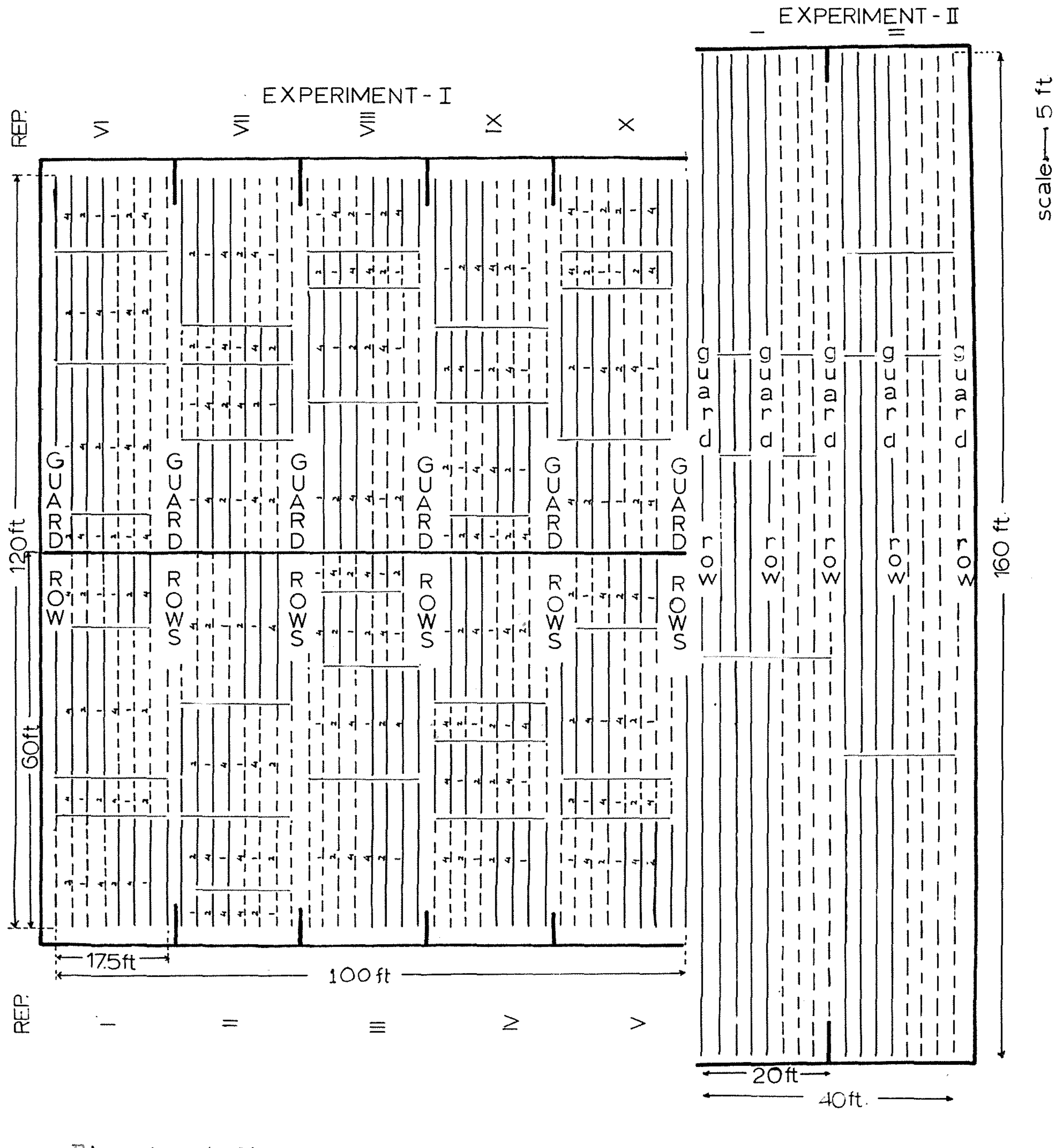


Fig. 1. A diagram of the lay-out of the whole experimental area. Experimeht-I and Experiment-II.

3.2.1. Experiment-I, Terminal Yield

This experiment formed the main section of the field trial. Its objective was to study the effect of four row spacings, three seed sizes and two varieties, and their interaction on tuber yield of the mature potato crop.

It was laid out in ten replicates of a randomised split-split-plot design. Each replicate an area of 1,050 sq.ft. was divided into four plots of spacing treatments of 6", 12", 18" and 24". Within each plot there were two sub-plots of variety treatments (Ilam Hardy and Rua) and each of these sub-plots was split into three sub-sub-plots of seed size treatments, using 1, 2, and 4 oz seed. The above description is illustrated in Fig. 2. In each replicate there were eight 60 foot rows, the outer two of which served as guard rows.

3.2.2. Experiment-II, Successional Lifting.

This was the second section of the field trial. Its objective was to study the effect of the various treatment combinations on the aspects of crop growth; in particular the leaf-area, dryweight change, tuber fresh weight, stems and tuber numbers per plant.

For ease of sampling, it was not completely randomised (see Fig. 3). One replicate an area of 3,200 sq.ft. was divided into four spacing treatments which were partially randomised to avoid variability in soil fertility. Each of these treatments were divided into two sub-plots of variety treatments within

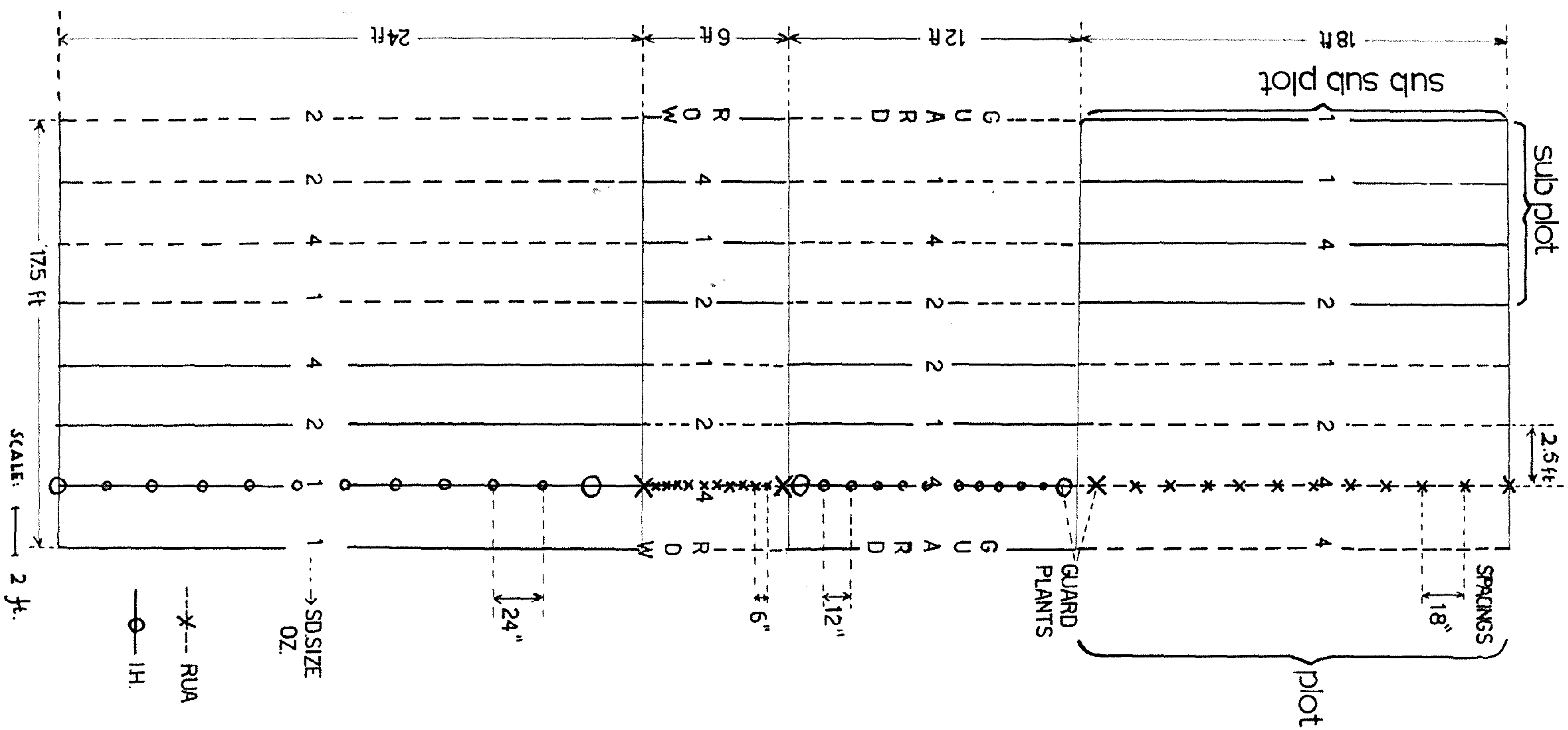


Fig. 2. A diagram of random combination of spacings, varieties, and seed sizes treatment in one replicate of Experiment-I.

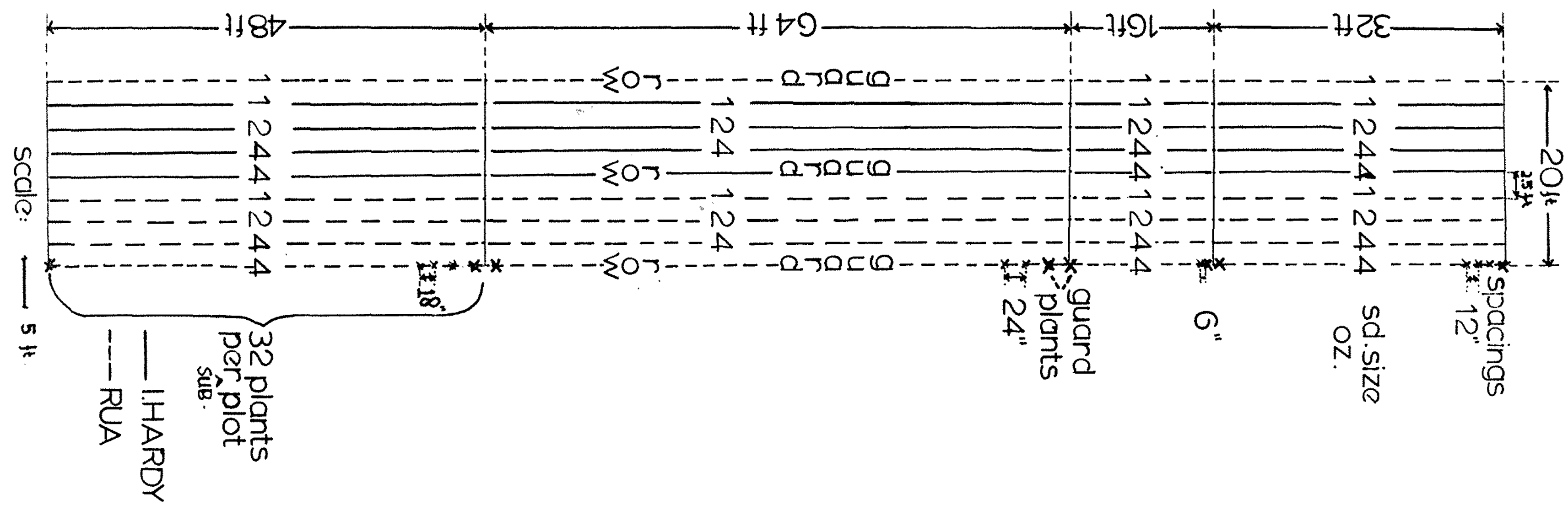


Fig. 3. A diagram of combined spacings, varieties, and seed size treatment in one replicate of Experiment-II.

which were contained three sub-sub-plots of seed size treatments.

There were nine rows within the main plot. As in Experiment-I the outer rows served as guard rows, but in addition the rows between each sub-plot were also used as guard rows. It was laid in two replicates.

The size of plots was determined by the necessity for successional liftings of plants at a fortnightly intervals during the twenty weeks of the main growing season of the crop.

3.3. TREATMENTS

Within row spacings were 6, 12, 18 and 24 inches. The 6"and 24" spacings were included to extend the investigations beyond the range of normal commercial practice. The distance between rows was constant at 30 inches apart.

The two varieties of potato chosen were Ilam Hardy and Rua. Ilam Hardy is a hybrid between the American Chippewa and the Scottish Arran Pilot. It has characteristics of high potential yield, good adaptation to a wide range of environmental conditions, and resistance to common mosaic virus. Rua is a Katahdin-Hardford cross with characteristics of blight, wind, drought, and mild mosaic virus resistances. Both varieties are among the major potato crops grown in New Zealand.

The stock was Certified Mother Seed, Group-2. This seed had been graded before arrival, but some culling was carried out to obtain more even line. This was done by weighing individual seed taken at random, followed by visual inspection to eliminate disease and any abnormal shapes. The standard seed sizes were arbitrarily classified as follows:-

Range of seed tuber size

Range (oz)	Mean (oz)	Group
0.5 - 1.5	1	Small Seed
1.5 - 2.5	2	Medium Seed
3.5 - 4.5	4	Large Seed

For both varieties, the detailed treatments with corresponding seed rates are shown in Table 1.

TABLE 1

Seed Rates (cwt/acre) for the various Spacings and Seed Sizes.

Spacings (inches)	Mean Seed wt.(oz)	Seed Rate(cwt/acr)
6	1	19.44
	2	38.88
	4	77.80
12	1	9.72
	2	19.44
	4	38.88
18	1	6.48
	2	12.96
	4	25.92
24	1	4.86
	2	9.72
	4	19.44

The whole trial was given a uniform dressing of 3 cwt. Super-phosphate, 2 cwt. of Sulphur of Ammonia, and 1 cwt. of Muriate of Potash per acre, applied along the drills just prior to planting.

The unsprouted seed tubers were planted by hand on 12th November 1965. They were placed at their appropriate distance using a marked stick. Careful use of a hand rack minimised the possibility of shifting the tubers seed during covering.

3.4. SAMPLING METHODS

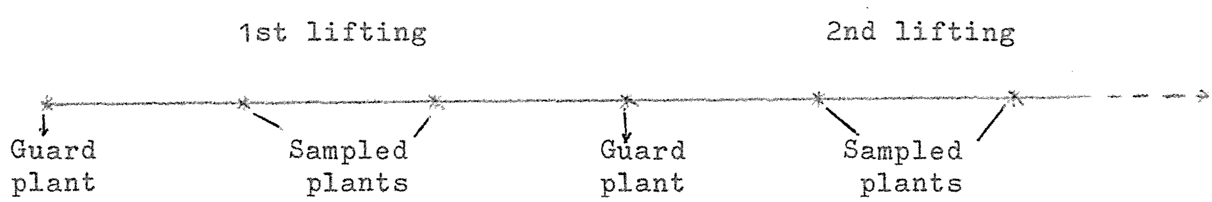
As sampling of Experiment-II was carried out at fortnightly intervals during the growing period, the sampling methods of this experiment will be discussed first.

3.4.1. Experiment-II, Successional Lifting.

3.4.1.1. Method of Lifting

From each sub-sub-plot two plants per treatment were lifted at fortnightly intervals. This produced 96 plants per lifting, which was considered to be the maximum number of plants that could reasonably be dealt with by one person.

The following diagram shows the pattern of lifting:



Two consecutive plants were sampled on any one lifting day. The next lifting was made alongside the previous one, omitting one plant in between, which acted as a guard plant. But when a dead or severely diseased plant was encountered within the row, the normal sampling pattern was modified so that only those plants which had a living plant at unit spacing on both sides was lifted.

The first lifting was made on 9th December, 1965, four weeks after planting. At this stage an estimated 100% emergence had resulted with Ilam Hardy and 60% with Rua. Although Rua emerged later than Ilam Hardy it was decided to lift both varieties at this stage in order that they could be sampled at the same period. However, Rua was estimated to be wholly emerged two weeks later at the second harvesting period. The number and date of lifting is shown in Table 2.

TABLE 2

Sequence of harvestings.

No.	Harvesting date.	
1	9th Dec. 1965 - Ilam Hardy)	100% emergence
2	23rd Dec. 1965 - Rua)	
3	6th Jan. 1966.	
4	20th Jan. 1966.	
5	3rd Feb. 1966.	
6	17th Feb. 1966	
7	3rd Mar. 1966.	
8	17th Mar. 1966	
9	31st Mar. 1966. Rua only	

3.4.1.2. Leaf Area Measurement

Speed and simplicity were the two basic criteria for selecting the method of measuring leaf area.

In view of the accuracy reported by Taha (1961), a comparison of his method with planimeter system is given in Appendix V, for this experiment a modified version of his method was adopted. The modification involved using a slightly larger steel pipe of 2.41 cms. cross-sectional area, but the subsequent procedure remained unaltered.

The procedure was as follows:-

1. All leaves were stripped from the stem and dropped at random into a tray. (Plate 1).
2. A circular punch of known diameter was pressed through a mass of leaves at a number of random positions, to obtain punched samples, called "discs."
3. A number between 50 and 125 full discs were selected and placed in a beaker for drying.
4. The whole leaves and the sample were dried in the oven to obtain dryweight.
5. The leaf area per plant was then worked out by following simple expression:

$$\frac{\text{Total dryweight of leaves}}{\text{dryweight of discs.}} \times \text{total area of discs.}$$

3.4.1.3. Dryweight Measurement

After the leaf area was measured the remainder of each individual plant was washed thoroughly and the tubers were separated from the plant. Fresh weights and numbers of tubers were recorded, as well as number of stems.

A

B

Plate 1. Measurement of leaf area

A. 'Discs' sample

B. leaves sample

The dryweight of leaves, stems, and tubers were determined separately. In the first three liftings the entire material was dried, but later in the season it was necessary to sub-sample the plant materials for dryweight estimation. All material was dried at 145°F.

3.4.2. Experiment-I, Terminal Yield

3.4.2.1. Method of Lifting

Experiment-I was harvested in five groups of two replications with an interval of seven days between liftings. This allowed a reasonable time for grading the yield.

For the ease of work and to avoid any possible contamination, all the guard plants (at the end of each sub-plot) were harvested first. This provided a clear boundary between the treatment plots (Plate 2).

Harvesting commenced on the 14th April 1966, and care was taken to cover all tubers produced. They were placed in labelled bags (Plate 3), for grading, and the yield of each grade was later recorded in the laboratory. The harvest was completed on the 12th May 1966.

3.4.2.2. Grading System

The grading system was based on tuber size using a standardised measuring system on similar lines to the specification for New Zealand Permanent Standard Grades of Potatoes (1961).*

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* Handbook No. 6, 1961, by New Zealand Grain, Seed and Produce Merchants' Federation.

Plate 2. Tuber yield in each sub-sub-plot

Plate 3. Tuber harvest prior to grading

This involved passing tuber through a square frame the dimensions of which were arbitrarily classified as follows:

Over $3\frac{1}{4}$"	-	Large Potato
$2\frac{1}{4}$" - $3\frac{1}{4}$"	-	Table Potato
$1\frac{1}{2}$" - $2\frac{1}{4}$"	-	Seed Potato
less $1\frac{1}{2}$"	-	Small Potato

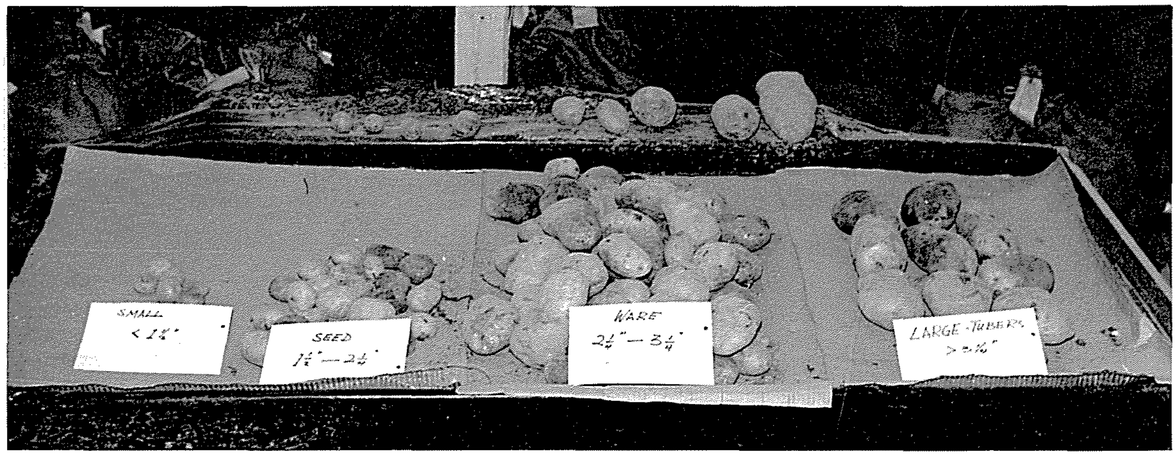
The above classifications was considered to be justified as it divided the tubers into four distinct groups (Plate 4).

For speed of grading reference tubers were arranged according to their size classification. Every tuber from each lot was measured either by visual estimation, i.e., by matching the tubers with the reference tubers, or by passing the tubers through the square frames. The tubers then separated into their classes and the weight of each class was recorded.

3.4.2.3. Dryweight Measurement

The dryweight of the tubers were measured with a "Potato hydrometer" (Plate 5). Each reading gave a direct value of dry matter percentage in the tuber. This method proved to be simple and enabled measurement of large samples of tubers. The procedure as follows:

1. Exactly 8 lbs of tubers were sampled from each of the two groups of table and large potatoes.
2. These tubers were placed in a wire basket,
3. The bulb of the hydrometer was hooked to the wire basket and the whole apparatus was lowered into a container of water.



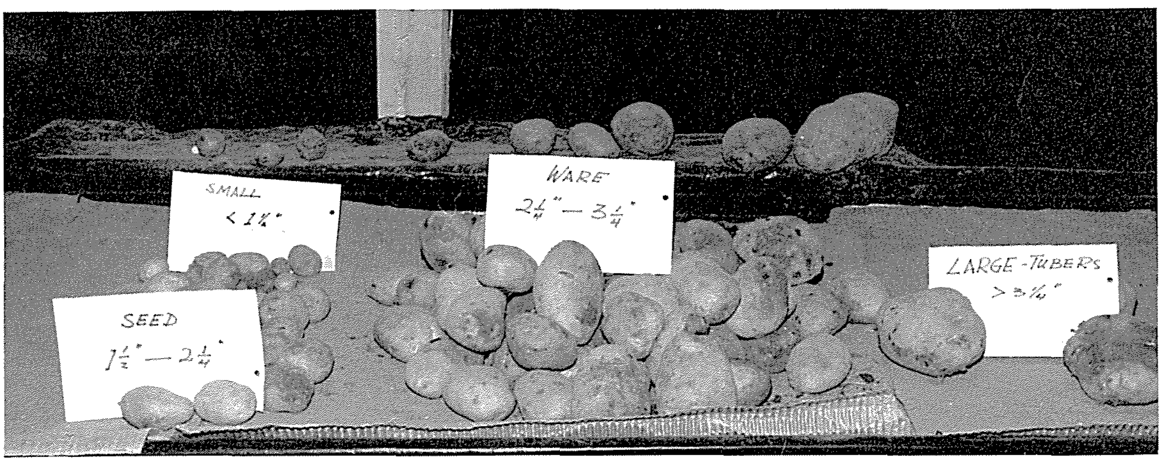


Plate 4. Classified tubers from each sub-plot Yield.

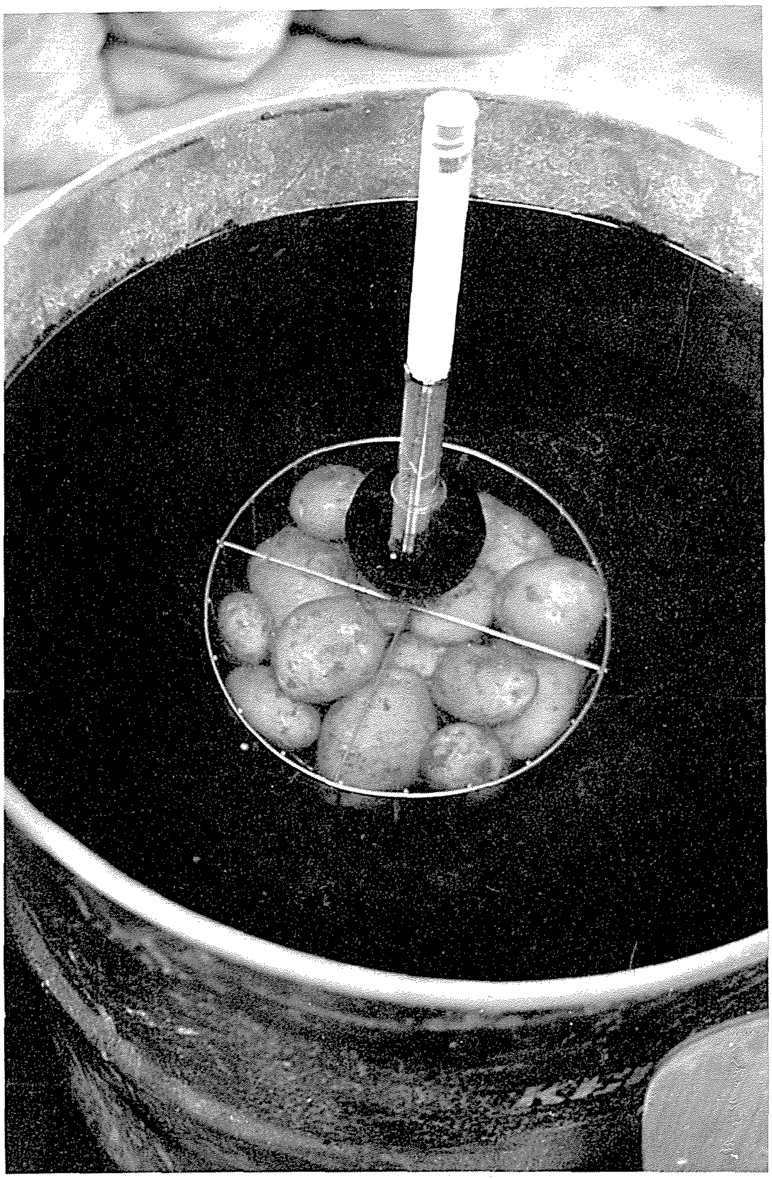


Plate 5. "Potato hydrometer" for measuring dryweight percentage.

4. Dry matter percentage was read as soon as the hydrometer came to rest floating in the water. The deeper the instrument sank, the higher was the reading.

The apparatus was designed by Potato Chips Institute International and has a proven high degree of accuracy, (Talburt, 1959).

For tuber yields of less than 8 lbs, the normal oven dryweight procedure was employed.

3.5. METHOD OF STATISTICAL ANALYSIS

3.5.1. Experiment-I, Terminal Yield

3.5.1.1. Form of Analysis of Variance

This consisted of 10 replicates of randomised split-split-plot design with 4 spacings, 2 varieties, and 3 seed sizes treatment.

A standard form of the analysis of variance was carried out as shown in Table 3. (Kempthorne, 1962). This reference contained an error in the E_3 and this has been corrected in Table 3.

An example of the method used is presented in detail in Appendix VI.

This procedure was used for the analysis of variance of tuber yield, except for the large tuber group due to a high number of missing plots. This resulted in trancation in the data, which could lead to downward biased estimates of variance and

TABLE 3

Form of Analysis of Variance of Split-split-plot design

Due to	d.f.	Mean Square	Expectation of Mean Square
Replicate = R	r - 1		
Spacing = S*	s - 1		
$Error_1 = E_1$	(r-1) (s-1)	E	$\sigma^2 (= \sigma_{ss}^2 + Z\sigma_s^2 + v.z.\sigma_w^2)$
Variety = V	v - 1		
V x S	(s-1) (v-1)		
$Error_2 = E_2$	(r-1)a(v-1)	S	$\sigma_s^2 (= \sigma_{ss}^2 + Z\sigma_s^2)$
Seed Size = Z	z - 1		
S x Z	(s-1) (z-1)		
V x Z	(v-1) (z-1)		
S x V x Z	(s-1)(v-1)(z-1)		
$Error_3 = E_3$	(r-1)s.v.(z-1)	SS	σ_{ss}^2

---

* (S), (V) and (Z) are abbreviations and used as symbols.

invalid analysis of variance. For this reason the analysis of variance was simplified and carried out on only those treatments with less than 5 null replicates, Glenday (1966).

There were 12 treatments which were analysable in the large potato. Because the range of data increased with the mean level, a transformation into logarithmic form was made in the analysis. Conclusions were drawn from the transformed mean, and the table of true mean and decoded S.E. is presented.

3.5.1.2. Interpretation of Interactions

The interaction was interpreted as follows:

1. A detectable difference at 5% and 1% level of probability (d.05 and d.01) was calculated for differences between levels of one factor within level of the other.
2. The table of means and S.E.'s was produced.
3. Then the d.05 (.01) was used to locate the significant difference in rows or columns of the table of means which changed or did not exist in other rows or columns of the table.

3.5.1.3. Presentation of Results

The results of analysis are presented in a tabulated form with the respective S.E.'s. In some cases the results are illustrated in graphical form.

3.5.1.4. Coefficient of Variation

Coefficient of variation were calculated where it was thought they would be useful and are included under the analysis of variance.

The formula used:

$$\text{Coefficient of Variation (V)} = \frac{\sqrt{\text{Final Error Mean Square}}}{\text{Sub-sub-plot Mean}} \times 100\%$$

3.5.2. Experiment-II, Successional Lifting

3.5.2.1. Form of Analysis of Variance

This experiment was designed as a subsidiary section to the Experiment-I with the objective of obtaining information on the trend of plant growth in response to the treatments during the growing period. The lay-out was determined by the number of plants that could be efficiently dealt with every fortnight and it was decided that a total of 96 plants harvested was the maximum. In view of this large number of plants and the elaborate work involved only a limited randomisation was possible, (see Section 3.2.2.).

Two replications with 2 plants per treatment to be harvested gave the total of 96 plants as the objective. It was realised that because of the incomplete randomisation and the small number of replicates the statistical interpretation of the results would be a minor aspect.

However, although the above simplified design was adopted, in view of the need for statistical interpretation of the results two forms of analysis was carried out.

It is important to note that during the experimental period all treatments produced useable results at all harvests, except in Rua at 1 oz seed treatment where poor results were obtained due to high numbers of missing plants within the plots. For this reason Rua 1 oz treatment was deleted altogether and only the bigger seed sizes common to both varieties were used for the analysis.

The following method of analysis was used:

1. A simple analysis of variance in a split-split plot design, with 2 replicates, 4 spacings, and 3 seed size treatments for each variety and in each harvesting period.

The results of this analysis were not presented as they were regarded as unsatisfactory.

2. The analysis of a split-split-split-plot design was adopted. Seven harvesting dates were split and became a treatment in addition to 2 replicates, 4 spacings, 2 varieties, and 2 seed sizes (2 oz and 4 oz seed) treatments. This method was attempted to detect the change in plant growth with the passage of time. It enabled the interaction between treatments with harvesting period also to be studied. Wilm (1945) formulated a form of analysis of variance for an experiment replicated in time (years) in a split-split-plot design. According to the nature of data recorded in this present experiment, a modification of the above method was made by elaborating the analysis into a split-split-split-plot design, as shown in Table 4.

TABLE 4

Analysis of Variance of Split-split-split plot

Source of Variation	Sum of Square	d.f.	Mean Square	F
Replicate = R		1		
Spacing = S		3		
$Error_1 = E_1$		3		
Variety = V		1		
V x S		3		
$Error_2 = E_2$		4		
Seed Size = Z		1		
Z x S		3		
Z x V		1		
Z x V x S		3		
$Error_3 = E_3$		8		
Harvesting = H		6		
H x S		18		
H x V		6		
H x S x V		18		
H x Z		6		
H x S x Z		18		
H x V x Z		6		
H x S x V x Z		18		
$Error_4 = E_4$		96		
TOTAL		223		

3.5.2.2. Transformation

The procedure was to examine the range (r) of yield for each treatment in relation to the mean yield level (m).

This suggested that range was directly proportionate to mean, so that a stabilising transformation of data:

$$Y = \log (x)$$ should be used (Kempthorne, 1962).

The stabilising transformation is required to ensure that variance within treatments are independent of mean level. (Snedecor, 1966).

3.5.2.3. Decoding S.E. of Transformed Data

The transformed mean and the S.E. were decoded by finding the 2 natural figures corresponding to the mean $\pm$ 1 S.E. limits, which were then taken to be 2 S.E.'s apart in the true scale.

The final mean quoted therefore is the true mean (not the decoded transformed mean) and its decoded S.E.'s.

All the interpretation and conclusions were drawn from transformed mean and transformed S.E.'s, and decoding was done only in the final step (Glenday, 1966)

3.5.2.4. Presentation of Results

Because the data were transformed most results are presented in graphical form from the transformed figures without decoding. The original data presented in the Appendices is untransformed form.

C H A P T E R IV

R E S U L T S A N D D I S C U S S I O N S

4.1. FIELD OBSERVATION

Meteorological data recorded during the experimental period between the months of November 1965 and May 1966 is given in Appendix III. Taken overall, the 1965/66 season was regarded as a warm and wet one for the Manawatu area. During the week of planting (12th November 1965), 1.12 inches of rainfall was recorded which provided a good moist seed bed.

The first emergence for Ilam Hardy was observed seventeen days after planting and for Rua three days later. A striking feature of this pattern was the uniform emergence of Ilam Hardy plants compared with uneven expression of Rua (Plate 6). This was reflected in the first lifting, on the 9th December 1965 four weeks after planting, when a 100% emergence was estimated for Ilam Hardy and 60% for Rua. It was two weeks later before 100% emergence was attained by Rua. Spacing treatment appeared to have no effect on the time of emergence, but an influence due to seed size was apparent; larger seed emerging earlier than small seed.

In general, the crop gew under good conditions, (Plate 7) but the warm and wet period during December 1965 was conducive to blight out-break. On the 10th January 1966 the first blight symptoms was detected and the laboratory examination confirmed that the late blight disease caused by Phytophthora infestans (Mont) de Bary was present in the crop (Plate 8). A protective spray programme up to this time was not possible due to unavailability of the equipment. However, with the positive identification of the disease, immediate action became necessary. The spray programme commenced on the 14th January 1966 and was conducted

Plate 6. Crop growth at four weeks after planting
- Uniform growth shown in Ilam Hardy
- Uneven growth shown in Rua

Plate 7. Crop growth at ten weeks after planting

Plate 8. Leaves infected by *Phytophthora infestans*

Plate 9. Spraying Diathane for controlling late blight disease using "Air-blast" machine

under the supervision of Mr. H.T. Wenham, Plant Pathologist at Massey University. The subsequent spray, using an air-blast spraying machine (Plate 9) was applied at weekly intervals (Appendix IV) and was found to be effective in controlling the disease and minimising further spread. Observation of the disease incidence showed Rua relatively resistant to late blight compared to Ilam Hardy. A trace of virus infection was detected in isolated cases in both varieties but was considered of negligible importance. Other types of disease were not observed.

Ilam Hardy showed an earlier senescence beginning in March. Rua, on the other hand appeared to have a longer period and did not start to degenerate until May. At the time of last harvesting Ilam Hardy had practically died off but Rua still maintained top growth.

4.2. EXPERIMENT-I, TERMINAL YIELD

4.2.1. Total Yield

Tuber yield was recorded in lb per plot. For the analysis of variance, the yield was recalculated in tons per acre, the results of which are given in Appendix VII.

Analysis of variance of total yield is given in Table 6.

The main effect of spacing, variety, and seed size is presented in Table 5. The results show that spacing treatment gave significant effect on the total yield. The 6" spacing yield more than the wider spacing. Between 12" and 18" spacing there was no difference, but both treatments were higher yielding than the 24" spacing.

TABLE 5

The effect of spacing, variety, and seed size on mean Total Yield (tons/acr.)

Treatment		Mean of total yield	
Spacing:	6"	30.4	S.E. ± 0.8
	12"	22.5	d.05 (.01) =
	18"	21.8	2.3 (3.1)
	24"	19.5	
Variety:	Ilam Hardy	24.70	S.E. ± 0.48
	Rua	22.41	d.05 (.01) =
			1.36 (1.83)
Seed Size:	1 oz	20.97	S.E. ± 0.47
	2 oz	24.60	d.05 (.01) =
	4 oz	25.10	1.32 (1.75)

Ilam Hardy was significantly heavier than Rua.

The effect of seed size on the total yield showed that 1 oz seed was significantly lower yielding than the bigger seed treatment. The advantage of 4 oz seed over 2 oz seed was not significant.

The lack of interaction between spacing and variety indicates that the influence of spacings on the yield did not change with the variety.

However, the interaction between spacing and seed size was significant, as shown in Table 7. This emphasised that the advantage of the 6" spacing over the wider spacing became significantly greater at larger seed sizes, as clearly illustrated in Fig. 4

TABLE 6

Analysis of Variance of Total Yield (tons/acre)

Sources of Variation	S.S.	d.f.	M.S.	F
1. Replication = R	672.02	9	74.67	
2. Spacing = S	4054.37	3	1351.46	35.57 **
Error (1) = E_1	1025.76	27	37.99	
3. Variety = V	312.70	1	312.70	11.56 **
V x S	133.54	3	44.51	1.65 NS
E_2	973.96	36	27.05	
4. Seed Size = Z	815.52	2	407.76	22.81 **
Z x S	331.44	6	55.24	3.09 **
Z x V	1126.60	2	563.30	31.50 **
Z x V x S	111.70	6	18.62	1.04 NS
E_3	2575.29	144	17.88	
TOTAL	12132.90	239		
Coefficient of Variation = 17.9 %				

TABLE 7

The effect of spacing-seed size interaction on Total Yield (tons/acre)

Seed Size	Spacing			
	6"	12"	18"	24"
1 oz	25.4	21.1	20.2	17.3
2 oz	31.7	23.2	22.2	21.3
4 oz	34.2	23.1	23.1	20.0
	S.E. ± 1.0 d.05 (.01) = 2.7 (3.5)			

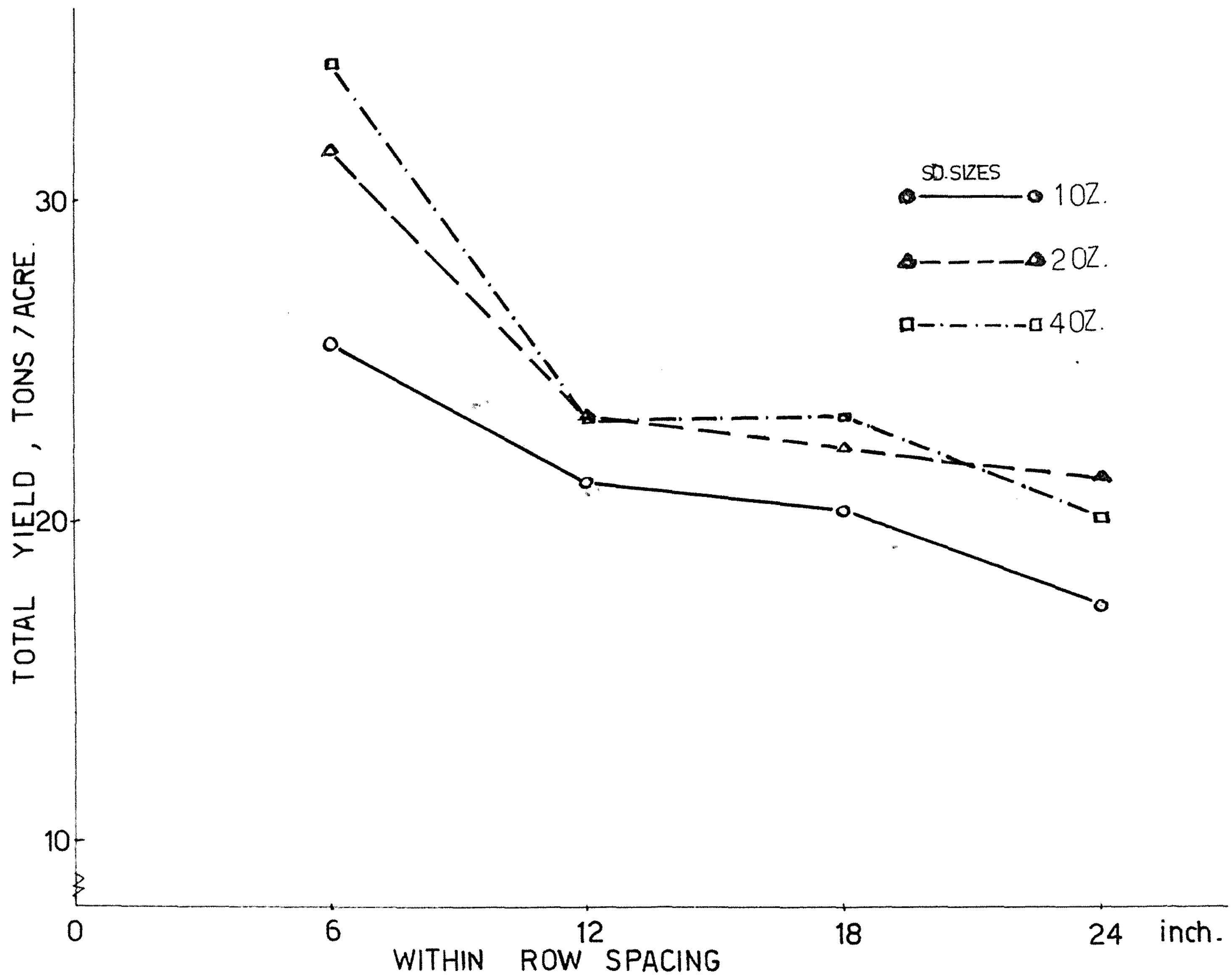


Fig. 4. The effect of spacing and seed size on Total Yield (tons/acre)

There was an interaction between variety and seed size (Table 8). In Ilam Hardy higher yield was obtained from the 1 oz and 2 oz seed, whereas in Rua the yield was progressively increased with increase in seed size.

TABLE 8

The effect of variety and seed size interaction on Total Yield (tons/acre)

Variety	Seed Size		
	1 oz	2 oz	4 oz
Ilam Hardy	24.7	25.9	23.5
Rua	17.2	23.3	26.7
	S.E. ± 0.7 d.05 (.01) = 1.9 (2.5)		

For general comparison, the effect of spacing, variety, and seed size is further examined and illustrated in a graphical form as shown in Fig. 5. It shows that the advantage of 6" spacing over the wider spacings had not changed with variety. In Rua 4 oz seed treatment was superior at the closer spacing, but in Ilam Hardy the 2 oz seed was the best at this spacing.

4.2.2. Table Potato Yield ($2\frac{1}{4}$" - $3\frac{1}{2}$")

The analysis of variance of table potato yield is presented in Table 10, and the yield recorded is given in Appendix VIII.

The mean yield as influenced by spacings, varieties, and seed sizes is shown in Table 9.

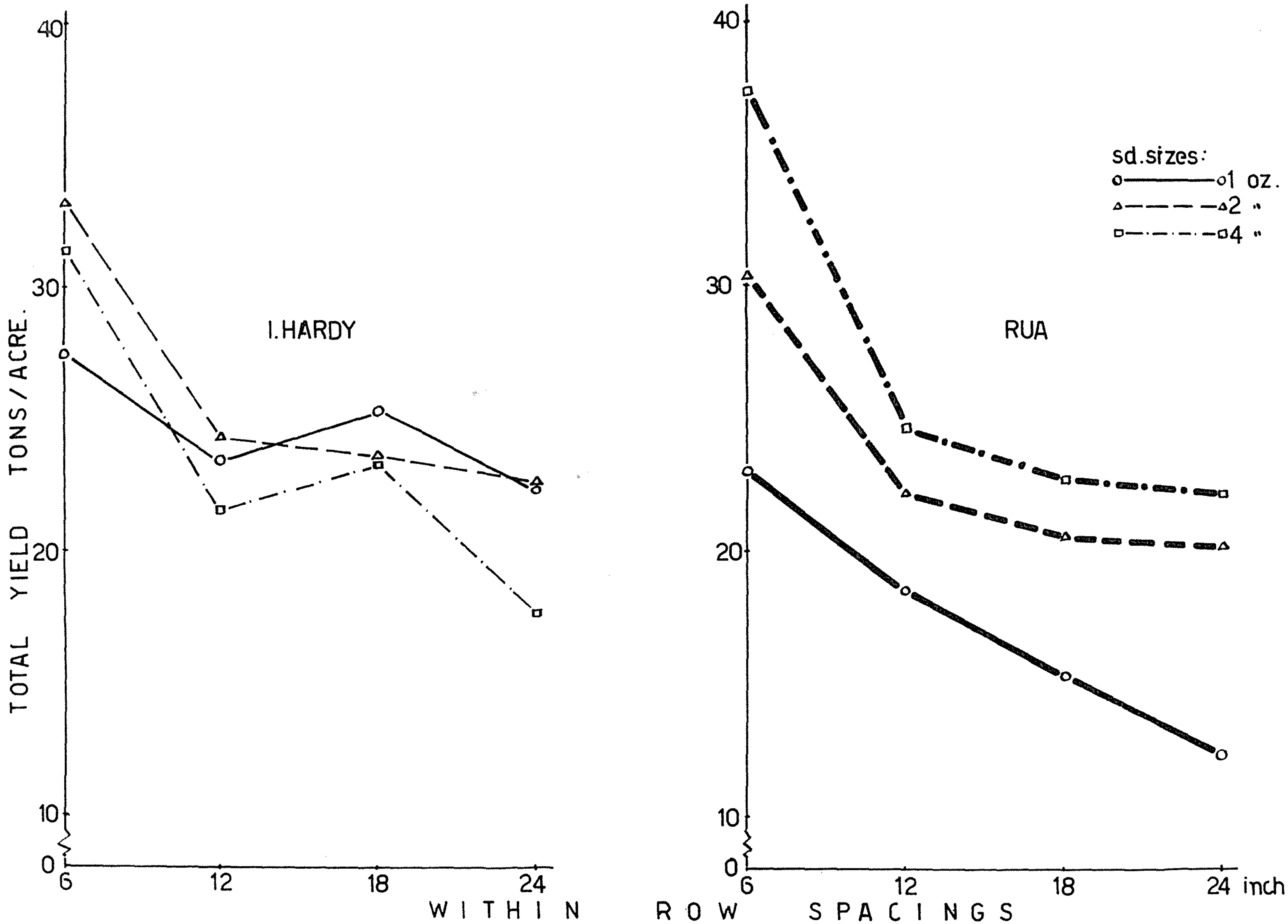


Fig. 5. The effect of spacing, variety, and seed size on Total Yield (tons/acre)

TABLE 9

The effect of spacing, variety, and seed size on the mean Table Potato Yield (tons/acre)

Treatment	Table Potato yield (ton/acr)	
Spacing: 6"	22.4	
12"	17.0	S.E. ± 0.6
18"	16.4	d.05 (.01) =
24"	14.6	1.6 (2.2)
Variety: Ilam Hardy	18.10	S.E. ± 0.37
Rua	17.07	d.05 = 1.08
Seed Size: 1 oz	15.85	S.E. ± 0.46
2 oz	18.38	d.05 (.01) =
4 oz	18.53	1.31 (1.72)

The spacing treatments affected the yield of table potatoes in a similar way to that of total yield : the 6" spacing was significantly higher than the wider spacings. Between 12" and 18" spacings there was no significant differences, but both treatments were superior to the 24" spacing.

In comparing the two varieties the slightly higher yield of Ilam Hardy just failed to reach significance.

With reference to the effect of seed size on the table potato yield it was found that larger seed sizes were superior to the 1 oz seed.

The interaction between spacing and variety is shown in Table 11. It produces two features:

TABLE 10

Analysis of Variance of Table Potato Yield (tons/acre)

Sources of Variation	S.S.	d.f.	M.S.	F
1. Replication = R	578.31	9	64.26	
2. Spacing = S	2021.86	3	673.95	35.01 **
E_1	519.85	27	19.25	
3. Variety = V	63.38	1	63.38	3.79 NS
V x S	159.08	3	53.03	3.17 *
E_2	602.33	36	16.73	
4. Seed-Size = Z	362.24	2	181.12	10.54 **
Z x S	115.39	6	19.23	1.12 NS
Z x V	944.66	2	472.33	27.49 **
Z x V x S	45.45	6	7.58	0.44 NS
E_3	2474.23	144	17.18	
TOTAL	73 65.78	239		
Coefficient of Variation = 23.5%				

TABLE 11

The effect of spacing and variety interaction on Table Potato Variety (tons/acre)

Variety	Spacing			
	6"	12"	18"	24"
Ilam Hardy	21.9	16.9	17.9	15.7
Rua	22.8	17.2	14.9	13.4
	S.E. ± 0.7 d.05 (.01) = 2.2 (2.9)			

1. Ilam Hardy shows the phenomenon of spacing effect : 6" ≫* (12", 18") > 24"; whereas Rua in the order of 6" ≫ 12" ≫ (18", 24").

2. Ilam Hardy was significantly better than Rua at the 18" and 24" spacings but not at the 6" and 12" treatments.

Between seed sizes and spacings there was no interaction, this indicated that the inferiority of 1 oz seed did not change with the spacing treatments.

The two varieties responded differently with the seed size treatments. This can be seen in the Table 12.

TABLE 12

The effect of variety and seed size interaction on Table Potato Yield (tons/acre)

Variety	Seed Size		
	1 oz	2 oz	4 oz
Ilam Hardy	18.71	19.05	16.53
Rua	12.99	17.70	20.52
	S.E. ± 0.66 d.05 (.01) = 1.82 (2.41)		

* ≫ = significantly higher at 1% level of probability
> = " " " 5% " " "

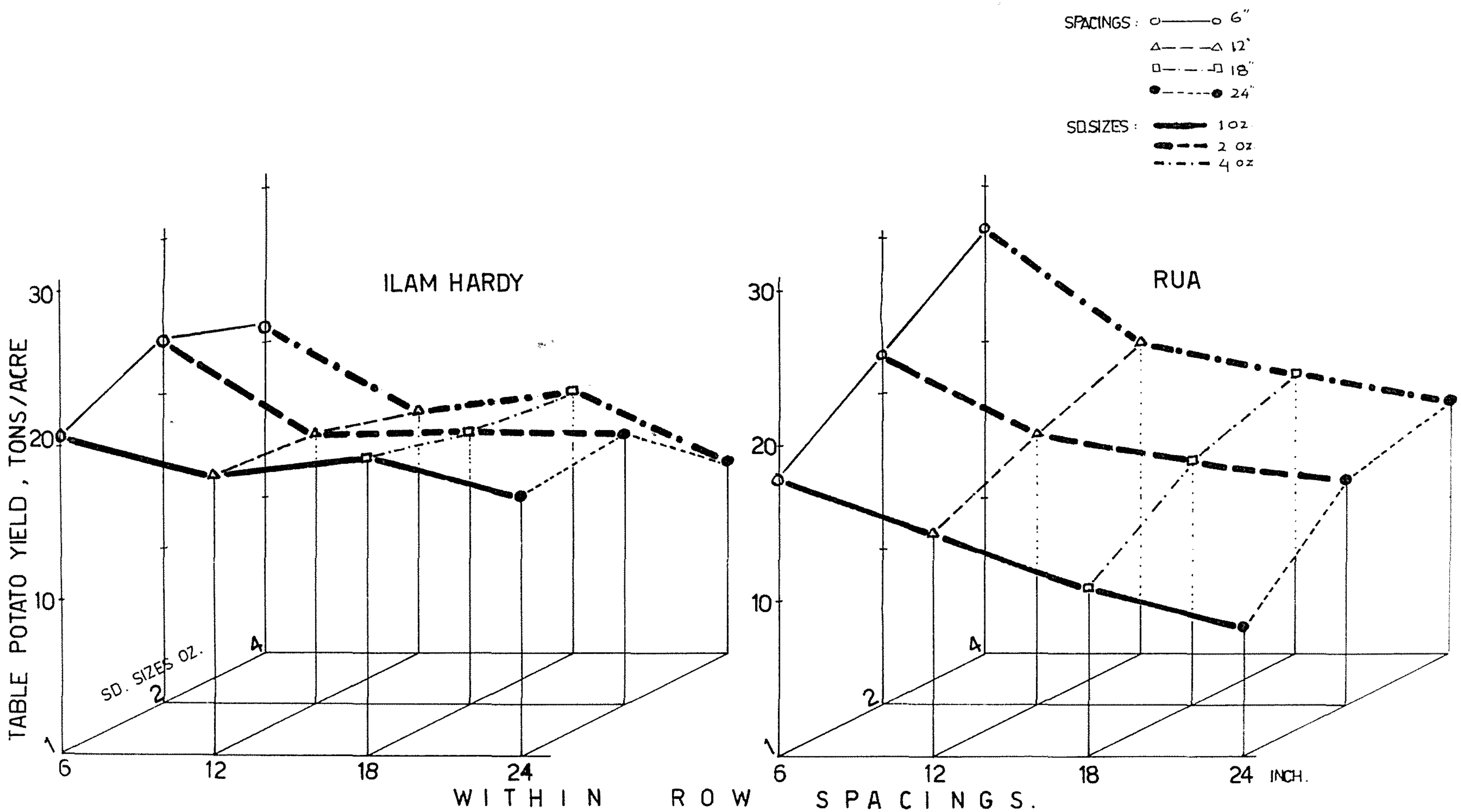


Fig. 6. A three dimensional graph showing the effect of spacing, variety, and seed size on T[illegible] [illegible]tato Yield (ton/acre)

It shows that:

1. At smaller seed sizes (1 oz and 2 oz) Ilam Hardy produced a higher yield than the larger seed. But the situation was reversed in Rua the advantage being to the bigger seed sizes.

2. In comparison between the two varieties, Ilam Hardy was only superior to Rua at the 1 oz and 2 oz seed whereas at the 4 oz seed Rua outyielded Ilam Hardy.

The overall effect of those three main treatments is illustrated in a three dimensional graph Fig. 6. This shows that the two varieties responded markedly to the different treatment combinations. For Ilam Hardy 2 oz seed planted in a close spacing gave the highest yield but for Rua the affect of increasing seed size and closer spacing was most apparent.

4.2.3. Large Potato Yield (Over $3\frac{1}{4}$")

Large potatoes were obtained only from a restricted number of treatments and in some cases only some replicates of a particular treatment.

A simple analysis of variance was carried out on those treatments with a positive yield in at least six of the ten replicates. The analysis of variance is given in Table 13, and the data of which is presented in Appendix IX.

The true mean of yield and decoded S.E. is presented in Table 14. There was no significant difference between treatments in Ilam Hardy. In Rua the 4 oz 18" spacing was significantly lower yield than the other treatments.

A further examination on the mean yield of large potatoes

TABLE 13

Analysis of Variance of Large Potato Yield, tons/acre
(transformed into loge)

Sources of Variation	S.S.	d.f.	M.S.	F
Replication	1.0052	9	0.1117	1.76
Treatment	2.0196	11	0.1836	2.89 **
Error	6.2852	99	0.0635	
TOTAL	9.3100	119		

TABLE 14

The Mean Yield of Large Potato (tons/acre)

Treatment			Large Potato Yield
Ilam Hardy:	1 oz	18"	2.28 S.E. ± 0.37
		24"	2.28 ± 0.36
	2 oz	18"	1.38 ± 0.24
		24"	1.58 ± 0.28
	4 oz	24"	1.43 ± 0.25
Rua	1 oz	18"	2.83 S.E. ± 0.46
		24"	2.22 ± 0.39
	2 oz	12"	2.63 ± 0.53
		18"	2.81 ± 0.45
		24"	3.57 ± 0.59
	4 oz	18"	1.44 ± 0.27
		24"	3.18 ± 0.49

TABLE 15

The mean yield of Large Potatoes in all Treatments (tons/acre)

Spacing	Ilam Hardy Seed Size 1 oz	Ilam Hardy Seed Size 2 oz	Ilam Hardy Seed Size 4 oz	Ilam Hardy Spacing Means	Rua Seed Size 1 oz	Rua Seed Size 2 oz	Rua Seed Size 4 oz	Rua Spacing Means
6"	0.00	0.00	0.19	0.06	1.65	1.25	0.19	1.03
12"	0.69	0.52	0.33	0.51	2.05	2.53	0.39	1.65
18"	2.28	1.38	0.86	1.51	2.83	2.81	1.44	2.36
24"	2.28	1.58	1.43	1.76	2.22	3.57	3.18	2.99
Size Means	1.31	0.87	0.70	0.96	2.19	2.54	1.29	2.01

is given in Table 15. It shows that in both varieties the yield was increased as the spacing increased, the difference in the yield being considerably higher in Rua. Only in Ilam Hardy did the yield of large potatoes decrease with increased seed size. In Rua the highest yield was produced at the 2 oz seed treatment. Taken overall, Rua produced a higher yield of large potatoes than did Ilam Hardy.

4.2.4. Seed Potato Yield (1½" - 2¼")

The analysis of variance of seed potato is given in Table 17 and the data is presented in Appendix X.

The analysis shows that the effect of spacing, variety, and seed size on the seed potato yield was highly significant. The mean yield as influenced by the three main treatments is presented in Table 16. It shows that the 6" spacing significantly produced higher seed potato yield than the wider spacing treatments. Between 12", 18" and 24" spacings, the differences in yield were not significant. In a comparison between the varieties, however, Ilam Hardy was significantly greater in yield than Rua. The difference in yield as the result of seed size treatment was in the order of 4 oz $\gg$ 2 oz $\gg$ 1 oz.

The seed size treatments gave significant interactions with 1. spacing, 2. variety, and 3. spacing and variety. The results of the first interaction emphasised the significantly increased seed potato yield when the seed size increased and the spacing decreased (see Table 18). As the spacing became wider the difference between seed size treatments became smaller; and

TABLE 16

The effect of spacing, variety and seed size on the Seed Potato Yield (tons/acre)

Treatment		Seed Yield	
Spacing:	6"	6.0	S.E. ± 0.8
	12"	3.5	d.05 (.01)=
	18"	2.9	2.2 (3.0)
	24"	2.1	
Variety:	Ilam Hardy	4.44	S.E. ± 0.15
	Rua	2.86	d.05 (.01) =
			0.45 (0.60)
Seed Size:	1 oz	2.77	S.E. ± 0.13
	2 oz	3.68	d.05 (.01) =
	4 oz	4.49	0.36 (0.47)

TABLE 17

Analysis of Variance of Seed Potato Yield (tons/acre)

Sources of Variation	S.S.	d.f.	M.S.	F
1. Replication = R	74.78	9	8.31	
2. Spacing = S	505.11	3	168.37	46.90 **
E_1	97.00	27	3.59	
3. Variety = V	150.69	1	150.69	54.80 **
V x S	5.91	3	1.97	0.72 NS
E_2	99.04	36	2.75	
4. Seed-Size = Z	119.24	2	59.62	44.16 **
Z x S	39.91	6	6.65	4.93 **
Z x V	18.59	2	9.29	6.88 **
Z x V x S	20.66	6	3.44	2.55 *
E_3	194.43	144	1.35	
TOTAL	1325.36	239		

at the 24" spacing there was little difference in the yield.

TABLE 18

The effect of seed size - spacing interaction on the Seed Potato Yield (tons/acre)

Seed Size	Spacing 6"	12"	18"	24"
1 oz	4.31	2.84	2.16	1.76
2 oz	6.05	3.54	2.92	2.23
4 oz	7.63	4.26	3.74	2.34
	S.E. ± 0.26 d.05 (.01) = 0.71 (0.94)			

The second interaction indicated that both varieties responded differently to the seed size treatments. Table 19 shows that in Ilam Hardy the advantage of seed size was not

TABLE 19

The effect of seed size - variety interaction on the Seed Potato Yield (tons/acre)

Seed Size	Variety: Ilam Hardy	Rua
1 oz	3.71	1.82
2 oz	4.71	2.66
4 oz	4.89	4.09
S.E. ± 0.18 d.05 (.01) = 0.51 (0.68)		

significant beyond 2 oz seed treatment. But in Rua this advantage on the seed potato yield increased up to the 4 oz seed size.

In the third interaction, i.e., between seed size, variety, and spacing, it was found that in Ilam Hardy the above results (seed size and variety interaction) only applied at the 6", 12" and 18" spacings. At the 24" spacing the effect of seed size was not significant, as shown in Table 20. In Rua, however,

TABLE 20

The effect of spacing, variety, and seed size interaction on the Seed Potato Yield (tons/acre)

Variety	Seed Size	Spacing 6"	12"	18"	24"
Ilam Hardy	1 oz	5.49	3.82	3.02	2.54
	2 oz	7.14	4.95	4.02	2.73
	4 oz	7.27	4.80	4.54	2.97
Rua	1 oz	3.14	1.86	1.30	0.97
	2 oz	4.96	2.12	1.82	1.73
	4 oz	7.99	3.72	2.94	1.71
S.E.± 0.37 , d.05 (.01) = 1.03 (1.36)					

there were variable results. At the 6" spacing the yield was in order of 4 oz $\gg^*$ 2 oz $\gg$ 1 oz; at the 12" and 18" spacings it was in the order of 4 oz $>$ (2oz, 1 oz); and at the 24" spacing the difference was not significant.

4.2.5. Small Potato Yield (Less 1½")

The analysis of variance of small potato yield is given in Table 22 and the data recorded is presented in Appendix XI.

The main effect of spacing, variety, and the seed size is shown in Table 21.

The results may be summarised as follows:

1. As the spacing became closer the yield of small potatoes increased significantly.
2. Ilam Hardy produced a higher yield than Rua

* $\gg$ = significantly higher at 1% level of probability
$>$ " " " 5% " " "

3. The yield was also significantly greater with an increase in the seed size.

The interaction between the treatments indicated that in both varieties higher yield at the 6" spacing over the wider spacing treatments became significantly greater as seed size increased.

TABLE 21

The effect of spacing, variety, and seed size on the Small Potato Yield (tons/acre)

Treatment	Small Potato Yield	
Spacing: 6"	1.50	S.E. ± 0.05
12"	0.82	d.05 (.01)=
18"	0.58	0.15 (0.21)
24"	0.45	
Variety: Ilam Hardy	1.20	S.E. ± 0.05
Rua	0.48	
Seed Size: 1 oz	0.59	S.E. ± 0.04
2 oz	0.83	d.05 (.01)=
4 oz	1.09	0.12 (0.16)

4.2.6. Percentage Yield Distribution

The influence of spacing, variety, and seed size on the percentage of yield distribution in different grades of potatoes is given in Table 23 and Appendix XII.

TABLE 22

Analysis of Variance of Small Potato Yield (tons/acre)

Sources of Variation	S.S.	d.f.	M.S.	F
1. Replication = R	4.42	9	0.49	
2. Spacing = S	39.59	3	13.20	77.65 **
E_1	4.51	27	0.17	
3. Variety = V	30.72	1	30.72	96.00 **
V x S	4.15	3	1.38	4.31 *
E_2	11.47	36	0.32	
4. Seed x Size = Z	10.09	2	5.05	33.67 **
Z x S	4.74	6	0.79	5.27 **
Z x V	0.45	2	0.23	1.53 NS
Z x V x S	1.75	6	0.29	1.93 NS
E_3	21.97	144	0.15	
TOTAL	133.86	239		

TABLE 23

The effect of spacing and seed size on the Percentage Yield Distribution in Ilam Hardy and Rua (%)

Treatment	Ilam Hardy				Rua			
	Large Potato	Table Potato	Seed Potato	Small Potato	Large Potato	Table Potato	Seed Potato	Small Potato
Spacing: 6"	0.20	71.63	21.57	6.60	3.93	75.93	17.17	2.97
12"	2.17	72.80	19.63	5.40	7.97	78.60	11.60	1.83
18"	6.20	74.17	16.13	3.50	12.80	75.60	10.07	1.53
24"	8.40	74.97	13.37	3.20	16.80	73.90	8.13	1.17
Seed Size: 1 oz	5.55	75.79	14.88	3.78	13.78	74.92	10.05	1.25
2 oz	3.72	73.95	17.78	4.55	11.68	75.75	10.85	1.72
4 oz	3.45	70.45	20.38	5.72	5.68	77.35	14.32	2.65
Variety:	4.25	73.39	17.68	4.68	10.38	76.01	11.74	1.87

The effect of spacing treatments showed a clear trend in the yield, particularly in the large and small grade potatoes. With increasing spacing from 6" to 24" distances, the percentages of large potatoes increased and that of small potatoes decreased in both varieties.

In the comparison between varieties, the tuber yield in Rua was obviously made up of a higher percentage of large and table potatoes than that of Ilam Hardy.

The effect of seed size on the percentage yield of the different grades showed a distinct trend. By increasing the seed sizes from 1 oz to 4 oz, the percentage of large potatoes was decreased and that of the small grades was increased. In table potato yield the two varieties showed a reversed trend. Increased seed size resulted in a decreased percentage of table potatoes in Ilam Hardy, but the opposite in Rua.

4.2.7. Dryweight Yield and Dry matter Percentage of Table Potatoes

The analysis of variance of dryweight yield is given in Table 25 and the data of which is presented in Appendix XIII.

The differences in dryweight yield as influenced by spacing, variety, and seed size is given in Table 24.

The results to a large extent follow those obtained in the analysis of freshweight of the table potato. It shows that:

1. 6" spacings were superior over the wider spacings,
2. Rua was significantly higher in dryweight yield than Ilam Hardy.
3. The 1 oz seed size was significantly lower in dryweig' yield than the larger seed treatments.

TABLE 24

The effect of spacing, variety, and seed size on the dry-weight Yield of Table Potatoes (tons/acre)

Treatment	Dryweight Yield (tons/acre)	
Spacing: 6"	4.21	S.E. ± 0.12
12"	3.20	d.05 (.01) =
18"	3.02	0.33 (0.44)
24"	2.71	
Variety: Ilam Hardy	3.18	S.E. ± 0.07
Rua	3.39	
Seed Size: 1 oz	2.94	S.E. ± 0.08
2 oz	3.43	d.05 (.01) =
4 oz	3.49	0.22 (0.30)

TABLE 25

The Analysis of Variance of D.W. Yield of Table Potatoes (tons/acre)

Sources of Variation	S.S.	d.f.	M.S.	F
1. Replication = R	20.00	9	2.22	
2. Spacing = S	76.01	3	2.53	3.20 *
E_1	21.34	27	0.79	
3. Variety = V	2.45	1	2.45	4.15 *
V x S	8.55	3	2.85	4.83 **
E_2	21.20	36	0.59	
4. Seed Size = Z	14.86	2	7.43	14.57 **
Z x S	5.23	6	0.87	1.71 NS
Z x V	36.16	2	18.08	35.45 **
Z x V x S	1.82	6	0.30	0.58 NS
E_3	73.60	144	0.51	
TOTAL	281.22	239		

The significant interaction between spacing and variety (Table 26) indicated that the superiority of Rua over Ilam Hardy was significantly greater at the closer spacing.

TABLE 26

The effect of spacing - variety interaction on the Dryweight Yield of Table Potatoes (tons/acre)

Variety	Spacing			
	6"	12"	18"	24"
Ilam Hardy	3.88	2.96	3.13	2.77
Rua	4.55	3.44	2.92	2.64
	S.E. ± 0.14 d.05 (.01) = 0.39 (0.52)			

The variety also showed a significant interaction with seed size (see Table 27). Rua had significantly higher yield than Ilam Hardy at the 4 oz seed, but this was non-significant at the 2 oz seed, becoming significantly lower at the 1 oz seed size.

TABLE 27

The effect of variety - seed size interaction on Dry Weight Yield of Table Potato (tons/acre)

Variety	Seed Size		
	1 oz	2 oz	4 oz
Ilam Hardy	3.30	3.36	2.90
Rua	2.58	3.51	4.08
	S.E. ± 0.11 d.05 (.01) = 0.32 (0.42)		

The dry matter percentage of the table potato yield was also recorded and analysed. The results showed that Rua (19.81%)

had a significantly higher dry matter percentage than Ilam Hardy (17.55%).

4.2.8. Discussion

In the experiment as a whole the total yield and also the table potato yield were very high and exceeded the average yield of commercial crops for this area, which normally range from 10 to 15 tons per acre (Miller, 1966). High yields recorded in this experiment can be attributed to a combination of several factors:

1. the favourable environmental conditions of climate and soil fertility,
2. the lack of damage from cultivation or spraying programme, and
3. the close attention and careful management throughout the growing period.

The different pattern in time of emergence between the two varieties may be explained in terms of differences in the physiological condition of the seed tuber. Ilam Hardy is known to have the ability to produce several crops of sprouts. Rua has fewer than the former but produces bigger sprouts which have a tendency to inhibit secondary eyes (Driver, 1966). Despite the factors such as growing conditions in the previous year and type of storage, Ilam Hardy generally sprouts readily and emerges in a fairly uniform pattern. On the other hand, Rua is generally uneven in emergence. This could be due to the previous history of the seed. In Rua tubers tend to form early and grow to a very large size. In the production of seed potatoes of this variety, early harvesting is often practised and this together with a long storage period could have effected the physiological ageing of the tubers. Another point to be noted is that Rua 1 oz seed resulted in a high number of misses. A possible explanation was due to several factors, such as immature stage - shorter dormant period (Krijth, 1962), rapid physiological ageing (Driver, 1966), and susceptibility of unsprouted seed to pathogens, such as Rhizoctonia solani Kuhn (Toosey, 1963).

The effect of spacing on total and table potato yield confirmed the previous finding in Section 2.1.1. The superiority of 6" spacing over wider spacing treatments was significant; the difference between the 12" and 18" spacing was small, but with the 24" spacing the yield was significantly lower than in the other three treatments. Dryweight yields (Table 24) showed a similar trend. There was evidence that the percentage of table and large potato to the yield declined with decrease in spacing. That is, the advantage of close spacing treatments on the table and large potato yield was accompanied by the significantly higher yield of small potatoes.

The superiority of Ilam Hardy in total yield may have resulted from differences in growth habit. Earliness, evenness, and high percentage of emergence in all seed size treatments could all contribute to the higher overall yield in this variety. The uneven and late emergence pattern of Rua, probably caused a late maturing crop, which in turn could have lowered the yield. But there is no known experimental evidence to support this. A feature of higher total yield of plants emerging early than those emerging later was in accordance with the report of Ivins & Montague (1955). However, since the differences in yield of table potatoes in both varieties was not significant, the difference in the total yield between the two varieties could largely be attributed to the small grade potatoes. A shorter growing period and possibly some effect of blight at the later stage of the growing period, may have accounted for the higher proportion of small grade potatoes in Ilam Hardy. Under such conditions the production of assimilates and its supply to the developing tubers would be reduced and consequently this would retard the enlargement of the tubers. In Rua it was unlikely to be so, where a longer growing period and resistance of this variety to blight disease, provides a greater supply of assimilates to the tubers and ultimately results in a greater number of large tubers. Further explanation in terms of leaf area and number of tubers will be discussed in Section 5.1.

A continuous increase in tuber yield as the seed size increased suggested that the initial advantage of plant growth from large seed was maintained for a long period. According to Bremner & El Saeed (1963), after the establishment phase, the behaviour of plants from large and small seed depends upon the intensity of interplant competition (for nutrients, water, and light) to which they are subjected. Under present experimental conditions, it appeared that interplant competition did not reach an intensity at which its effect became a limiting factor to the growth of the plant and to the production of tubers, except at the 6" spacing. With the latter treatment the effect of interplant and intertuber competition (for assimilates) became apparent. This resulted in a higher percentage of small grade potatoes produced in that treatment. On the other hand, the advantage of wider spacing and small seed size on the percentage of large and table potatoes did not compensate for the lower yield recorded. The significant interaction between variety and seed size showed that varieties responded differently to the seed treatment. In Ilam Hardy, 2 oz seed was the most efficient for the production of table potato at the 6" spacing, but in Rua the advantage of seed size was maintained beyond the 2 oz seed treatment.

4.3. EXPERIMENT - II, SUCCESSIONAL LIFTING

In the following discussion, the dates at which Ilam Hardy (9.12.65) and Rua (23.12.65) reached an estimated emergence of 100% will be taken as the respective zero points in references to stages of plant growth.

4.3.1. Leaf Area

4.3.1.1. Leaf Area per Plant

The analysis of variance of leaf area (transformed into loge), is given in Table 29 and the data of which is presented in Appendix XIV. It shows that the overall effect of spacing, variety, and seed size on leaf area per plant was not significant. For the use of comparison between the spacing treatments, the untransformed mean of leaf area per plant was produced in Table 28.

TABLE 28

The effect of spacing on Leaf Area per Plant (dm^2)

(untransformed data)

Spacing	L.A. per Plant
6"	34.31
12"	60.81
18"	60.81
24"	71.45

It shows that there was an increased trend of leaf area as the spacing increased. The difference between the 12" and the 18" spacing was small; but between 6" and 24" spacing the differences were considerable.

Between harvesting dates there was a significant difference in leaf area per plant, it was in the order of (1, 2) $<$ 3, 4, 5, 6 $>^*$ 7th harvest, as shown in Table 30. The leaf area was rapidly increased up to the 3rd harvest (6 and 4 weeks after emergence for Ilam Hardy and Rua respectively). Following

TABLE 30

The effect of harvesting date on the Leaf Area per Plant (dm^2)

(untransformed data)

No.	Harvesting date	L.A. per plant	decoded S.E.
1	23.12.65	23.88	± 2.36
2	6.1.66	55.77	± 6.02
3	20.1.66	102.57	± 13.38
4	3.2.66	109.52	± 13.63
5	17.2.66	113.13	± 10.23
6	3.3.66	78.50	± 9.95
7	17.3.66	51.06	± 5.58
	9.12.65. Ilam Hardy) 23.12.65. Rua)	100% emergence	

* $>$ ($<$) = significantly higher (lower) at 5% level

TABLE 29

The Analysis of Variance of L.A. per plant dm^2
(Transformed into loge)

Source of Variation	S.S.	d.f.	M.S.	F
Replication = R	0.1231	1	0.1231	0.90 NS
Spacing = S	3.2923	3	1.0974	8.06 NS
E_1	0.4086	3	0.1362	
Variety = V	0.0001	1	0.0001	< 1 NS
V x S	1.3803	3	0.4601	2.69 NS
E_2	0.6853	4	0.1713	
Seed Size = Z	0.1814	1	0.1814	3.29 NS
Z x S	0.3780	3	0.1260	2.29 NS
Z x V	0.6881	1	0.6881	12.49 **
Z x V x S	0.0225	3	0.0075	0.14 NS
E_3	0.4411	8	0.0551	
Harvest = H	14.0860	6	2.3477	20.41 **
H x S	3.9374	18	0.2187	1.90 *
H x V	5.7311	6	0.9552	8.31 **
H x V x S	1.6821	18	0.0935	0.81 NS
H x Z	0.6436	6	0.1073	0.93 NS
H x Z x S	1.3980	18	0.0777	0.68 NS
H x Z x V	0.4017	6	0.0670	0.58 NS
H x Z x V x S	1.5660	18	0.0870	0.76 NS
E_4	11.0362	96	0.1150	
TOTAL	48.0892	223		
Coefficient of Variation = 19.54%				

this, the rate of leaf expansion slowed down to reach a peak on the 5th harvest (10 and 8 weeks after emergence in Ilam Hardy and Rua respectively) and gradually decreased toward the end of the growing season.

The interaction between the harvesting date and spacing is illustrated in Fig. 7. (transformed to loge), the data for which is presented in Appendix XV. Although there was no overall spacing effect in the analysis, the interaction indicated that the spacing comparison (especially between the 6" and the wider spacings) became significantly greater at the last four harvests. The difference in leaf area between 12", 18", and 24" spacing was not significant, except at the 5th harvest, the 24" was significantly higher than the closer treatments. In general, all spacings effects gave similar trends, i.e., a rapid increase in leaf area up to the 3rd harvest (6 weeks for Ilam Hardy and 4 weeks for Rua after emergence). At this stage of growth, the 6" and 12" spacings appeared to have reached the maximum value. Thereafter, the 18" and 24" spacings, still increase with a slow rate when 2 and 4 weeks later the peak points were reached by that the respective treatments. From the maximum points, a declining trend was shown in the leaf area as the plant aged.

The interaction between harvesting and variety is illustrated in Fig. 8. (transformed to loge), and the data for which is presented in Appendix XVI. It shows that Ilam Hardy produced a higher leaf area than Rua in the early part of the growing period. As the season advanced the difference in leaf area was small; but the high value in Rua was maintained up to

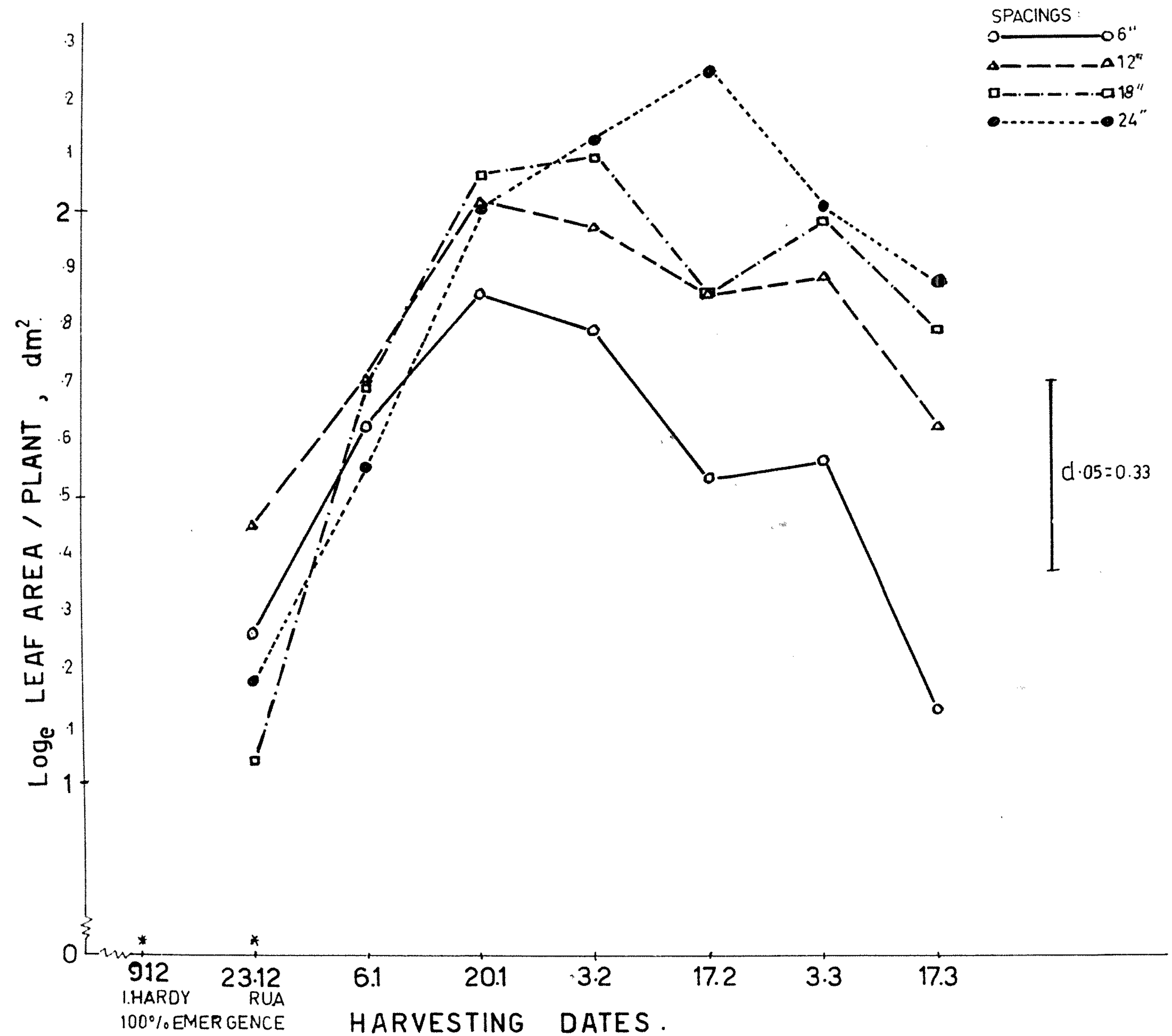


Fig. 7. The effect of harvesting date - spacing interaction

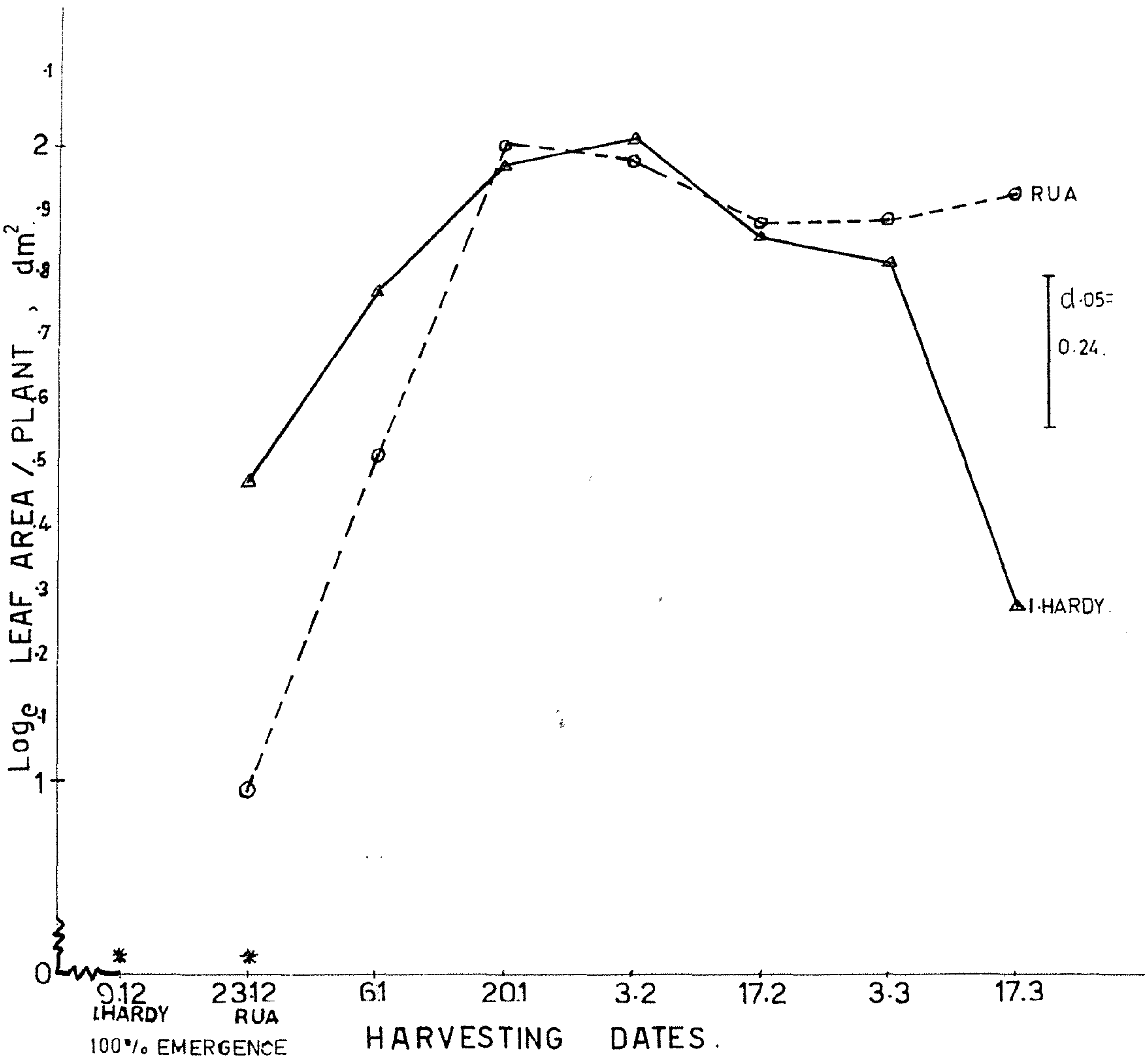


Fig. 8. The effect of harvesting date - variety interaction on L.A. per plant (dm^2), transformed into loge.

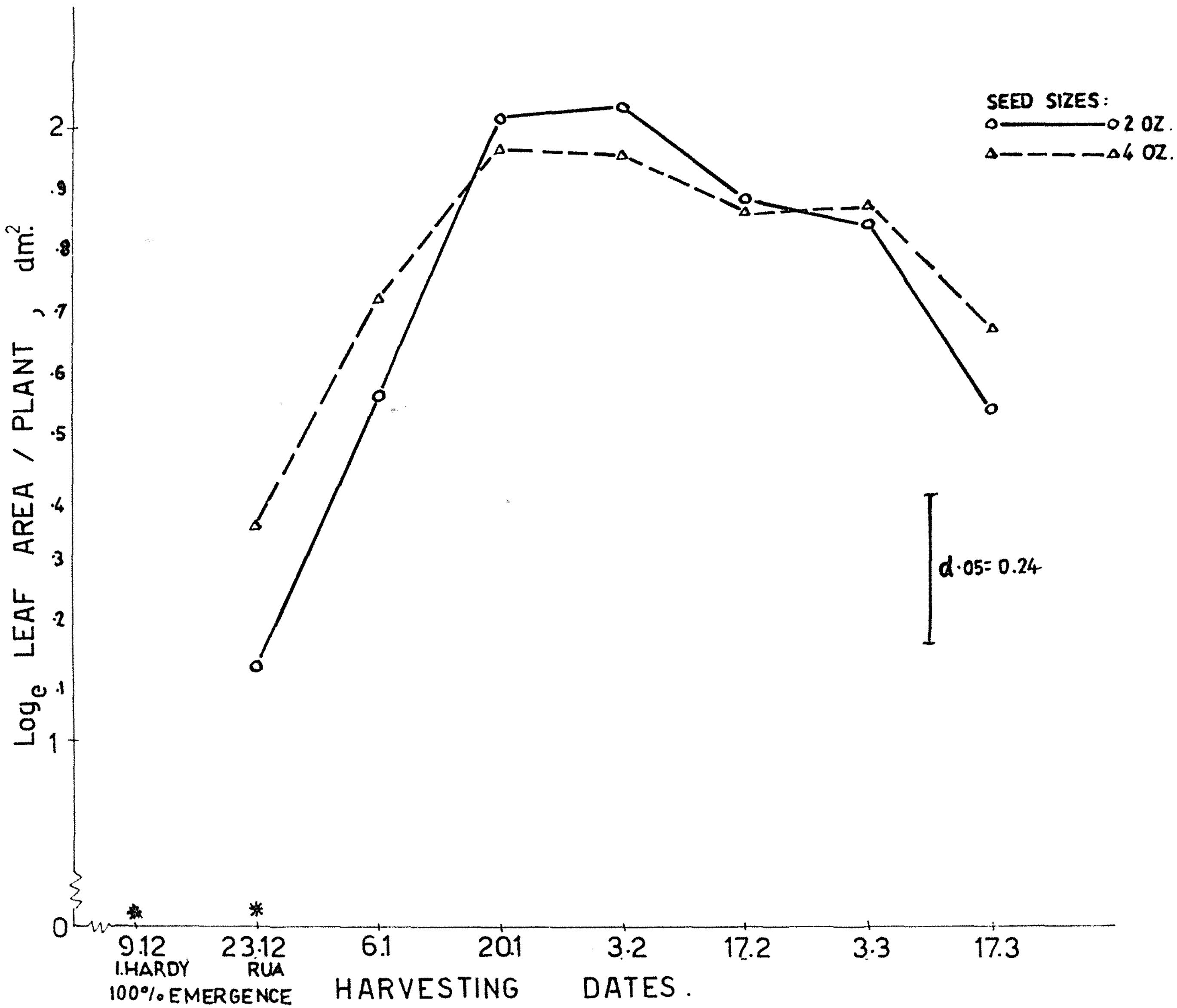


Fig. 9. The effect of harvesting date - seed size interaction on L.A. per plant (dm^2), transformed into $\log_e$.

the last harvest when it became significantly greater than Ilam Hardy.

Although the difference in leaf area between 2 oz and 4 oz seed size, was not significant, the comparison in Fig. 9 shows that the latter was higher than the former treatment in the early and later stages of growth.

4.3.1.2. Leaf Area Index (L.A.I.)

The L.A.I. was obtained by dividing the leaf area (dm^2) with the appropriate spacing area of soil (dm^2) per plant. The results are plotted in graphical form as shown in Fig 10 a,b,c,d,e, and the data of which are presented in Appendix XVII. It is to be noted that Rua 1 oz seed treatment was deleted from the analysis due to inadequate data. But the 1 oz seed of Ilam Hardy is presented in order to obtain a comparison between the 1 oz and larger seed sizes in that variety.

Fig. 10 (a to e) show that in both varieties at the 2 oz and 4 oz seed treatments, the 6" spacing was consistently higher L.A.I. than the wider spacings in most of the growing period. At the 1 oz Ilam Hardy seed, the L.A.I. of the 6" spacing did not show a similar pattern as above, but a lower value was produced. Taken overall, within the variety and seed size treatments the 12", 18" and 24" spacing did not show a great deal of differences in L.A.I., but there was an indication that the L.A.I. was lowered as the spacing increased.

A striking difference between Ilam Hardy and Rua was clearly shown in Fig. 10 a,b,c and d,e. In Ilam Hardy a sigmoid

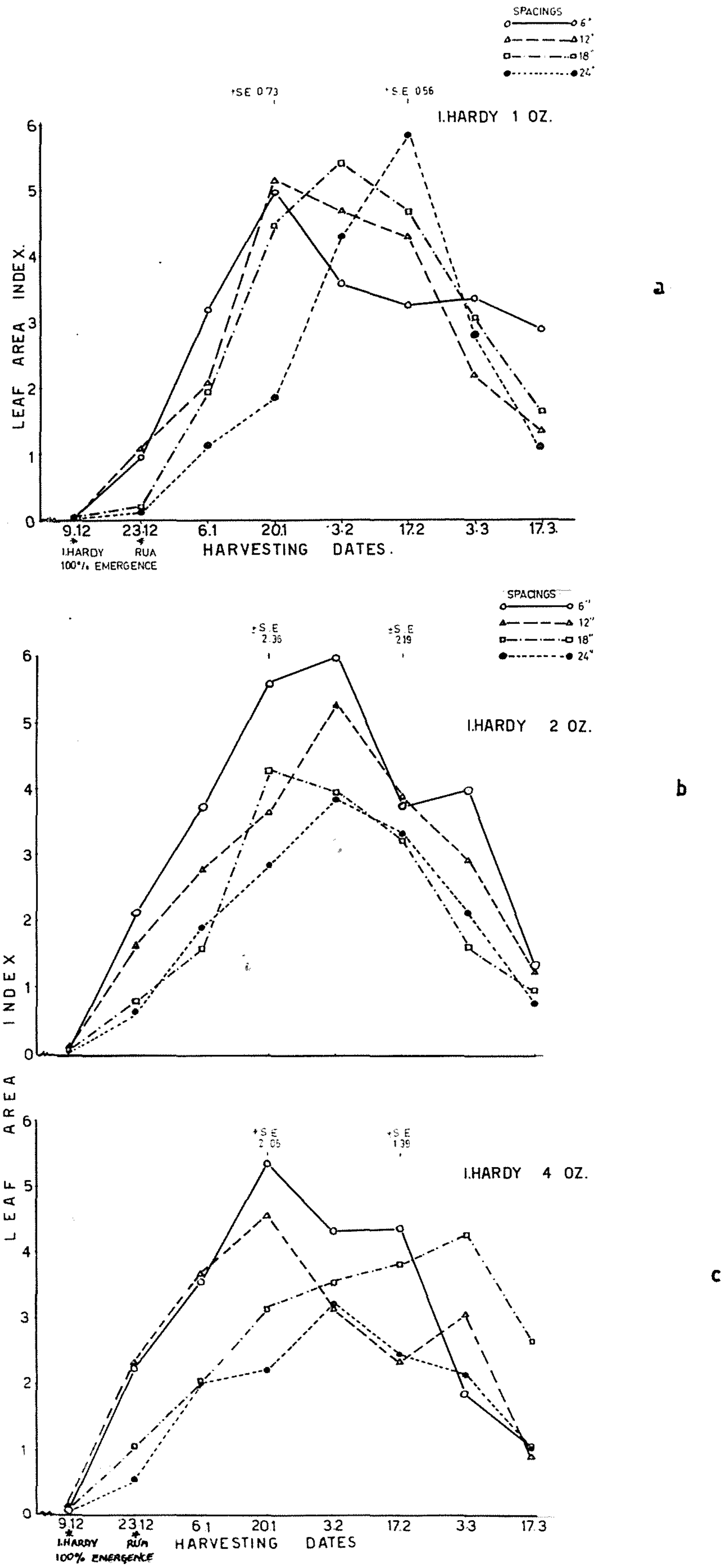


Fig.10. The effect of spacing, and seed size on L.A.I. in Ilam Hardy and Rua variety.

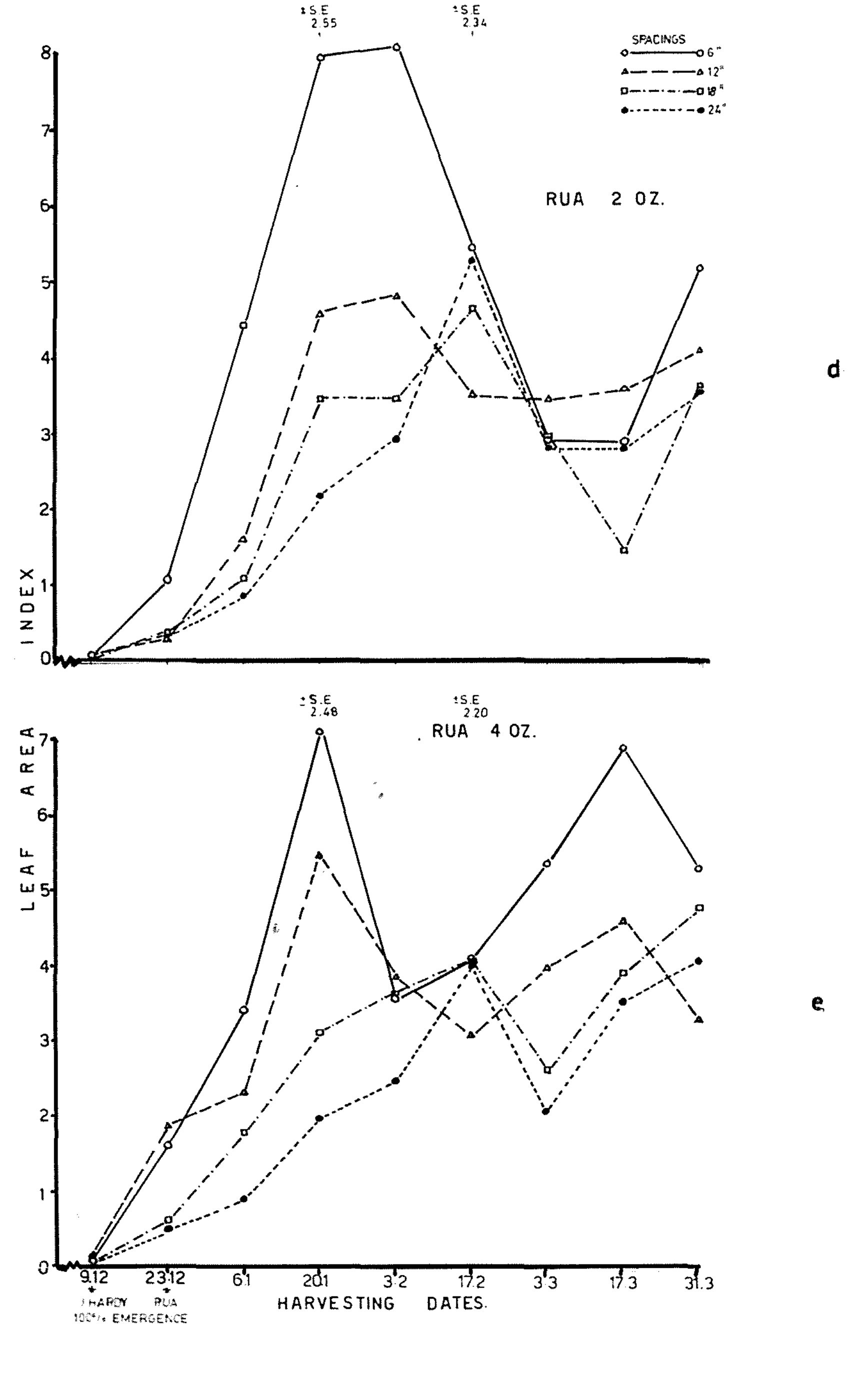


Fig. 10 (continued)

type curve with an initial rise to a peak and a final fall was indicated in all seed and spacing treatments. But in Rua there was a tendency for a second peak of L.A.I. being formed at the later stage of growing period. This feature is shown in all treatments of the latter variety. However, the L.A.I. appeared to be higher in Rua than in Ilam Hardy.

Between the 2 oz and the 4 oz seed treatment there was little difference in the L.A.I. in both varieties. Within Ilam Hardy the 1 oz seed treatment did not show any disadvantages in comparison with the bigger seed size.

In all cases the maximum L.A.I. in the different treatments showed a great variation, This indicated that there was no definite effect of spacing, varieties, and seed sizes on the peak of L.A.I.

4.3.2. Tuber Dryweight (g)

4.3.2.1. Tuber Dryweight per Plant

The analysis of variance of tuber dryweight per plant (transformed into loge) is given in Table 32, the data for which is presented in Appendix XVIII.

The result shows that the overall effect of spacing and variety on dryweight of tuber was not significant. The seed size treatments shows a significant effect where the 4 oz seed gave a higher dryweight yield of tuber per plant than the smaller seed treatment, as tabulated below:

Seed Sizes	Tuber D.W. g	decoded S.E.
2 oz	118.96	± 2.86
4 oz	135.11	± 3.64

Between harvesting periods there was a significant increase in dryweight from the initiation of tuber up to the 5th harvest (12 and 10 weeks after emergence for Ilam Hardy and Rua respectively), as shown in Table 31. Then the rate of increase

TABLE 31

Tuber dryweight (g) at different harvesting dates

No.	Harvesting date.	Tuber Dry weight	decoded S.E. ±
1	6.1.66	6.24	0.42
2	20.1.66	49.60	4.39
3	3.2.66	95.54	9.38
4	17.2.66	150.42	11.25
5	3.3.66	226.41	19.55
6	17.3.66	244.37	23.55
	9.12.65. Ilam Hardy) 23.12.65. Rua) 100% emergence		

in dryweight slowed down toward the end of growing period.

The interaction between harvesting date, variety and spacing, in one hand, and harvesting date, variety and seed size, on the other, is further examined in Fig. 11 to 12 (transformed into loge) in order to illustrate the relative rate of dryweight change in the tuber (the data, see Appendix XIX). In all cases a rapid increase in tuber dryweight has taken place within 4 weeks after tuber initiation,* thereafter the rate of increase

* Apparent tuber initiation given by extrapolation of the line to the time when the weight was zero.

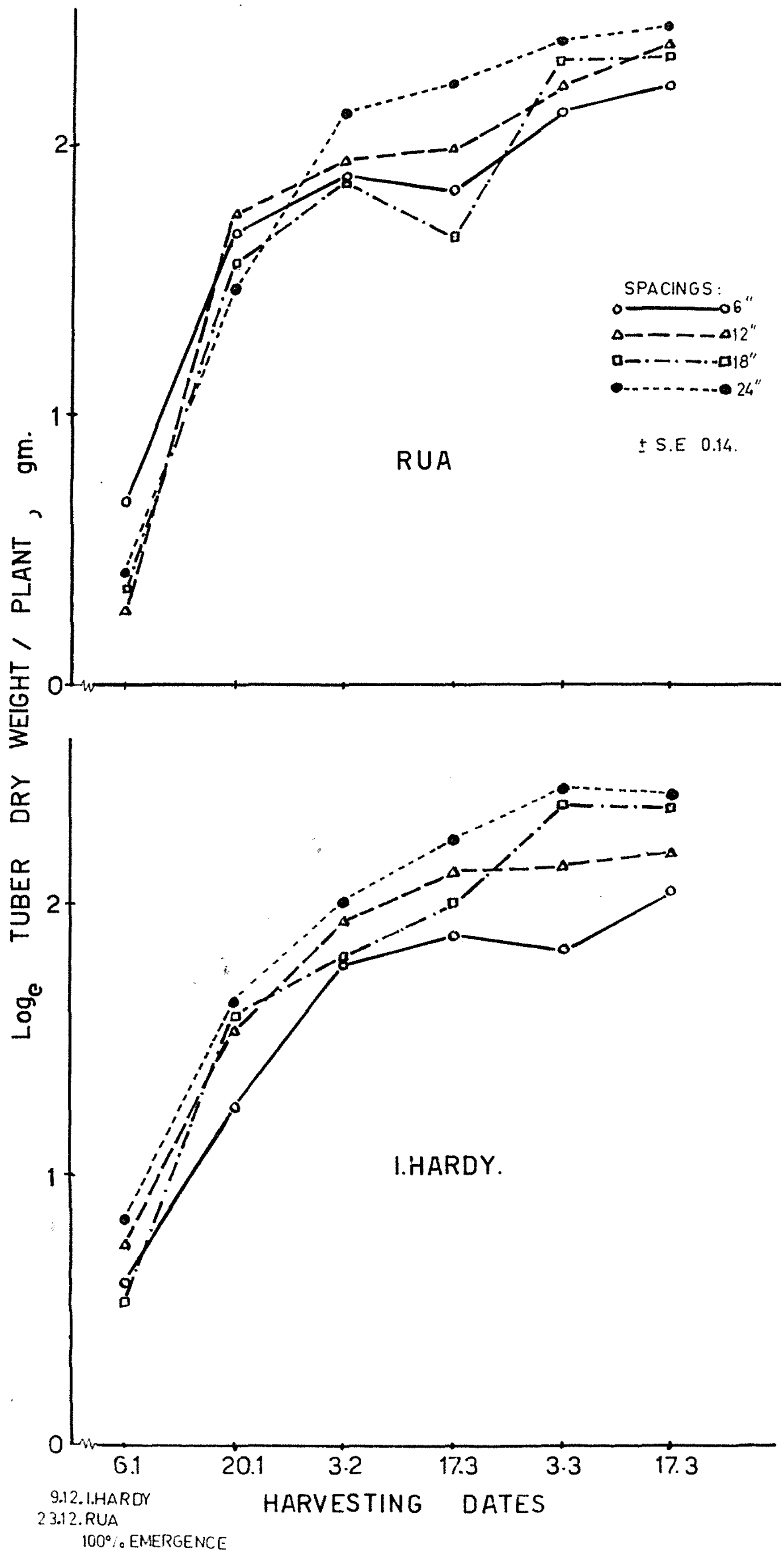


Fig.11. The effect of harvesting date - variety - spacing interaction on Tuber D.W. per plant (g), transformed into loge.

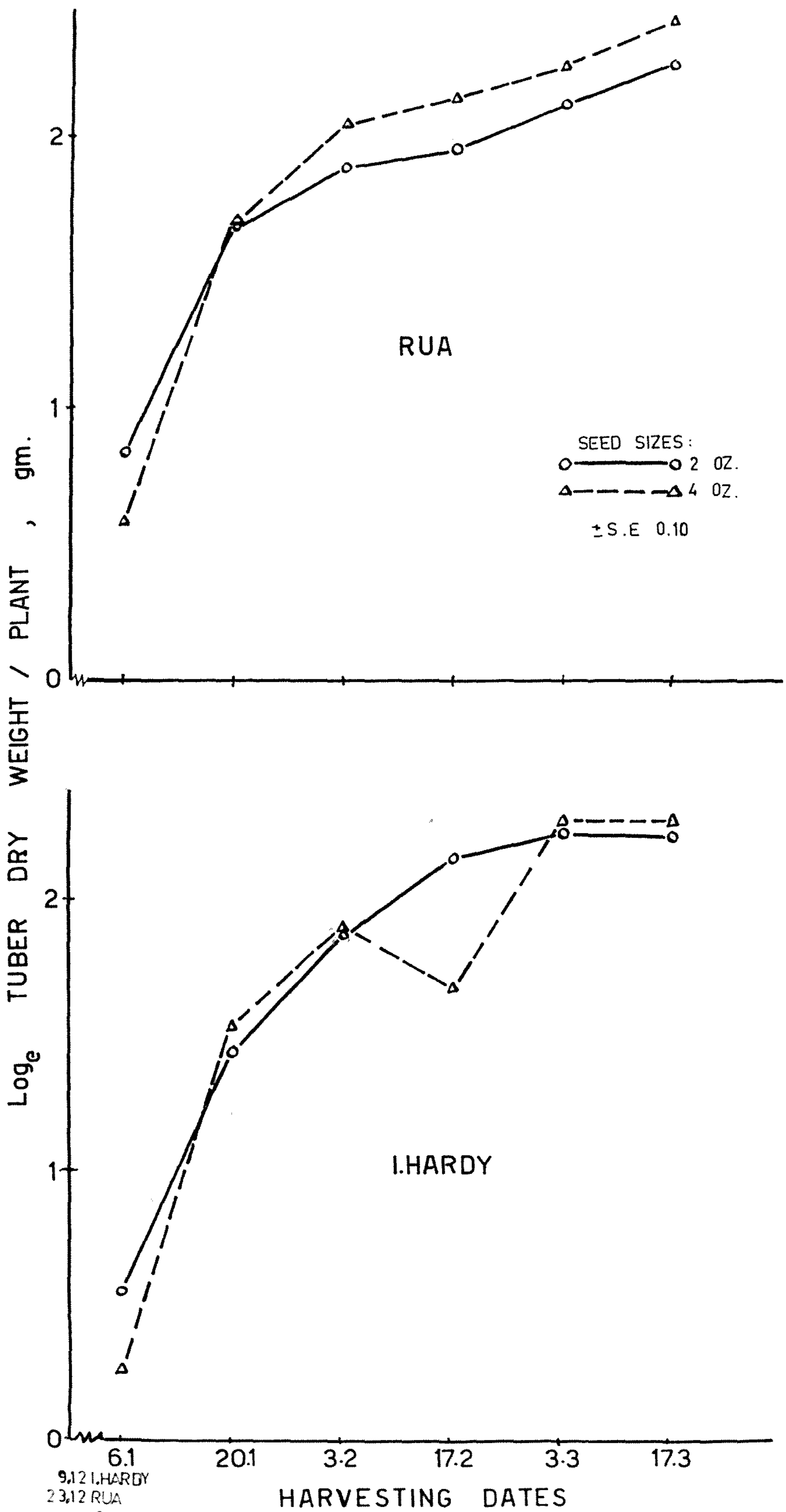


Fig. 12. The effect of harvesting date - variety - seed size interaction on Tuber D.W./plant (g), transformed into loge.

TABLE 32

The Analysis of Variance of Tuber Dryweight per Plant (g), transformed to loge

Source of Variation	S.S.	d.f.	M.S.	F
Replication = R	0.029	1	0.029	0.15 NS
Spacing = S	1.166	3	0.389	1.95 NS
E_1	0.597	3	0.199	
Variety = V	0.007	1	0.007	0.05 NS
V x S	0.385	3	0.128	0.98 NS
E_2	0.523	4	0.131	
Seed Size = Z	0.594	1	0.594	11.88 **
Z x S	0.155	3	0.052	1.04 NS
Z x V	0.299	1	0.299	5.98 *
Z x V x S	0.634	3	0.211	4.22 *
E_3	0.396	8	0.050	
Harvesting = H	65.901	5	13.180	162.71 **
H x S	1.472	15	0.098	1.21 NS
H x V	0.891	5	0.178	2.20 NS
H x V x S	0.796	15	0.053	0.65 NS
H x Z	0.640	5	0.128	1.58 NS
H x Z x S	0.436	15	0.029	0.36 NS
H x Z x V	0.736	5	0.147	1.81 NS
H x Z x V x S	1.280	15	0.085	1.04 NS
E_4	6.814	80	0.081	
TOTAL	83.751	191		
Coefficient of Variation = V = 21.4%				

declined as the plants aged. In Ilam Hardy all curves tended to flatten in the last harvest, but in Rua a continuous upward trend became a feature.

A comparison between the spacing effect can be generalised, that the advantage of wider spacing became clearly shown in both varieties as the plants became mature. These differences are more pronounced in Ilam Hardy than in Rua.

The influence of seed sizes appeared to be little different. Both varieties showed that 4 oz seed treatment was slightly higher than the 2 oz seed sizes. The difference was more marked in Rua variety.

4.3.2.2. Tuber Dryweight per Unit Area (g/sq.ft)

In Fig. 13 the change in tuber dryweight with time are plotted on an area basis, i.e., dividing the tuber dryweight (gm) by the appropriate spacing area of the soil (sq.ft) in its consecutive harvesting period (the data see Appendix XX). The objective is to demonstrate the effect of spacing, variety, and seed size on the dryweight accumulation in the tuber in a unit area basis as corresponding measurement to L.A.I. and yield.

Here the trends are the reverse of those shown in Figs. 11 and 12: the 6" spacing produced highest tuber dryweight yield. This spacing effect is more pronounced in Rua than in Ilam Hardy. The 6" and the 12" spacings markedly out-yielded the wider spacing treatments in Rua, but in Ilam Hardy the difference was slight.

The graph also shows that the advantage of 6" spacing becomes greater as the seed size increases (Fig. 13 a,c,d,e),

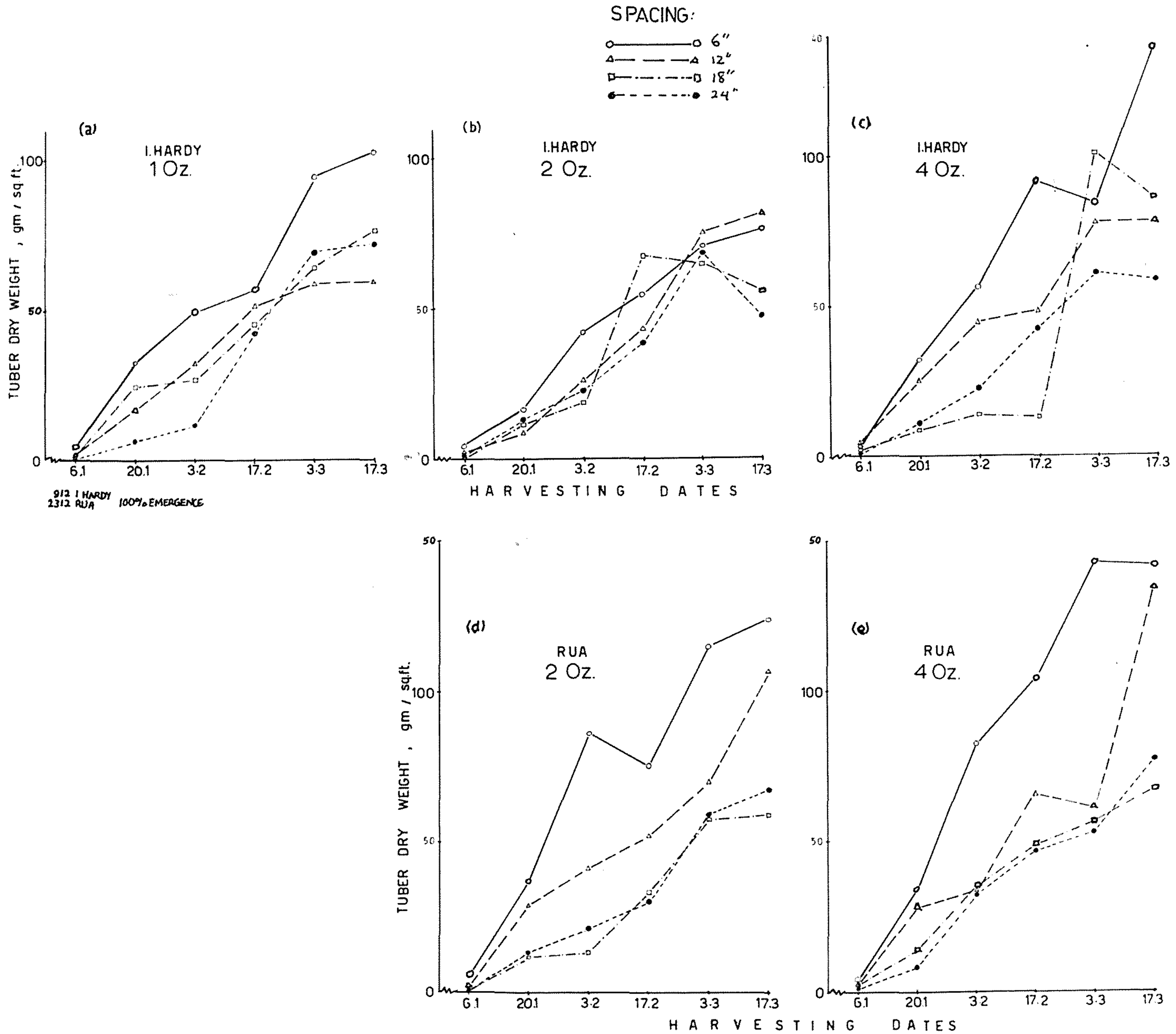


Fig. 13. The effect of all treatments combinations on Tuber D.W. per unit area (g/sq.ft.)

except in Fig. 13 b where the yield of Ilam Hardy 2 oz appeared to drop in the last harvest.

However, there was a difference between varieties. Rua produced a greater dryweight than Ilam Hardy. The difference was particularly large at the close spacings in all seed size treatments. At the last harvest Rua still showed an increase in dryweight accumulation, whereas at this time Ilam Hardy had reached the maximum yield.

4.3.3. Dryweight of "Remainder" per Plant

Dryweight of "remainder" was the dryweight of that portion of the plant other than the tubers. No separate weights were taken of the tops and roots because the latter represented a very small proportion of the "remainder". This measurement was used to indicate the change in top growth as influenced by the treatments.

The analysis of variance (transformed into $\log_e$) is given in Table 34, and the data for which is presented in Appendix XXI.

It shows that there was no significant effect of spacing, variety, and seed size on the dryweight of "remainder". The significant effect of harvesting period was in the order of $1 < 2 \overset{*}{<} 3, 4, 5, 6, > 7$th harvest (Table 33). The dryweight was rapidly increased up to the 4th harvest (8 and 6 weeks after 100% emergence for Ilam Hardy and Rua respectively), thereafter the

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* = significantly lower at 5% level of probability

TABLE 33

The effect of harvesting date on the D.W. of "Remainder" per Plant (g), transformed into loge

No.	Harvesting date	Loge D.W. of "Remainder"	S.E.
1	23.12.65	1.11	
2	6.1.66	1.60	
3	20.1.66	1.98	
4	3.2.66	2.10	
5	17.2.66	1.97	± 0.06
6	3.3.66	2.00	
7	17.3.66	1.79	
	9.12.65 - Ilam Hardy) 23.12.65 - Rua) 100% emergence		

yield tended to decline slowly toward the end of growing period. An illustration of the significant interaction between harvesting and spacing is shown in Fig.14. Although there is no overall effect of spacing, throughout the investigation the 6" spacing was consistently lower in dryweight of "remainder" than the wider spacings. In the last three harvestings the difference between 6" and 24" became significant, whereas between 12" and 18" the difference was small.

Between the two varieties, however, Ilam Hardy was significantly higher yield up to the 5th harvest, thereafter Rua became superior to Ilam Hardy (Table 35).

TABLE 34

Analysis of Variance of D.W. of "Remainder" (g) per plant, transformed into $\log_e$

Source of Variation	S.S.	d.f.	M.S.	F
Replication = R	0.176	1	0.176	1.09 NS
Spacing = S	2.548	3	0.849	5.27 NS
E_1	0.482	3	0.161	
Variety = V	0.287	1	0.287	1.07 NS
V x S	1.317	3	0.439	1.04 NS
E_2	1.071	4	0.268	
Seed Size = Z	0.062	1	0.062	1.72 NS
Z x S	0.054	3	0.014	< 1 NS
Z x V	0.493	1	0.493	13.69 **
Z x V x S	0.127	3	0.042	1.17 NS
E_3	0.289	8	0.036	
Harvesting = H	22.715	6	3.786	37.49 **
H x S	3.276	18	0.182	1.80 *
H x V	5.785	6	0.964	9.54 **
H x V x S	2.056	18	0.114	1.13 NS
H x Z	1.268	6	0.211	2.00 NS
H x Z x S	1.739	18	0.097	< 1 NS
H x Z x V x S	2.448	18	0.136	1.35 NS
H x Z x V	0.753	6	0.126	1.25 NS
E_4	9.694	96	0.101	
TOTAL	56.640	223		

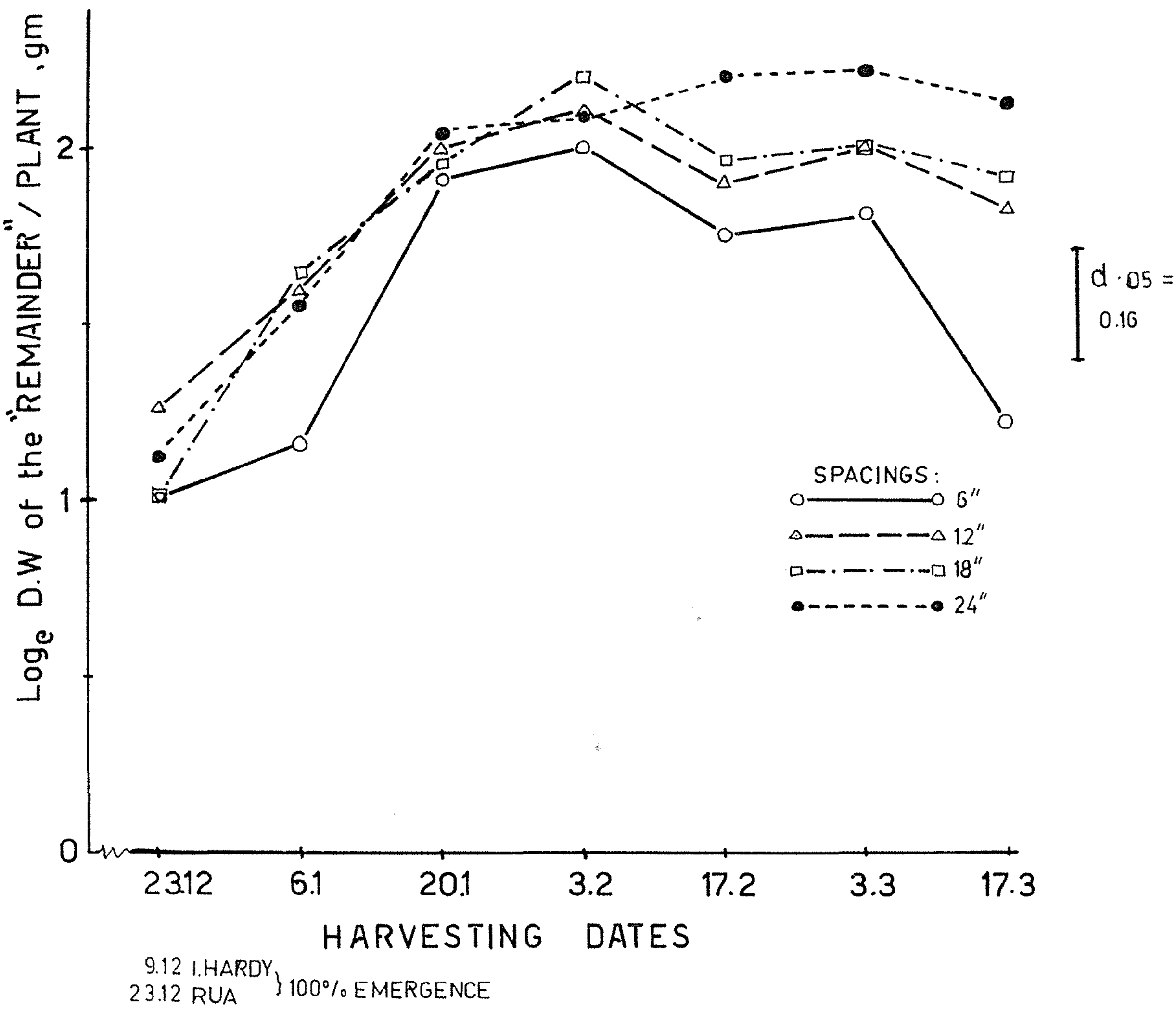


Fig. 14. The effect of harvesting date - spacing interaction on D.W. of "Remainder" per plant (g), transformed into loge.

TABLE 35

The effect of harvesting - variety interaction on D.W. of "Remainder" (g), transformed into loge

Harvest	D.W. of "remainder"	
	Ilam Hardy	Rua
1	1.38	0.84
2	1.75	1.45
3	2.01	1.96
4	2.16	2.05
5	2.08	1.85
6	1.89	2.12
7	1.52	2.03
S.E. ± 0.08		

4.3.4. Dry Matter Partition

The dryweight of the tuber and the "remainder" (the foliage plus the roots) per unit area was plotted additively in graphical form as illustrated in Fig.15. The data for this is given in Appendix XXII and XXIII. This addition of both components gave a total dryweight of the plant at the successive lifting periods. Each point in the graphs represents the mean of 4 plants.

A striking feature of these illustrations is the large contribution of tuber dryweight to the total dryweight for the greater part of the season in all treatments. The partition of dry matter into the tuber appeared to commence within four weeks after the first harvesting period (4 and 2 weeks after emergence for Ilam Hardy and Rua respectively). Up to the 3rd harvest most of the assimilate was utilised for the growth of the foliage. Thereafter a relatively greater dryweight was contributed to the

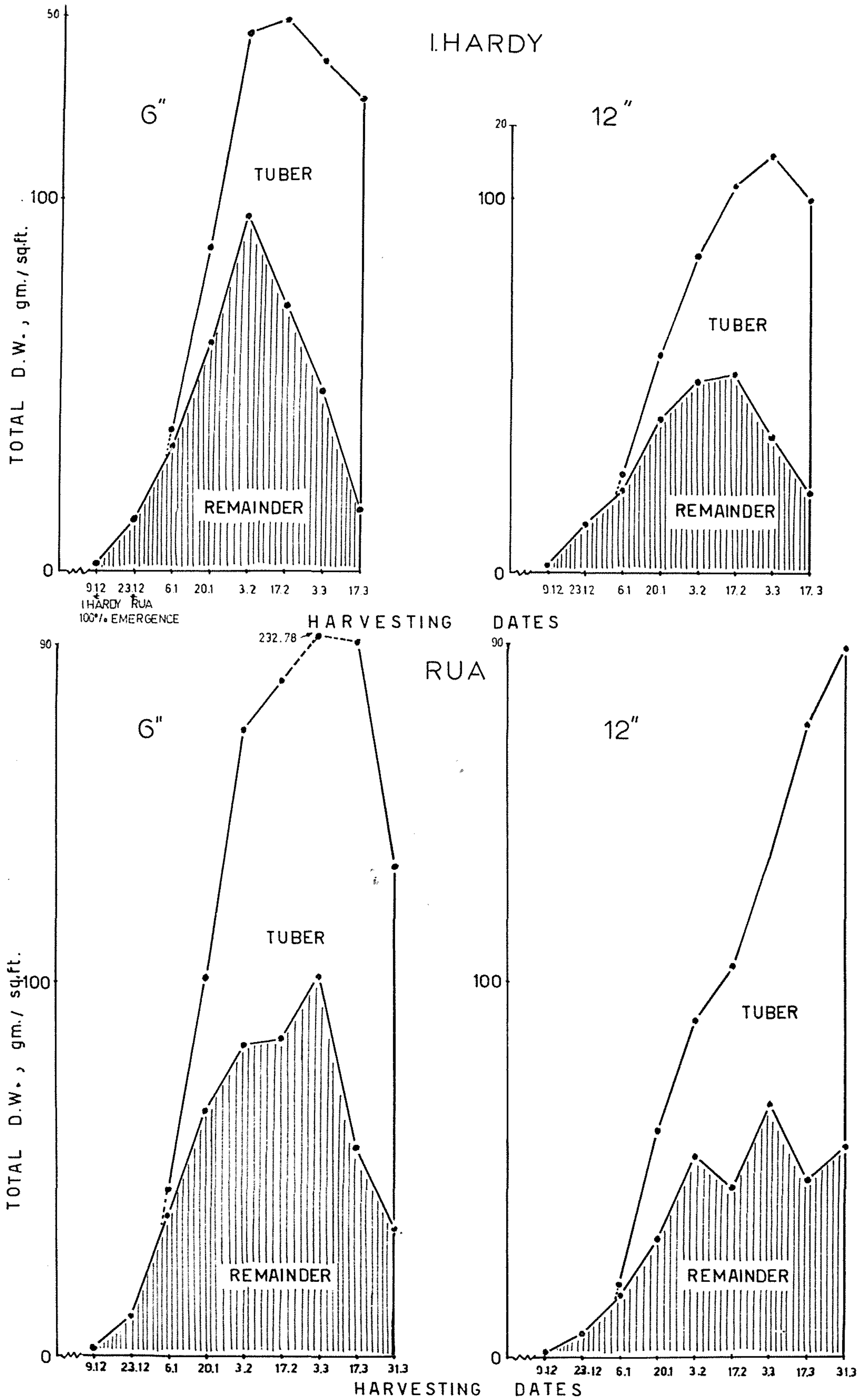
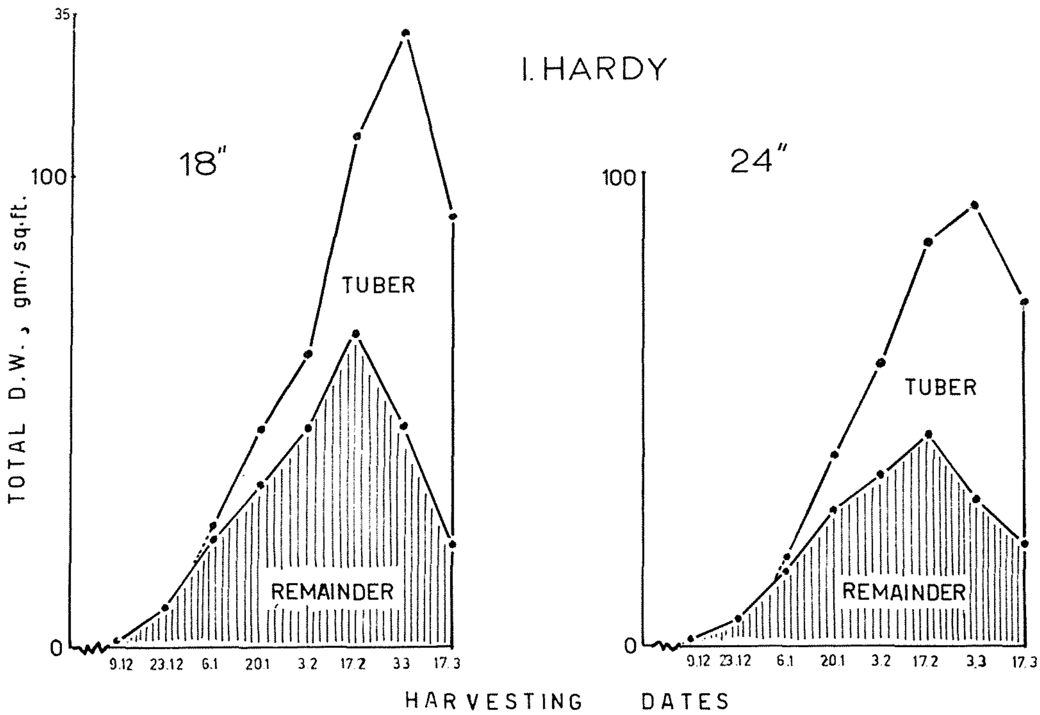


Fig.15. Total D.W. and Dry Matter Partition in all treatment combinations.



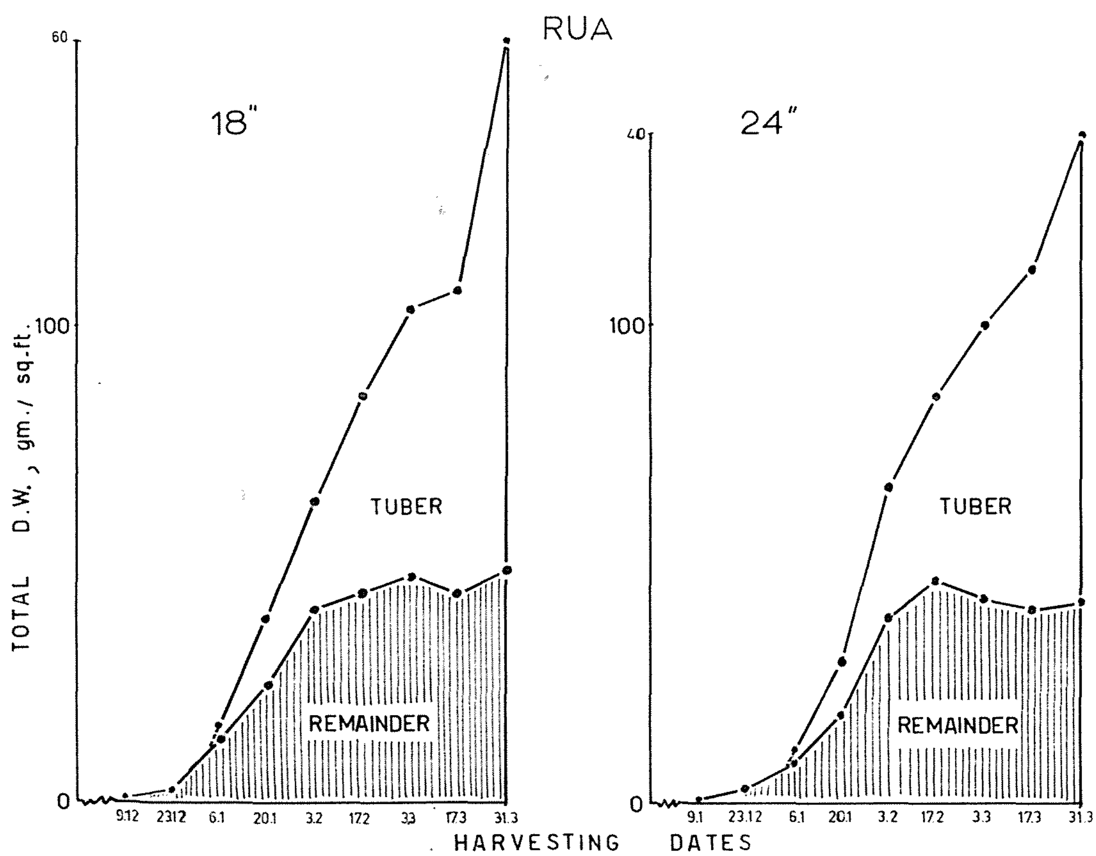


Fig 15 (continued)

tubers. This rapid increase in dry matter of the tuber appeared to be accompanied by a corresponding decrease in dry matter of the "remainder." This suggests that the partition of dry matter into the tuber occurred at the expense of the "remainder", particularly toward the end of the growing season.

In a comparison between the two varieties, Rua recorded a total dryweight higher than Ilam Hardy in all cases. The dry weight of the "remainder" did not appear to differ a great deal. Thus, the difference in total dryweight gain between the two varieties is attributed mainly to the tuber. A decline in the dryweight of the "remainder" followed by a corresponding drop in total dryweight for Ilam Hardy, indicates an earlier maturity of this variety compared with Rua. In the latter the total dryweight still increased up to the last harvest. It is obvious that Rua maintained a longer growing period, than Ilam Hardy, which gave the former the advantage of further increase in dry matter accumulation in the tuber.

Within each variety the spacing effect showed a similar pattern in dry matter change. For Ilam Hardy all spacing treatments showed a sudden drop in dryweight in the last harvest, but in Rua an upward trend is exhibited. An important feature of these results is the marked superiority of the 6" treatments over the other spacing intervals which is reflected in a higher total dryweight production for both varieties. Between the 12" and 18" treatment for Ilam Hardy there was little difference but both are slightly higher than the 24" spacing. In Rua, however, the 12" gave a higher total dryweight than the 18" and the 24", which between both there was little difference. The graphs seem to

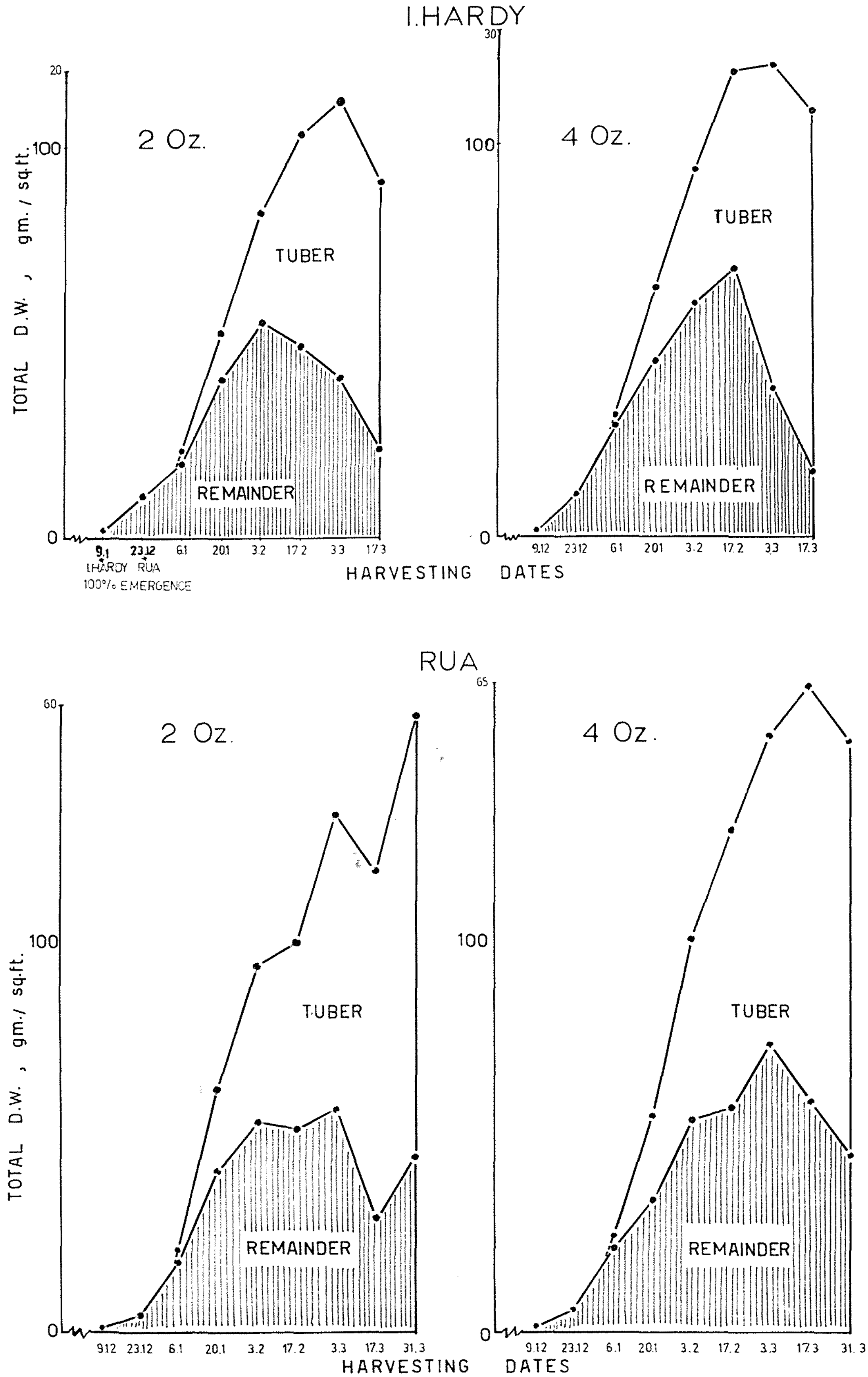


Fig. 16. Total D.W. and Dry Matter Partition at 2 and 4 oz seed size in Ilam Hardy and Rua.

indicate that as the spacing became wider the partition of dry matter into the "remainder" proportionately became greater.

The influence of seed sizes is shown in Fig. 16, in which the 4 oz seed gave a higher total dryweight than the 2 oz seed treatment. This superiority of 4 oz seed is marked in Rua variety.

4.3.5. Net Assimilation Rate (N.A.R.)

The N.A.R. was calculated based on Milthorpe's (1963) mathematical equation as shown in section 2.2.2. Total dryweight (= dryweight of tubers plus the "remainder") and leaf area per plant is given in Appendix XIV, XXII and XXIII.

In Table 36 the value of N.A.R. at different treatments was recorded. It was calculated between 2 and 12 weeks after emergence for Ilam Hardy, between 0 and 10 weeks for Rua. It showed that the value was extremely variable. This was mainly due to a considerable variation in the dryweight and the leaf area value. Fluctuation in weather conditions (Watson, 1952), was probably another factor. Moreover, lack of replication and possible error involved in the mathematical calculation may considerably bias the results. The negative value was encountered during the growing period, the cause of which is unknown.

A trend of initial increase in N.A.R. at the early phase of the growing period seems evident. But thereafter, all that may be said is that N.A.R. tends to decline with time.

However, between the spacing and seed size treatments there appeared to be no difference in N.A.R. Taken overall, it shows that Rua had a slightly higher N.A.R. than Ilam Hardy.

TABLE 36

The effect of spacing, variety, and seed size on N.A.R.
($g/dm^2/2$ weeks)

Treatment	Harvesting Interval				
	23/12-6/1	6/1-20/1	20/1-3/2	3/2-17/2	17/2-3/3
Spacing: 6"	0.597	0.420	-3.950	0.765	0.872
12"	0.317	0.635	-0.132	0.562	-0.232
18"	0.555	0.422	-0.295	0.877	0.840
24"	0.450	0.792	0.507	0.190	0.610
Variety: I.Hardy	0.394	0.398	0.285	-0.094	0.540
Rua	0.566	0.736	-0.223	0.526	0.505
Seed Size: 2 oz	0.499	0.675	-2.327	0.336	0.384
4 oz	0.461	0.460	0.384	0.096	0.661

4.3.6. Tuber Fresh Weight

4.3.6.1. Tuber Fresh Weight per Plant

In each lifting period the tuber fresh weight was also recorded. The data is presented in Appendix XXIV.

The main effects of spacing within each variety and seed size treatment is illustrated in a histogram form as shown in Fig. 17.

The influence of spacing in each harvest showed variable results. In the early part of the lifting period the difference between spacing treatment was small but with the passage of time the advantage of wider spacing became apparent. In all cases, the 6" spacing was lower in fresh weight gain per plant compared with the wider spacings. The difference between the 12" and 18" spacing was more obvious at the end than at the beginning of the season, whereas the 24" spacing, in most cases, was superior in fresh weight yield to the closer spacing in the last three harvests.

The rate of increase in fresh weight of the tubers over the two week intervals was relatively higher in Rua than Ilam Hardy. Also Rua showed a longer period of "bulking."*

In each variety the difference between seed size treatments was not a greal deal. It appeared that the advantage of wider spacings became greater at the larger seed size treatment.

The diagrams illustrate that the main bulking of the tubers took place largely at the later stage of the growing period.

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*"Bulking rate" is the rate of increase in fresh weig of tubers per plant per week.

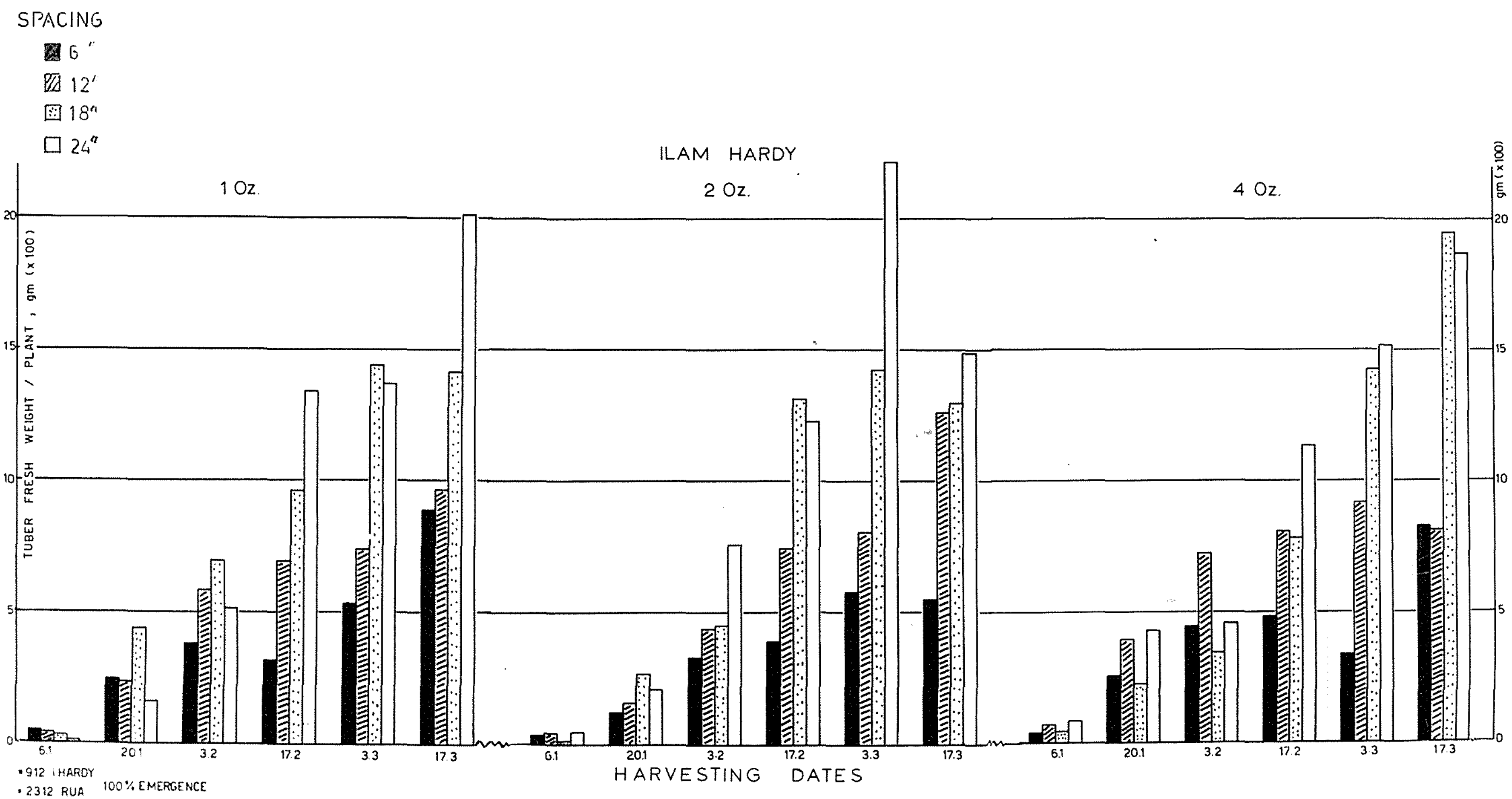

Fig.17. The effect of spacing variety, and seed size on Tuber Fresh Weight (gm x 10^2)

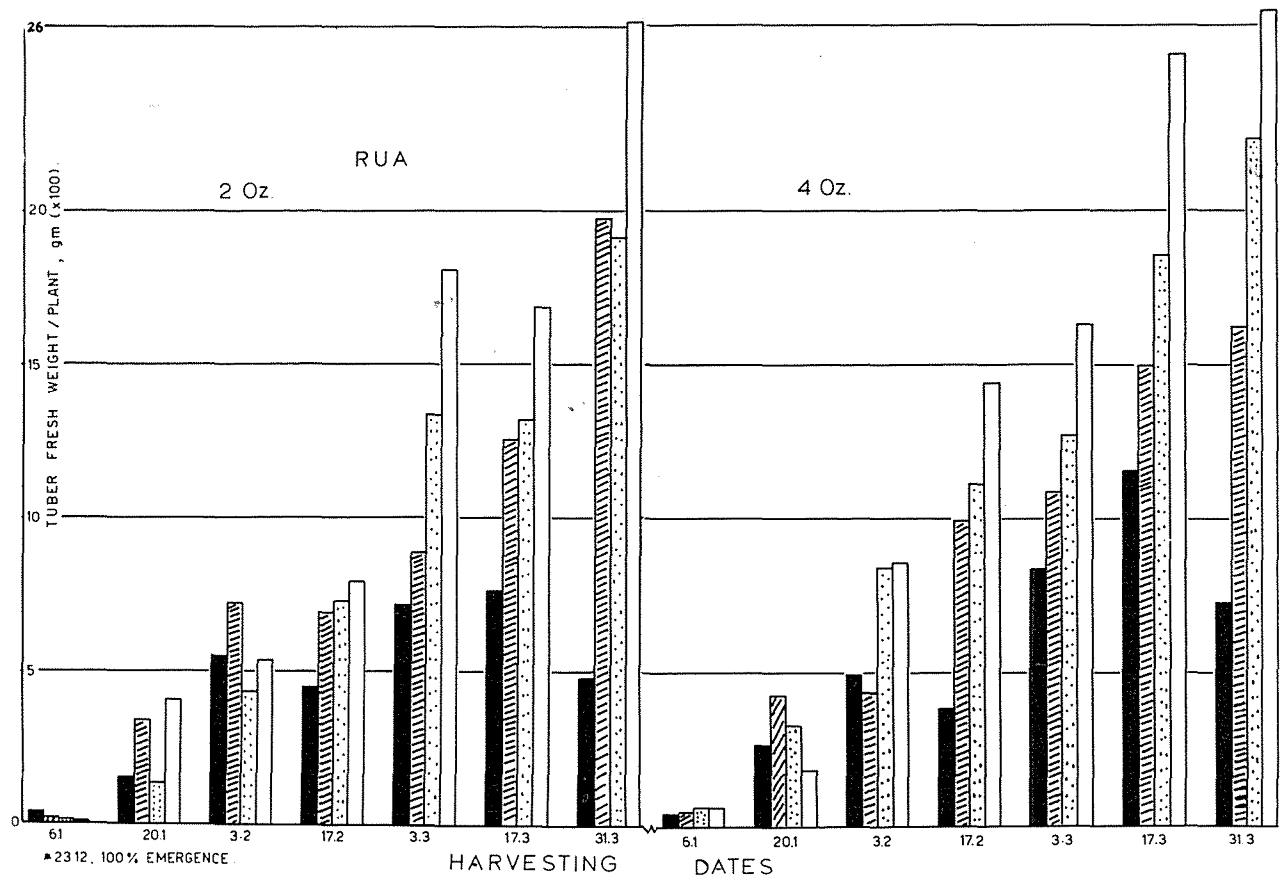

Fig. 17. (continued)

THE EFFECT OF SPACING AND SEED SIZE ON THE YIELD OF POTATOES

Spacing	Seed Size	Seed Rate	Total Yield	Large and Table potato	Seed and Small potato
inch	oz.	cwt/ac	ton/ac	ton/ac	ton/ac
6	1	19.44	25.36	20.11	5.25
	2	38.88	31.67	24.05	7.62
	4	77.80	34.20	24.56	9.64
12	1	9.72	21.06	17.59	3.47
	2	19.44	23.20	18.82	4.38
	4	38.88	23.14	17.89	5.25
18	1	6.48	20.18	17.56	2.62
	2	12.96	22.24	18.81	3.43
	4	25.92	23.10	18.60	4.50
24	1	4.86	17.25	15.13	2.12
	2	9.72	21.29	18.64	2.65
	4	19.44	19.97	17.05	2.92

How do you get high L.A.I. before bulking occurs

Yield – [illegible] Taki

4.3.6.2. Tuber Fresh Weight per Unit Area

Tuber fresh weight was also further examined in a unit area basis. This was done by dividing the fresh weight yield in each lifting period by the appropriate area of soil (sq.ft). The effect of all treatments on the fresh weight per sq.ft. is given in a graphical form as shown in Fig. 18.

The influence of spacing showed a reversed position. The 6" spacing gave an earlier and higher rate of "bulking" than the wider spacings in all treatments. This advantage became greater at the 4 oz seed size. The difference between the 12" and the 18" spacings was small, both showed higher fresh weight yield over the 24" spacing throughout the experimental period.

Rua, had a higher yield than Ilam Hardy. Moreover, a longer duration of tuber growth is also indicated in the former variety.

The difference in yield between seed size treatments within each variety was small.

4.3.7. Tuber Numbers

Any swollen tip on a stolon, as small as the size of a marble, was considered to be a tuber. After the measurement of leaf area, the tubers were picked up from each plant and put into a washing tray where they were then counted and recorded. The analysis of variance of the data (Appendix XXV) is given in Table 38.

It shows that the spacing and varietal effect was not significant. Both these treatments together with seed size effect

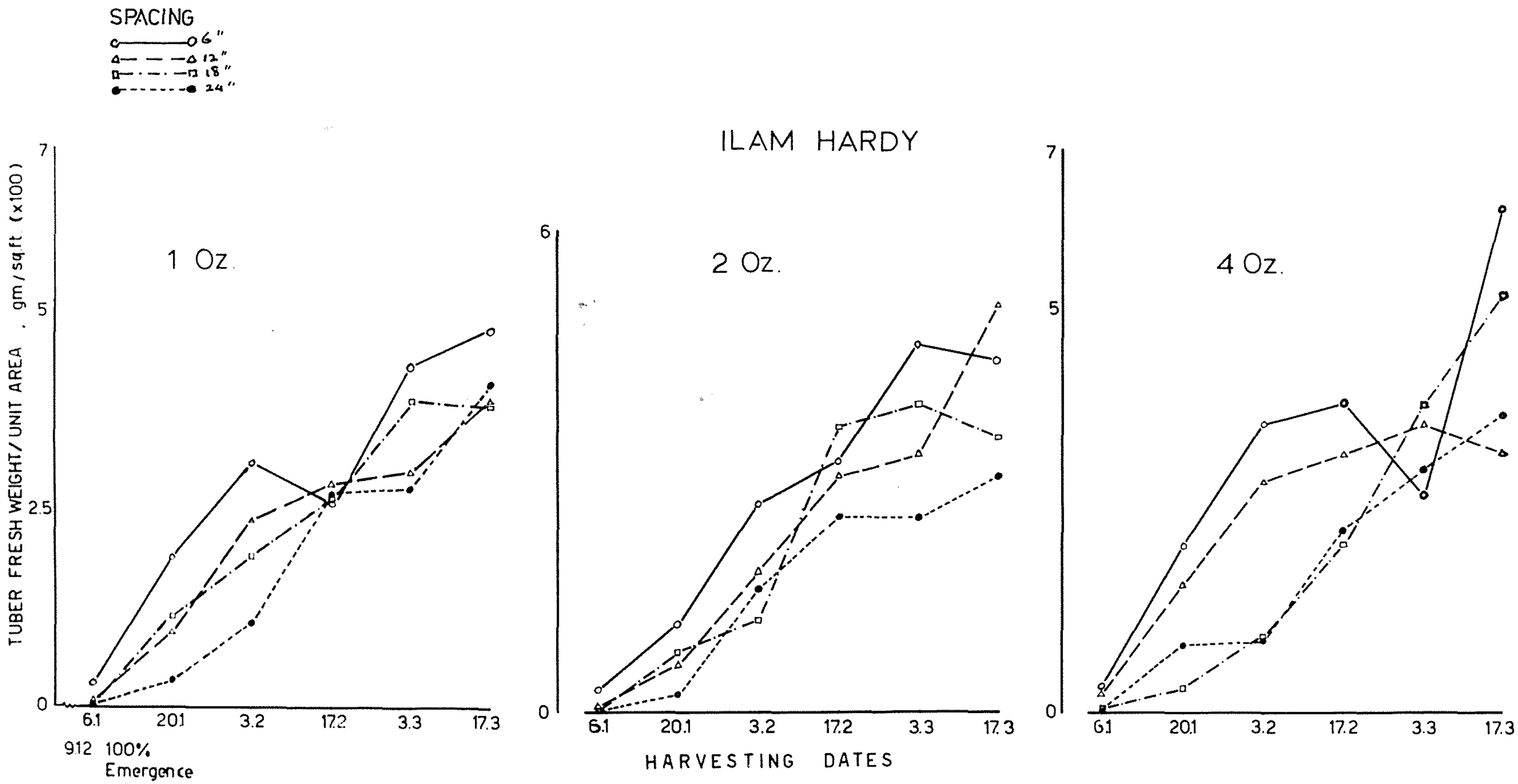

Fig.18. The effect of spacing, variety, and seed size on Tuber Fresh Weight per unit area (gm/sq.ft, x 10^2)

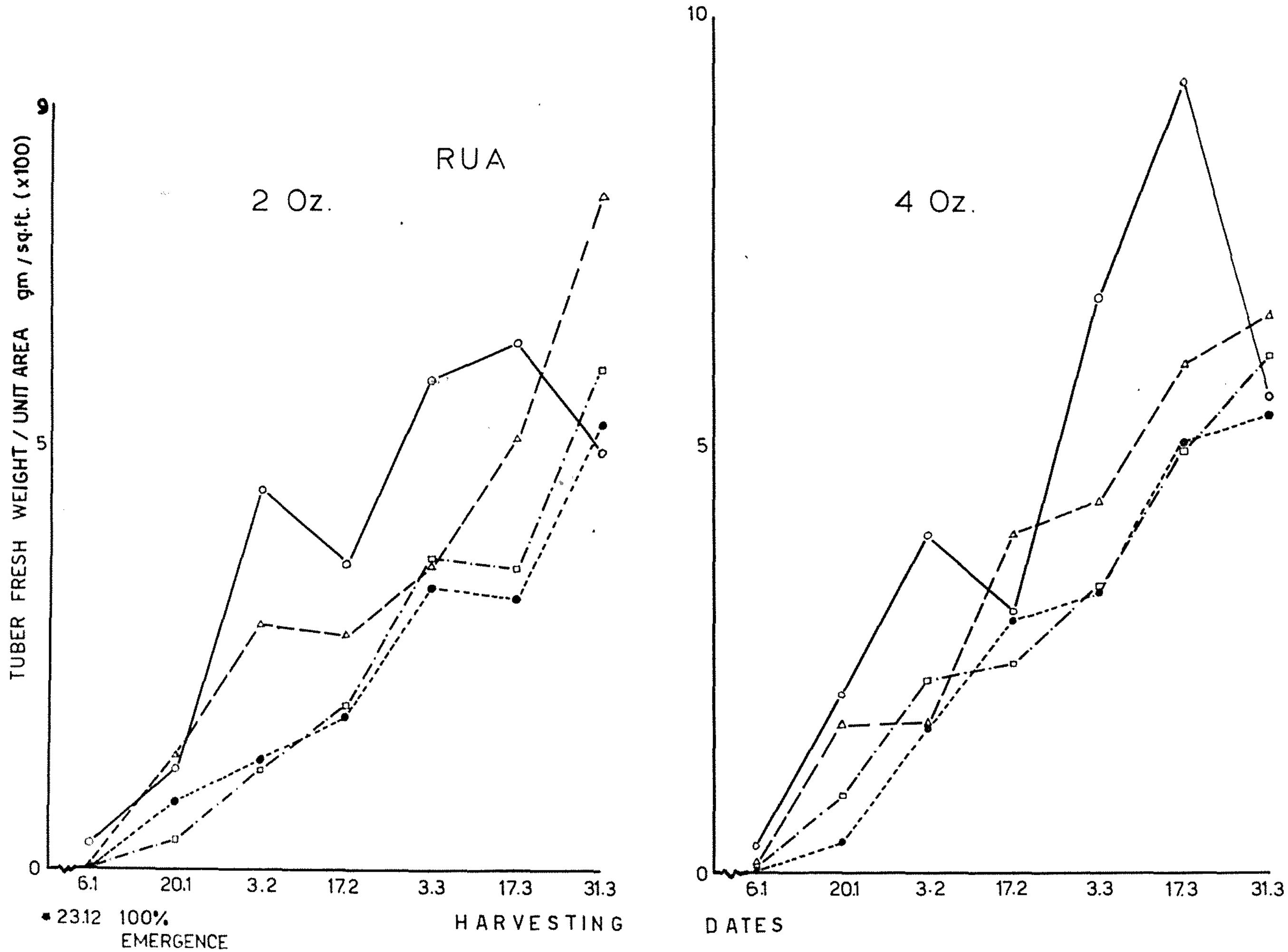

Fig. 18 (continued)

on the number of tuber are examined in Table 37.

TABLE 37

The effect of spacing, variety, and seed size on the mean Tuber Number per plant.

Treatment	Tuber No/plant	S.E.
Spacing: 6"	7.52	
12"	10.25	± 0.67
18"	10.63	
24"	12.04	
Variety: Ilam Hardy	10.94	± 0.67
Rua	9.28	
Seed Size: 2 oz	5.27	± 0.43
4 oz	11.43	

Although the overall effect of spacing was not significant, the mean number of tubers showed an upward trend as the spacing increased. Between the 12" and 18" treatments there was little difference, but the difference was large between 6" and the 24" spacing where a higher number was produced by the latter.

The difference between the two varieties was very small, Ilam Hardy being slightly higher than Rua.

The 4 oz seed was significantly higher in tuber numbers than was the 2 oz seed treatment.

The interaction between seed size and variety indicates that only at the 2 oz seed treatment was Ilam Hardy higher than Rua (see Table 39).

The mean number of tubers per plant in each harvesting intervals is illustrated in a histogram form as given in Fig. 19.

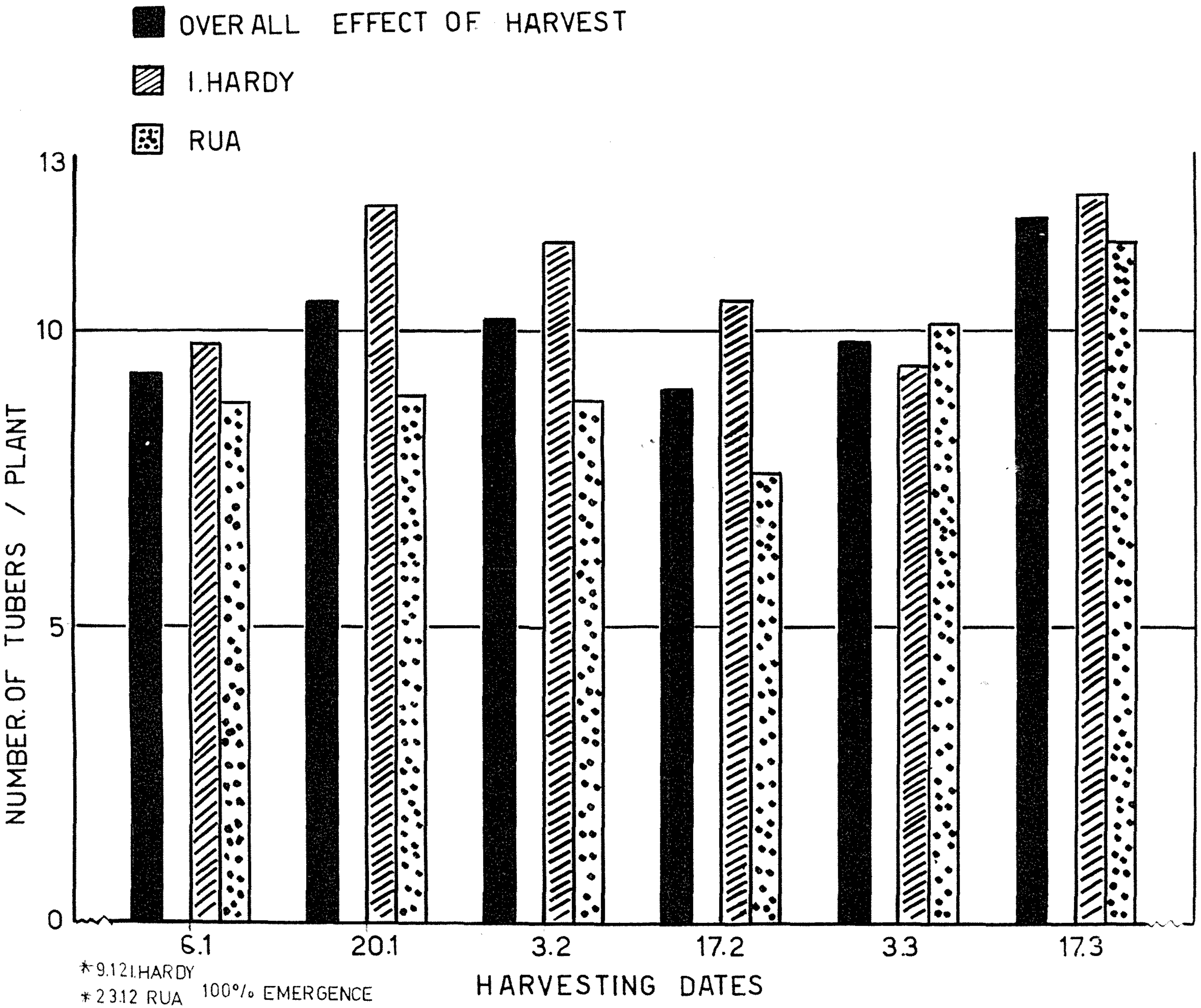

Fig.19. The effect of overall harvesting intervals and harvesting - variety interaction on mean Number of Tuber per Plant

TABLE 38

The Analysis of Variance of Tuber Number per 2 Plants.

Source of Variation	S.S.	d.f.	M.S.	F
Replication = R	24.79	1	24.79	< 1 NS
Spacing = S	2060.30	3	686.77	8.00 NS
E_1	257.65	3	85.88	
Variety = V	523.38	1	523.38	3.06 NS
V x S	366.73	3	122.24	<1 NS
E_2	684.94	4	171.24	
Seed Size = Z	1338.79	1	1338.79	18.95 **
Z x S	119.23	3	39.74	< 1 NS
Z x V	441.05	1	441.05	6.24 *
Z x V x S	427.14	3	142.38	2.02 NS
E_3	565.20	8	70.65	
Harvesting = H	693.58	5	138.72	1.63 NS
H x S	1930.61	15	128.71	1.51 NS
H x V	385.22	5	77.04	<1 NS
H x V x S	416.30	15	27.75	<1 NS
H x Z	820.68	5	164.14	1.93 NS
H x Z x S	763.93	15	50.93	<1 NS
H x Z x V	138.54	5	27.71	<1 NS
H x Z x V x S	393.39	15	26.23	<1 NS
E_4	6819.92	80	85.25	
TOTAL	19171.37	191		

(the data see Appendix XXVI). It shows that within 6 weeks after emergence in both varieties, the number of tubers slightly increased. Thereafter a declining trend was indicated. But in the last two harvests there was tendency for the number of tubers to increase more rapidly again.

Ilam Hardy, however, obviously produced a higher number of tubers than Rua in most of the harvesting period.

TABLE 39

The effect of seed size - variety interaction on Number of Tuber per Plant

Variety	Seed Size	
	2 oz	4 oz
Ilam Hardy	10.4	11.5
Rua	7.2	11.4
S.E. ± 0.6		

4.3.8. Stem Number

The main stems arise from the mother tuber and these were counted at each harvesting occasion. The data of the main stem numbers per 2 plants are given in Appendix XXVII. The analysis of variance is presented in Table 41.

The effect of spacing, variety, and seed size on the stem numbers is given in Table 40.

The spacing effect shows a trend to an increase in numbers of stems as the spacing became wider. This difference was not significant.

TABLE 40

The effect of spacing, variety, and seed size on the Number of Stems per Plant

Treatment	Stem No. per plant	S.E.
Spacimg: 6"	2.8	± 0.3
12"	3.3	
18"	3.1	
24"	3.4	
Variety: Ilam Hardy	3.58	± 0.16
Rua	2.69	
Seed Size: 2 oz	2.87	± 0.08
4 oz	3.41	

The comparison between varieties, on one hand, and seed size, on the other, showed that Ilam Hardy was significantly higher than Rua and that the 4 oz seed was superior to the small seed size treatment.

The results of variety and seed size interaction indicated that in Rua the 4 oz seed size produced significantly higher number of stems than the smaller seed treatment. In Ilam Hardy there was no difference between the seed size treatment.

The overall effect of harvesting and the harvesting-variety interaction is illustrated in a histogram as shown in Fig. 20, the data of which is given in Appendix XXVIII. Between the harvesting period the number of stems increased slightly up to 8 weeks and 6 weeks after emergence for Ilam Hardy and Rua respectively. Then it shows a considerable drop until the last harvest when a slight increase in stem numbers was again recorded. Of the two varieties, (see Table 42) Ilam Hardy was markedly higher than Rua

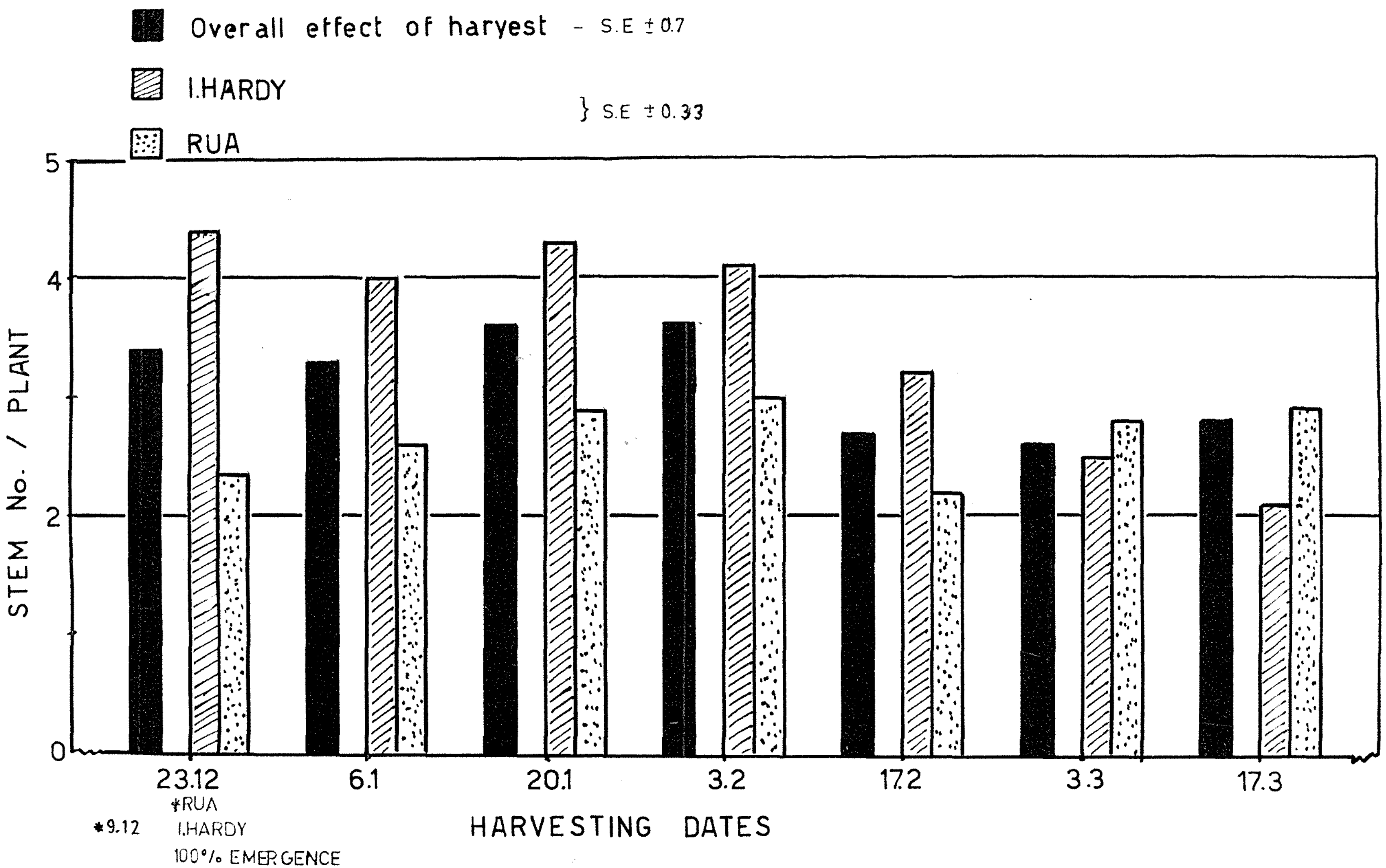

Fig.20. The overall effect of harvesting intervals and harvesting - variety interaction on mean Number of Stem per Plant.

TABLE 41

Analysis of Variance of Stem Number per 2 Plants

Source of Variation	S.S.	d.f.	M.S.	F
Replication = R	13.02	1	13.02	5.11 NS
Spacing = S	49.66	3	16.55	6.49 NS
E_1	7.66	3	2.55	
Variety = V	175.02	1	175.02	16.37 *
V x S	31.59	3	10.53	< 1 NS
E_2	42.75	4	10.69	
Seed Size = Z	64.29	1	64.29	24.17 **
Z x S	16.53	3	5.51	2.07 NS
Z x V	34.57	1	34.57	13.00 **
Z x V x S	16.75	3	5.58	2.10 NS
E_3	21.29	8	2.66	
Harvesting = H	139.47	6	23.25	3.27 **
H x S	153.21	18	8.51	1.20 NS
H x V	151.10	6	25.18	3.55 **
H x V x S	136.29	18	7.57	1.07 NS
H x Z	22.33	6	3.72	< 1 NS
H x Z x S	141.35	18	7.85	1.11 NS
H x Z x V	66.56	6	11.09	1.56 NS
H x Z x V x S	77.56	18	4.31	< 1 NS
E_4	681.84	96	7.10	
TOTAL	2042.84	223		

during most of the growing period. But toward the last two harvests Rua was higher than Ilam Hardy.

TABLE 42

The effect of variety - seed size interaction on the Number of Stems per Plant

Variety	Seed Size	
	2 oz	4 oz
Ilam Hardy	3.51	3.65
Rua	2.23	3.16
S.E. ± 0.11		

4.3.9. Discussion

The difficulties involved in the statistical analysis of results from Experiment-II have been pointed out in Section 3.5.2. Despite the inconclusive results in the analysis, some comment on the effects of the various treatments on the leaf area, dry weight, stem and tuber numbers are included in this discussion. This section is divided into 2 sub-sections: (1) leaf area and N.A.R., (2) dry and fresh weight yield.

4.3.9.1. Leaf Area and N.A.R.

Although the effect of spacing on leaf area did not reach a significant level, a trend showed that the advantage was at the wider spacings. The interaction between harvesting and spacing indicated that this advantage in leaf area per plant did not become significant until the 6th and 4th week after emergence for Ilam

Hardy and Rua respectively. It appeared that prior to this stage, interplant competition (for nutrient, water, and light) did not become a limiting factor to the growth of plants. But, thereafter, this effect became evident and the intensity of competition increased as the growing period advanced. At the closer spacing, the effect of competition became more acute and resulted in a consistently lower leaf area per plant at the 6" spacing treatment. Lower leaf area per plant seems to be associated with lower stem numbers (Table 40). As the size of leaves was not greatly affected by the spacing distance (Taha, 1961), thus, a lower leaf area recorded at the closer spacing is possibly due to a lower number of leaves.(However in this experiment leaves were not counted). This contention was supported by the results of El Saeed's (1963) work, who suggested that the leaf number decreased at the close spacing as a direct or indirect result of competition for light.

Between the seed size treatments there was little difference in the leaf area. Large seed started with a greater number of stems, but there was no advantage in leaf area per plant over the smaller seed size at the beginning nor at the later stages of growth.

The effect of spacing on L.A.I. gave a reverse picture to that described on a per plant basis : the 6" spacing produced a higher L.A.I. at all stages than did the wider spacings. There was a tendency for the differences to be reduced in Ilam Hardy toward the end of the season, but there was no evidence of this in Rua. Higher leaf area per plant at the wider spacings was insufficient to compensate for the lower number of stem calculated per unit area basis as shown in Table 43. Therefore a lower value of L.A.I. at the wider spacings resulted. The variation in time at which L.A.I. reached maximum value may be influenced by the degree of intensity of interplant competition. At the closer

TABLE 43

Mean L.A. per plant, L.A.I., Stem no.per plant, and Stem no/sq.ft. at different spacing treatments

Treatment	L.A. Per plant	L.A.I.	Stem no/pl.	Stem no/ sq.ft.
6"	34.31	7.51	2.8	2.24
12"	60.81	6.65	3.3	1.32
18"	60.81	4.43	3.1	0.83
24"	71.45	3.91	3.4	0.68

spacings the intensity of interplant competition was likely to be high and consequently the development of leaves was affected earlier than at the wider spacings. The results were that the peak of L.A.I. at the closer spacings occurred earlier than those at the wider spacing treatments.

In each harvest the difference in L.A.I. between the two varieties, to a large extent was similar to that of leaf area per plant. The advantage of Rua at the later stage of growing period was clearly exhibited. An interesting point was that the L.A.I. curve in this variety tend to form a second peak in all treatments. Based on the evidence of an increased number of stems toward the end of growing season, the above feature was probably due to the formation of new shoots. Further investigation of this aspect is required.

The L.A.I. curve showed little difference between the seed size treatments. There was an apparent advantage of large seed on L.A.I. in early and late growing period (see Table 45).

The variable results in N.A.R. have already been pointed out in Section 4.3.5. In a specific study of N.A.R and tuber growth, Burt (1964) concluded: "plants with very similar leaf area and grown under the same condition of light, temperature, and mineral supply, growth and N.A.R. were related to the rate of tuber growth." In the present experiment the results were very inconclusive.

4.3.9.2. Tuber Dry Weight and Fresh Weight Yield

Dryweight of the tuber and the "remainder" per plant, were both in favour of the wider spacings. The rate of increase in both components at different spacing treatments showed little difference at the beginning of the season. But with the passage of time the closer spacing was slowed down and led to an ultimately lower dryweight yield.

With regard to dryweight of tuber per plant, the advantage of wider spacing seemed to be supported by two factors:

1. higher number of tubers, and
2. higher "bulking rate," in a per plant basis as shown in Table 44.

But when the yield was expressed in a unit area basis, the closer spacing markedly out-yielded the wider spacings. Correspondingly, the number of tubers and bulking rate was also higher at this treatment. This suggested that higher numbers of

TABLE 44

Mean Tuber no. per plant and per sq.ft, "Bulking Rate" [(B.R.) (g x 10^2/2 weeks)] per plant and per sq. ft. at different Spacing treatments.

Spacing	Tuber no/pl.	Tuber no/sq. ft.	B.R./pl.	B.R./sq.ft
6"	7.52	6.02	1.14	0.91
12"	10.25	4.10	2.38	0.88
18"	10.63	2.83	3.26	0.86
24"	12.04	2.41	3.91	0.77

plants per unit area at the closer spacings produced more tubers than could be produced at the wider spacings at the same unit area. Thus, the advantage of wider spacings in a per plant basis did not compensate for the lower yield when calculated on a unit area basis.

The difference in tuber dryweight between the varieties was small. Although Ilam Hardy produced higher number of tubers than Rua, the latter had a higher bulking rate than the former (Table 47). For this reason, Rua produced a greater proportion of large size tubers as compared with Ilam Hardy.

The advantage of larger seed in tuber dryweight did not become apparent until the later part of the season. Plants from larger seed were bigger and provided a greater assimilating surface, which in turn produced a higher yield. Higher numbers of stem and tuber at the wider spacing confirmed the finding by Toosey (1959) who reported that tuber number is proportional to main stem number.

The pattern of dry matter partition supports the results of Taha (1961)'s experiment. In all treatments it showed:

1. a phase of short duration (within 6 and 4 weeks after emergence for Ilam Hardy and Rua respectively) in which most of dry matter was directed to top growth.

2. a phase in which most of the assimilates were being utilized in tuber growth (longer period)

3. a phase of rapid decrease in dryweight of "remainder" due to the onset of senescence.

In the last phase, there was a tendency for Rua to continue to increase in both components. But in Ilam Hardy there was a rapid drop of "remainder" followed by the corresponding drop of the total dryweight. In all cases, tuber dryweight was proportionately higher at the end of the growing period. This is in accordance with Burt's (1964) findings when he suggested that, "although the leaves and stems had some capacity to utilize or store the products of photosynthesis, this capacity was much less than that of the tubers."

Within each variety the pattern of dry matter partition was practically similar. On a unit area basis at the closer spacing higher total dryweight yield was supported by the fact that proportion of dry matter entering the tubers was higher than at the wider spacings.

CHAPTER V

GENERAL DISCUSSION

5.1. LEAF AREA AND YIELD

The relationship between leaf area and dryweight yield is clearly demonstrated in Fig. 21. It showed that the change in total and tuber dryweight with time follows to a great extent the change in leaf area. This evidence supports Watson (1947, 1952)'s conclusion: "a close relationship exists between the increase in dryweight and leaf area."

The course of L.A.I. and tuber bulking, as revealed by fortnightly sampling, in both varieties and the overall effect of treatment combinations is illustrated in Fig. 22. The course of L.A.I. and tuber bulking is in accordance with the general plan of tuber growth as suggested by Borah & Milthorpe, 1959 (Section 2.2.4). The linear phase of increase in tuber bulking coincides with the time when L.A.I. was decreasing. In Rua, it has been pointed out that the L.A.I. curve tend to form a second peak toward the end of growing period. Evidence revealed that the linearity of the tuber bulking curve was not greatly influenced by the upward trend of the L.A.I. curve. On the other hand, a rapid drop in L.A.I. curve of Ilam Hardy at the last three harvests, only slightly caused a downward shift of tuber bulking curve. This lack of apparent relationship between L.A.I. and bulking rate value is illustrated in Fig. 22 and Table 47. Thus, it brings up the fact that the bulking rate of tubers appear to be independent of leaf area, which is similar to the finding reported by Radley *et al* (1961).

Although the apparent time of tuber initiation in both

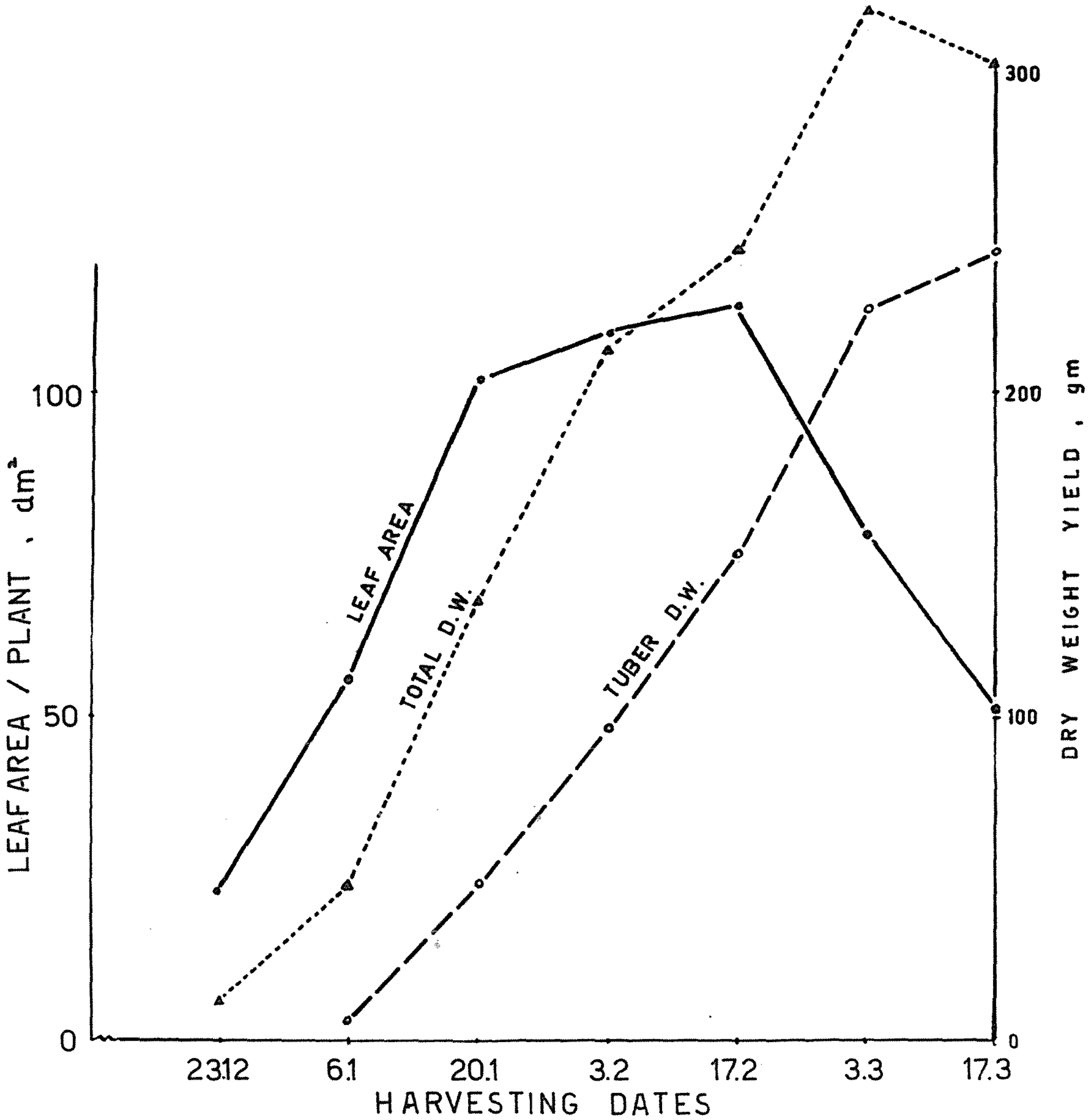

Fig. 21. Relationship between leaf area per plant (dm^2) and dryweight yield (g)

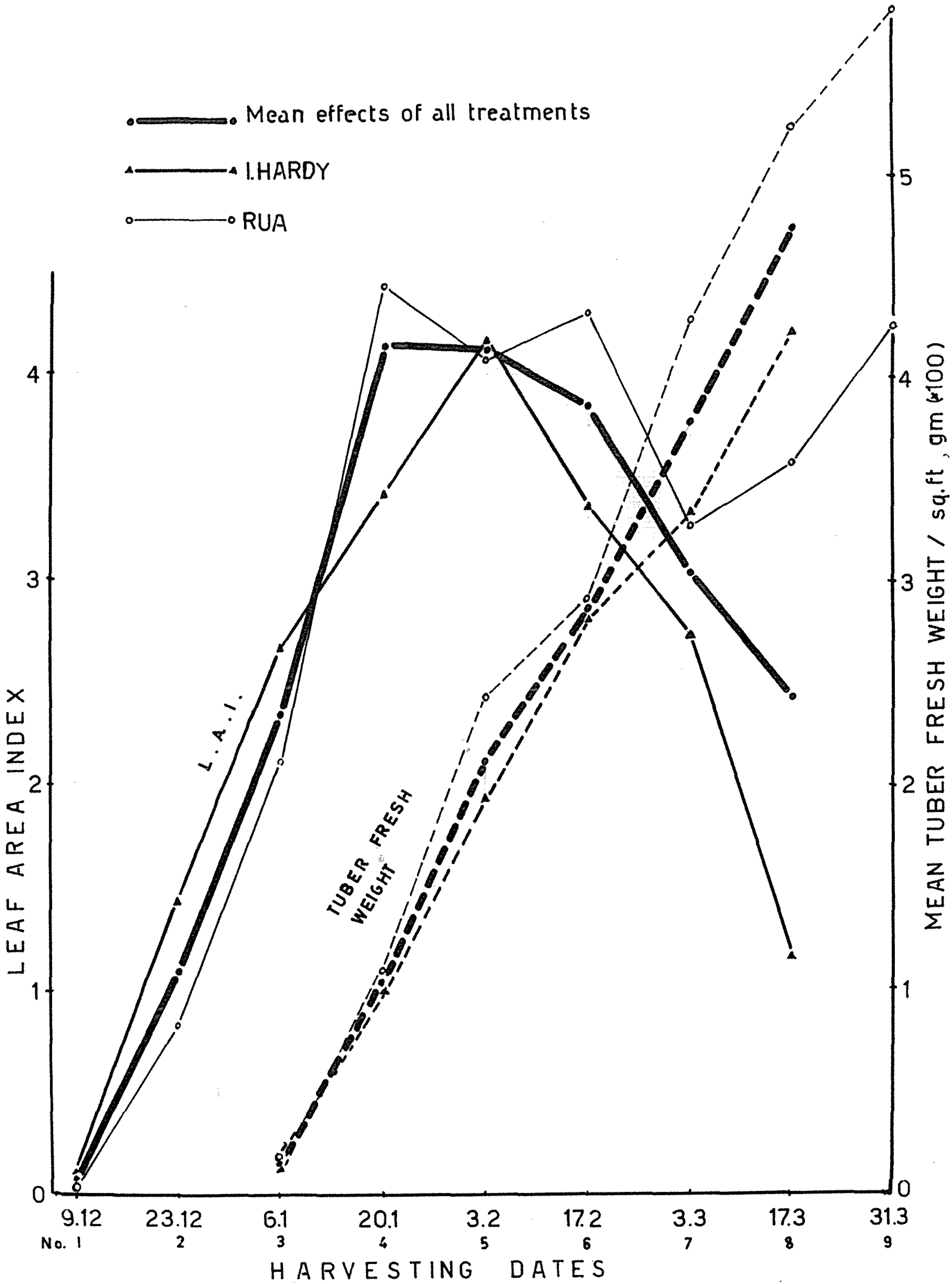

Fig. 22. Relationship between L.A.I. and tuber fresh weight (g/sq.ft.)

varieties was difficult to determine, it may be said that the difference in this aspect was small. But with the advance of growing period, the curve of tuber bulking in the two varieties diverged from each other with Rua having the advantage. The superiority of this variety in the rate and duration of bulking appeared to be related to the period at which most assimilates were diverted into the tubers during the advanced stage of growth, and to the persistence of leaf cover. The difference in the tuber yield between the two varieties may be accounted for by these two factors. Radley et al (loc.cit.) has also reported small differences in bulking rate between varieties. The results of this experiment therefore support the premise that duration of bulking is of great importance in determining the final yield.

An attempt to demonstrate the role of N.A.R. in yield failed to produce satisfactory results; the variation in leaf area therefore is considered to be a more important factor in determining the yield than the variation in N.A.R.

There were an apparent relationship between tuber yield recorded in Experiment-I and the results of growth analysis in Experiment-II. The advantage of close spacing on tuber yield over the wider spacings was supported by the higher fresh and dryweight yield in this variety over the growing period. Both L.A.I. and the leaf area duration (L.A.D.)* were consistently higher at the 6" spacing (see Table 45). Although Bremner & Taha (1966) pointed out that L.A.D. is less important in determining

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* Leaf Area Duration, is L.A.I. integrated over the growth period, and represented by the area under the L.A.I. curve (Bremner & Taha, 1966)

yield, the value of L.A.D. in this experiment appeared to have some influence on the tuber yield. The trend was that as the spacing decreased, the L.A.D. increased; and correspondingly the bulking rate also increased (see Tables 46 and 47). As it was not possible to determine the leaf persistence between the spacings treatments, the role of L.A.D. in determining the yield may be relatively important.

In the production of table potatoes; Taha (1961) has suggested three factors were involved:

1. The number of tubers formed - that is the number of "sinks" competing for the available assimilates.
2. The propensity of the plant for continuation of tuber initiation.
3. The amount of assimilates available for tuber growth.

At the closer spacing both number and dryweight gain was higher than at the wider spacing on a unit area basis. But, in the former, due to a higher intensity of intertuber competition, the available assimilates appeared to be insufficient to supply the greater number of developing tubers. Consequently, a higher proportion of the tubers failed to develop to a reasonable size, and this was reflected in the increased percentage of small grade potatoes at the closer spacing. On the other hand, a greater percentage of the tuber yield at the wider spacings fell into table and large grade potatoes, but the total yield tended to be lower.

The superiority of Ilam Hardy over Rua in total yield seems anomalous. In all attributes : leaf area, bulking rate, and dryweight gain, Ilam Hardy was consistently lower than Rua. But a greater number of tubers produced in the former variety, and this appeared to give an advantage in that a big number of "sinks" were provided for utilizing the available assimilates. Although the difference in yield of table potatoes between the two varieties was not significant, higher figures in Ilam Hardy suggested that this variety was more efficient for the production of this grade under the particular conditions. Early senescence and the affect of late blight disease possibly caused a rapid drop in leaf area and consequently reduced the rate of bulking at the end of the growing period. This in turn resulted in a higher percentage of small grade potatoes. In Rua, however, the advantage in leaf area, bulking rate, and dryweight gain was not reflected in higher total yield. A possible explanation is that this variety produced a smaller number of tubers; therefore a greater supply of assimilates which was produced by greater leaf area was distributed among smaller number of "sinks". Ultimately, a higher proportion of tubers developed into large size. This was particularly so, when the plants were at the wider spacing treatments. But with the closer spacing viz., 6" and 12" apart, the intensity of intertuber competition increased. The size of tuber was consequently reduced and more fell into the group of table potatoes. Furthermore, in Rua there was a tendency for a continuation of tuber initiation. This is shown by a considerable increase in the number of tubers in the last two harvests. Considering its longer leaf persistence and resistance of this variety to late blight disease, it might have been expected that in the later season Rua would have a greater potential yield than Ilam Hardy.

A comparison of yields between seed size treatments showed smaller differences. The advantage of large seed at the early stage and late growing period in L.A.I. did not show any relationship to its lower value of L.A.D. (see Tables 45 and 46). The difference between L.A.I. in 1 oz and 2 oz seed at each harvest was not great, and the value of L.A.D. in both treatments was similar. This suggested that the difference in yield between the seed treatments could be due to a difference in the bulking rate. In Table 47 the mean of bulking rate was highest at the 2 oz seed size. That is, the lower bulking rate and the greater number of tubers at large seed size treatment gave an adverse affect on the tuber size in this treatment, which resulted in a higher percentage of small grade potatoes in the total yield recorded.

The interaction between seed size and spacing in one hand, and between seed size and variety on the other, was significant. The yield of table potatoes in Rua (with a smaller number of tubers) was associated with increased seed size and with planting at the close spacing. For the variety with higher number of tubers (Ilam Hardy) the yield of table potatoes was significantly lowered when the seed size increased beyond 2 oz and planted at the 6" spacing. In both varieties the difference in table potatoes was negligible when 2 oz seed was used and planted at the 12" spacing. But when the spacing between plants became wider and the seed size became smaller, the advantage was with Ilam Hardy.

However, the advantage of the 6" spacing on table potatoes over the wider spacing was supported by the fact that all factors attributed to yield differences were superior at this treatment. As far as table potato yield is concerned, both varieties did not show a noticeable adverse affect to the decreased spacing treatments. But in the seed size, Ilam Hardy was obviously more sensitive to these treatments as compared with Rua. Therefore in this experiment the most efficient treatment combinations for table potato production appear to be at the 6" spacing with 2 oz and 4 oz seed for Ilam Hardy and Rua respectively.

5.2. SEED RATE

The estimated seed rate for both varieties - Ilam Hardy and Rua - and their corresponding tuber yield in each treatment combination is given in Table 48. It shows that there is a tendency for increased total yield with an increase in the seed rate planted. The effect of the treatments on the yield of table and large potato was small, though the advantage of higher seed rate was still maintained.

Similar seed rates per acre from varying combination of spacing and seed size (see Table 48) enabled a comparison between yield of different treatments. At the same seed rate the yield of total and/table potato was markedly higher from combination of close spacings and small seed sizes. These results are at variance with those of Boyd & Lessells (1954) as quoted in Section 2.3.1. They suggested that "within fairly wide limits, the differences in yield from various seed size and spacing combinations at the same seed rate, are practically negligible." From this experiment, the 6" spacing was undoubtedly superior to the wider spacing in yield at the same seed rate. However, at the 12", 18", and 24" spacing treatments, as far as table potato yield is concerned, there is an indication that the yield was relatively independent of seed rate within the range 9.72 - 38.88 cwt. per acre.

A comparison between seed size treatments, shows that small seed had a greater advantage over large seed at the same seed rate. The results of this experiment were in accordance with those of Taha (1961) and El Saeed (1963). The 4 oz seed size did not give any advantage to the table potato yield at all seed rates, despite an increase in the yield of small grade potatoes.

The importance of economic and practical aspects of this experiment was also considered and the estimated costs and gross margin are given in Appendix XXIX. This is an attempt to give a rough estimate of the return on an acre basis in relation to the seed rate. For the ease of calculation the yield figures were taken to the nearest whole number. All the costs involved and the prices of table potatoes were based on the average 1966 figures for local market and were obtained from the Department of Agriculture, Palmerston North.* Other factors such as weed spraying, defoliation etc., which are only practiced by some growers, were not included in the calculation.

The most profitable rate at which to plant a crop appeared to be largely determined by the relative prices of the purchased seed and marketed table potatoes. The relationship between the seed rate and monetary return is illustrated in Fig. 24. It shows that highest estimated gross margin was obtained at a seed rate 38.88 cwt. per acre from the combination of 6" spacing with

* Unpublished data

2 oz seed size. At the seed rate 19.45 cwt. (approx. 1 ton) per acre, a combination of 6" and 1 oz seed was markedly more profitable than from the wider spacings and large seed at the same seed rate. The 12", 18" and 24" spacings with 1 oz and 2 oz seed (seed rate range between 6.48 - 19.72 cwt. per acre) did not differ a great deal in the gross margin. This advantage of 12" spacing as compared with the 18" spacing was due to increased cost of seed in the former treatment.

With regard to different seed rates as influenced by the seed sizes, it shows that the profitable seed rate was from small seed size treatments. The 4 oz seed was obviously inferior in all cases.

Fig. 24 revealed that increased seed rate by decreasing the spacing was highly profitable with the range of spacing used in this experiment. But increasing seed rate by increasing seed size, did not become beneficial beyond 2 oz seed treatment. Thus the combination of spacing and seed size was relatively important in determining the amount of seed planted.

However, the rate of planting range between 10 - 40 cwt. per acre gives a reasonably good monetary return, provided the costs and prices involved were still within the vicinity of the present level. Although high seed rate from 6" spacing is not yet commonly practiced in this area, the evidence of superiority of this treatment in table potato production is promising for future potato growing. It is expected that a high seed rate would produce a higher percentage of small grade potatoes. But with the successful research in the use of Disyston, Solvinex, and Thimet (Close, 1966) for controlling aphids as ...

there is an increasing tendency for saving own seed. In this case, the cost of seed would be reduced, and a higher return could be expected.

Based on the results of this experiment using a seed rate up to 2 tons per acre from 1 oz or 2 oz seed planted at 6" spacings can be recommended. Undoubtedly, further research, particularly in different seasonal conditions, is necessary for confirmation of the present results.

TABLE 45

Mean L.A.I. at different treatments

Treatments	HARVESTING DATE									
	9/12	23/12	6/1	20/1	3/2	17/2	3/3	17/3	31/3	Mean
Spacing: 6"	0.02	1.79	3.76	6.51	5.45	4.43	3.58	3.05		3.57
12"	0.51	1.26	2.58	4.55	4.23	3.18	3.35	2.56		2.78
18"	0.02	0.69	1.62	3.49	3.64	3.95	2.88	2.10		2.29
24"	0.02	0.50	1.35	2.31	3.13	3.81	2.27	2.02		1.92
Variety: I.Hardy	0.04	1.42	2.65	3.40	4.16	3.36	2;76	1.16		2.37
Rua	0.01	0.83	2.01	4.46	4.07	4.30	3.28	3.57	4.25	2.98
Seed Size: 1 oz (I.H)	0.04	0.70	2.08	4.09	4.47	4.25	2.82	1.74		2.52
2 oz	0.02	0.91	2.21	4.32	4.78	4.12	2.85	1.86		2.63
4 oz	0.02	1.34	2.45	4.11	3.58	3.57	3.19	2.98		2.66
Mean	0.08	1.09	2.33	4.14	4.13	3.84	3.02	2.41		

TABLE 46

Mean estimate of Leaf Area Duration (Rua 2 oz seed at 6" spacing = 100)

Treatments		I.Hardy	Rua	Seed Size Mean	Spacing Mean
1 oz	6"	67.9		65.0	
	12"	65.6			
	18"	71.8			
	24"	54.7			
2 oz	6"	83.6	100.0	65.0	84.3
	12"	67.3	64.5		78.4
	18"	51.2	54.1		58.6
	24"	49.1	50.2		47.6
4 oz	6"	62.7	94.3	61.8	
	12"	63.3	69.3		
	18"	62.3	57.0		
	24"	42.7	42.6		
Variety Mean		61.9	66.5		

TABLE 47

The effect of treatments on Mean Bulking Rate (between week 4-16 of growing period inclusive) g x 100/2 weeks/sq.ft.

Treatment	Period Between Sampling						
	6-20/1	20-3/2	3-17/2	17-3/3	3-17/3	17-31/3	Mean
Spacing: 6"	1.36	1.67	- 0.31	1.54	1.41		1.13
12"	1.07	1.09	0.42	0.40	1.09		0.81
18"	0.69	0.73	1.14	1.08	0.50		0.80
24"	0.48	0.74	1.11	0.59	0.82		0.75
Variety: I.Hardy	0.87	0.95	0.85	0.59	0.84		0.82
Rua	0.95	1.34	0.33	1.41	1.13	0.42	0.93
Seed Size: 1 oz	0.96	0.97	0.53	0.81	0.52	I.Hardy (Rua)	0.76
2 oz	0.69	1.29	0.67	1.05	0.41	1.25	0.89
4 oz	1.08	0.99	0.68	0.82	1.63	-0.21	0.83
Mean	0.90	1.08	0.60	0.92	0.92	0.48	0.84

TABLE 48

Seed Rates and the corresponding Yield at different treatment combinations

Spacing	Seed Size	Seed Rate	Total Yield	Large & Table Potato	Seed & Small Potato
inch	Oz.	Cwt/acr.	Ton/acr.	Ton/acr.	Ton/acr.
6"	1	19.44	25.36	20.11	5.25
	2	38.88	31.67	24.05	7.62
	4	77.80	34.20	24.56	9.64
12"	1	9.72	21.06	17.59	3.47
	2	19.44	23.20	18.82	4.38
	4	38.88	23.14	17.89	5.25
18"	1	6.48	20.18	17.56	2.62
	2	12.96	22.24	18.81	3.43
	4	25.92	23.10	18.60	4.50
24"	1	4.86	17.25	15.13	2.12
	2	9.72	21.29	18.64	2.65
	4	19.44	19.97	17.05	2.92

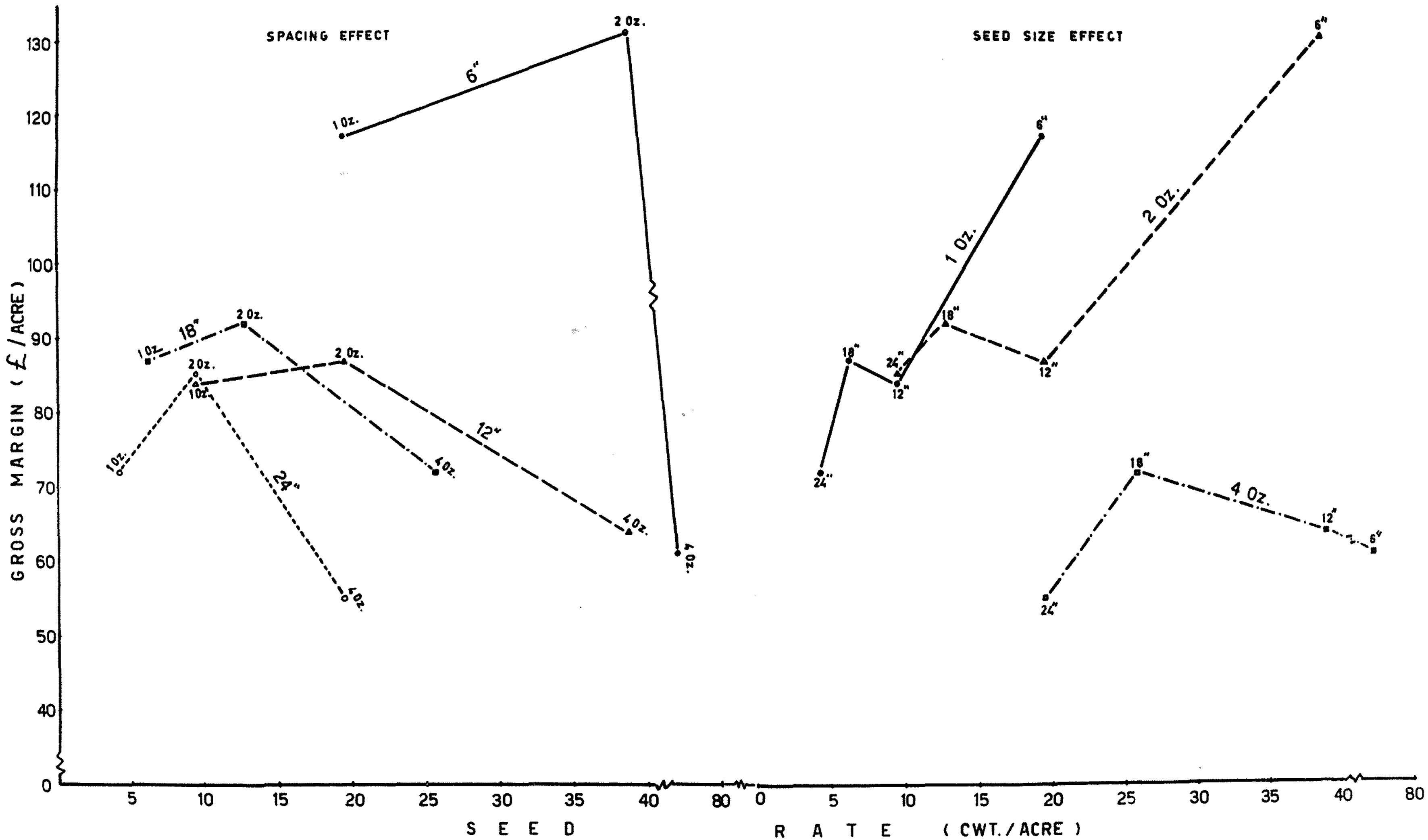

Fig. 24. Gross margin at different seed rates.

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

The effects of 4 within-row spacings and 3 seed sizes on tuber yield of two main New Zealand varieties of potato were investigated.

There were two experimental plots: the first involved terminal yield studies; the second, a subsidiary, was designed for successional lifting where growth analysis was undertaken.

The effects of spacings on tuber yield showed a marked superiority of 6" spacing over all of the wider spacing treatments. The differences in total and table potato yields at the 12" and 18" spacings were not significant, but both treatments were higher yielding than the 24" spacing.

Ilam Hardy variety produced higher total yields than did Rua, but the difference in table potato yields was not significant.

The 1 oz seed size was inferior to 2 and 4 oz seed treatments, but there was no significant difference between the latter two.

The close spacing and large seed size combinations were superior in tuber yields to the wider spacing and small seed treatment. Using Ilam Hardy, maximum yield was gained from 2 oz seed at 6" spacing, while for Rua 4 oz seed at 6" spacing was the best.

Close spacing treatments showed an advantage in leaf area, fresh and dryweight of tubers, and stem and tuber numbers on a unit area basis.

Leaf persistence and its consequent effect on duration of bulking appeared to have an important influence on yield differences between varieties.

The differences in subsequent growth from 2 oz and 4 oz seed were not large, but the tendency was for an advantage from the larger seed treatment.

Practical aspects of results based on converted seed rates and economic considerations were also put forward.

R E F E R E N C E S

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APPENDICES

APPENDIX I

PAST HISTORY OF EXPERIMENTAL GROUND

Dairy-farm No. 1   Field No. 5a.   Area 1.58 acres.

Soil record

14/4 1958   Sown with pasture, seed mixture :
15 H.1
5 P.R.6
4 Cocks-foot
3 Red Clover
2 White Clover

Sowing rate: 29 lbs/acre.
Fertilisers: 3 cwt. S.S. and
4 lb. D.D.T./acre.

Top-dressing

Date	Type	Quantity	Overdrilling
11/4-61	Surpentine Super (S.S.)	1 cwt.	
	D.D.T. (super)	1 cwt.	
12/2-62	S.S.	2 cwt.	H.1 7 lbs
3/5-63	S.S.	2 cwt.	
16/3-64	S.S.	3 cwt.	
18/2-65	Super-Phosphate	2 cwt.	

APPENDIX II

SOIL - CULTIVATION

Date:	
15 - 17th September, 1965	Prior to cultivation the pasture was heavily grazed by 56 yearling cows.
22 - September, 1965.	The ground was rotary-hoed aiming to kill the grass before ploughing took place.
30 - September, 1965.	The ground was ploughed using "reversible-digger plough." Then fallowed.
23 - October, 1965.	Discing, to break up the lumps.
26 - October, 1965.	Grubbing, to break up the soil and kill some of the weed.
4 - November, 1965.	Discing, to kill the weed before moulding.
X 5 - November, 1965.	Riding in 30" rows using double mould board plough.
8 - November, 1965.	Experimental pegs and signs were set-up.
12 - November, 1965.	Planting date.
24 - December, 1965.	Moulding. It was considered a little late due to Rua variety being very uneven in their emergence.

Appendix II (Continued)

(a)

(b)

Sequence of events in preparation of the trial:

(a) pre-cultivation grazing by yearling cows

(b) ploughing

(c) planting distance

(d) grubbing

(e) moulding

(c)

(d)

(e)

Appendix II (continued)

APPENDIX III

Meteorological readings during the experimental period
(Average of 7 days period)

Date	Total R.F.inch	R.H.%	Max.Temp. °F	Min.Temp °F
Nov.1965.1st-7th	1.78	78.1	62.3	44.9
8th-14th	1.96	73.0	66.9	48.0
15th-21st	0.26	72.9	64.0	42.9
22nd-30th	1.20	73.7	66.0	47.7
Total	4.22			
No.of days	12			
Dec.1965.1st-7th	0.43	79.6	65.3	49.6
8th-14th	0.02	83.6	74.4	56.7
15th-21st	2.86	69.4	71.8	53.8
22nd-31st	1.05	73.0	67.0	51.7
Total	4.36			
No. of days	15			
Jan.1966.1st-7th	2.12	79.5	73.0	55.9
8th-14th	0.50	73.4	65.3	49.8
15th-21st	0.08	82.7	72.0	56.4
22nd-31st	1.45	80.6	74.5	56.3
Total	4.15			
No. of days	11			

(Cont'd next page)

Meteorological Station

(Appendix III, Meterological readings continued.)

Feb.1966.1st-7th	0.67	79.2	73.3	56.5
8th-14th	0.00	75.2	77.1	56.9
15th-21st	0.42	80.4	78.1	62.9
22nd-28th	3.77	90.6	71.1	69.6
Total	4.86			
No. of days	11			
Mar.1966.1st-7th	0.45	80.9	70.1	54.2
8th-14th	0.00	72.7	70.8	52.4
15th-21st	0.03	78.3	73.1	51.3
22nd-31st	1.33	82.1	72.8	56.1
Total	1.81			
No. of days	7			
Apr.1966.1st-7th	0.82	80.4	65.2	51.5
8th-14th	0.31	76.4	67.2	48.3
15th-21st	0.29	85.2	65.3	45.6
22nd-30th	2.68	84.4	63.6	48.4
Total	4.10			
No. of days	12			
May 1966.1st-7th	0.72	80.6	60.3	42.6
8th-20th	0.46	81.7	62.1	42.7
Total	1.18			
No. of days	6			

APPENDIX IV

Weed and Late Blight disease control

1. Weed: 2/12.1965. Band spray with "Paraquat."
Thereafter weed control was done by hand-hoeing.

2. Late Blight spray: An Airblast-spraying machine was used. It give a very high speed of air-flow, capable of breaking the spray material into very fine particles which are carried to the target and deposited in a fine even spread overall surfaces.

The spray programme as follows:

Date	Material used
14/1 1966	Diathane M22 with the rate about 0.75 lb per 0.5 acre. Continuously humid weather required for a thorough spraying to be done. This programme was carried out weekly up to the 16/2/66.
23/2 1966	Diathane M45 with the same rate with the addition of Stantox (sticker). This has the advantage of giving a good surface cover for a longer period. This was repeated at weekly intervals until a fortnight before harvesting. Altogether 12 sprays were applied giving very satisfactory results.

Appendix IV (continued)

Late blight symptoms when first detected in the crop.

APPENDIX V

Comparison between Small (0.636 cm^2) and Large (2.27 cm^2) Punch in estimating the Leaf area of Potato (after Taha, 1961)

Sample No.	Planimeter Area dm^2.	SMALL PUNCH ESTIMATE			LARGE PUNCH ESTIMATE		
		Area dm^2	Bias	%	Area dm^2	Bias	%
1	12.07	14.15	+ 2.08	17.23	11.46	-0.61	5.05
2	10.59	8.52	- 2.07	19.55	9.88	-0.71	6.70
3	11.52	10.54	- 0.98	8.51	12.14	+0.62	5.38
4	13.31	14.62	+ 1.31	9.84	12.43	-0.88	6.61
5	15.89	18.38	+ 2.48	15.61	14.58	-1.31	8.24

APPENDIX VI

A method used in the Analysis of Variance of Split-split-plot design of Total Yield (tons/acr.). The data is presented in Appendix VII.

I. Analysis Table:

Sources of Variation	S.S.	d.f.	M.S.	F
1. Replication = R	672.02	9	74.67	
2. Spacing = S	4054.37	3	1351.46	35.57 **
Error (1) = E_1	1025.76	27	37.99	
3. Variety = V	312.70	1	312.70	11.56 **
V x S	133.54	3	44.51	1.65 N.S.
E_2	973.96	36	27.05	
4. Seed-Size = Z	815.52	2	407.76	22.81 **
Z x S	331.44	6	55.24	3.09 **
Z x V	1126.60	2	563.30	31.50 **
Z x V x S	111.70	6	18.62	1.04 N.S.
E_3	2575.29	144	17.88	
TOTAL	12132.90	239		

II Table of sum of the items

(1) Replication x spacing table

Spacing	REPLICATION										Spacing Total
	I	II	III	IV	V	VI	VII	VIII	IX	X	
6"	197.18 X_1 (6)	157.40	177.38	221.52	156.51	171.43	198.43	180.65	204.84	159.48	1824.82 S_1 (60)
12"	152.56	118.03	150.47	148.74	149.53	115.07	117.23	136.43	132.54	127.39	1347.99
18"	160.33	134.30	142.43	121.48	124.00	109.82	132.53	128.65	141.05	115.85	1310.44
24"	118.70	137.49	103.11	139.81	117.64	120.95	103.36	98.45	121.63	109.12 X_{40}	1170.26 S_4
Replication	628.77 R_1 (24)	547.22	573.39	631.55	547.63	517.27	551.55	544.18	600.06	511.84 R_{10}	5653.51 G (240)

Replication S.S. = $\frac{R_1^2 + R_2^2 \ldots\ldots R_{10}^2}{24} - \frac{G^2}{240}$ = 672.02 ....(R)

Spacing S.S. = $\frac{S_1^2 + S_2^2 + \ldots\ldots S_4^2}{60} - \frac{G^2}{240}$ = 4054.37.................. (S)

T_1 S.S. = $\frac{X_1^2 + X_2^2 \ldots\ldots X_{40}^2}{6} - \frac{G^2}{240}$ = 5752.15 .... (T_1)

E_1 S.S. = $T_1 - (S + R)$ = 1025.76. ....(E_1)

(2) Variety x Spacing table.

Variety	Spacing 6"	12"	18"	24"	Variety Total
Ilam Hardy	y_1 (30) 920.43	694.46	722.22	626.62	V_1 (120) 2963.73
Rua	904.39	653.53	588.22	543.64 y_8	2689.78 V_2
Spacing Total	S_1 (60) 1824.82	1347.99	1310.44	1170.26	G (240) 5653.51

Spacing S.S. = S

$$\text{Variety S.S.} = \frac{V_1^2 + V_2^2}{120} - \frac{G}{240} = 312.70 \ldots (V)$$

$$T_2\text{S.S.} = \frac{Y_1^2 + Y_2^2 + \ldots\ldots Y_8^2}{30} - \frac{G}{240} = 4500.61 \ldots (T_2)$$

$$\text{(Variety x Spacing) S.S.} = T_2 - (S + V) = 133.54 \ldots (V \times S)$$

(3) Variety x Spacing x Replication table.

Variety	Repl.	Spacing 6"	12"	18"	24"	Replication Total
Ilam Hardy		N_1 (80)				
	I	99.68	73.23	93.76	61.37	328.04
	II	60.68	56.33	61.22	68.72	246.95
	III	89.70	76.76	69.94	56.69	293.09
	IV	108.58	73.71	66.14	71.80	320.23
	V	72.23	79.17	70.41	55.31	277.12
	VI	91.41	69.66	62.86	73.56	297.49
	VII	104.84	58.26	77.83	62.06	302.99
	VIII	97.97	80.19	74.36	57.46	309.98
	IX	108.11	64.67	75.65	66.37	314.80
	X	87.23	62.48	70.05	53.28	273.04
Rua	I	97.50	79.33	66.57	57.33	300.73
	II	96.72	61.70	73.08	68.77	300.27
	III	87.68	73.71	72.49	46.42	280.30
	IV	112.94	75.03	55.34	68.01	311.32
	V	84.28	70.36	53.59	62.33	270.56
	VI	80.02	45.41	46.96	47.39	219.78
	VII	93.59	58.97	54.70	41.30	248.56
	VIII	82.68	56.24	54.29	40.99	234.20
	IX	96.73	67.87	65.40	55.26	285.26
	X	72.25	64.91	45.80	55.84 N_{80}	238.80
Spacing Total		1824.82 S_1 (60)	1347.99	1410.44	1170.26 S_4	5653.51 G (240)

$$T_3.\ S.S. = \frac{N_1^2 + N_2^2 + \ldots\ldots\ldots N_{80}^2}{3} - \frac{G^2}{240} = 7172.35\ldots(T_3)$$

$$E_2.\ S.S. = T_3 - [(R + S + E_1) + V + (V \times S)] = 973.96\ldots(E_2)$$

(4) Size x Spacing table.

Spacing	Seed Size 1 oz	2 oz	4 oz	Spacing Total
	Q_1 (20)			S_1 (60)
6"	507.32	633.42	684.08	1824.82
12"	421.17	463.97	462.85	1347.99
18"	403.70	444.77	461.97	1310.44
24"	345.07	425.75	399.44 Q_{12}	1170.26 S_4
	1677.26 Z_1 (80)	1967.91	2008.34 Z_3	5653.51 G (240)

Spacing S.S. = S

$$\text{Seed Size S.S.} = \frac{Z_1^2 + Z_2^2 + Z_3^2}{80} - \frac{G^2}{240} = 815.52 \ldots\ldots (Z)$$

$$T_4\text{.S.S.} = \frac{Q_1^2 + Q_2^2 \ldots + Q_{12}^2}{20} - \frac{G^2}{240} = 5201.33 \ldots\ldots (T_4)$$

(Seed Size x Spacing) S.S.$=T_4 - (S \times Z)$ $=331.44 \ldots\ldots (Z \times S)$

(5) Seed Size x Variety table.

Variety	Seed Size 1 oz	2 oz	4 oz	Variety Total
	P_1 (40)			V_1 (120)
Ilam Hardy	987.58	1035.10	941.05	2963.73
Rua	689.68	932.81	1067.29 P_6	2689.78 V_2
	Z_1		Z_3	G (240)
Seed Size Total	1677.26	1967.91	2008.34	5653.51

Variety S.S. = V

Seed Size S.S. = Z.

$$T_5.S.S. = \frac{P_1^2 + P_2^2 + \ldots\ldots\ldots + P_6^2}{40} - \frac{G^2}{240} = 2254.82\ldots(T_5)$$

(Variety x Seed Size) S.S. = $T_5 - (V + Z)$ = 1126.60..(V x Z)

(6) Spacing x Variety x Seed Size table.

Variety	Seed Size	Spacing 6"	12"	18"	24"	Seed Size Total
I.Hardy	1 oz	M_1 (10) 277.37	235.59	251.56	223.06	987.58
	2 oz	330.72	242.67	237.23	224.48	1035.10
	4 oz	312.34	216.20	233.43	179.08	941.05
Rua	1 oz	229.95	185.58	152.14	122.01	689.68
	2 oz	302.70	221.30	207.54	201.27	932.81
	4 oz	371.74	246.65	228.54	220.36 M_{24}	1067.29
Spacing Total		S_1 (60) 1824.82	1347.99	1310.44	S_4 1170.26	G (240) 5653.51

$$T_6.S.S. = \frac{M_1^2 + M_2^2 + \ldots\ldots\ldots + M_{24}^2}{10} - \frac{G}{240} = 6885.87\ldots.(T_6)$$

$$(\text{Spacing x Variety x Seed Size})\ S.S. = T_6 - [S + V + (V \times S) + Z + (S \times Z) + (Z \times V)] = 111.70\ldots(S \times V \times Z)$$

$$\text{Grand Total } (T_7)\ S.S. = \frac{\text{Sum (all items)}^2}{1} - \frac{G}{240} = 12132.90\ldots.(T_7)$$

$$E_3.S.S. = T_7 - [R + S + E_1 + V + (V \times S) + E_2 + Z + (Z \times S) + (V \times Z) + (V \times S \times Z)] = 2575.29\ldots\ldots(E_3)$$

III Interpretation of Results.

(1) The significant effect of spacing treatment.

Spacing Mean table.

Spacing	Mean of Total yield.Ton/acr.	S.E.
6"	30.4	± 0.8
12"	22.5	± 0.8
18"	21.8	± 0.8
24"	19.5	± 0.8

$$\text{S.E. of Mean} = \sqrt{\frac{E_1 M.S}{60}} = \sqrt{\frac{37.99}{60}} = 0.80$$

Detectable difference at 5% (1%) level of probability:

$$d.05\ (.01) = t.05\ (.01)\ E_1\ d.f. \times \sqrt{\frac{2 \times (E_1 MS)}{60}}$$

$$= 2.052\ (2.771) \times 1.13 = 2.32\ (3.13)$$

(2) The significant effect of variety.

Variety Mean Table.

Variety	Mean of Total yield.Ton/acr.	S.E.
Ilam Hardy	24.70	± 0.48
Rua	22.41	± 0.48

$$\text{S.E. of Mean} = \sqrt{\frac{E_2 MS}{120}} = \sqrt{\frac{27.05}{120}} = 0.48.$$

Only two comparisons involved d.05 (.01) not necessarily calculated.

(3) Spacing - Seed Size Interaction

Spacing x Seed Size table of Mean

Spacings	Seed Size		
	1 oz	2 oz	4 oz
6"	25.4	31.7	34.2
12"	21.1	23.2	23.1
18"	20.2	22.2	23.1
24"	17.3	21.3	20.0
	S.E. ± 0.95		

$$\text{S.E. of Mean} = \sqrt{\frac{E_3 M.S.}{20}} = \sqrt{\frac{17.88}{20}} = 0.95$$

$$d.05\ (.01) = t.05\ (.01)\ E_3\ d.f. \times \sqrt{\frac{2 \times (E_3 MS)}{20}}$$

$$= 1.980\ (2.617) \times 1.34 = 2.7\ (3.5)$$

(4) Seed Size - Variety Interaction

Seed Size x Variety table of Mean

Variety	Seed Size		
	1 oz	2 oz	4 oz
Ilam Hardy	24.7	25.9	23.5
Rua	17.2	23.3	26.7
	S.E. ± 0.67		

$$\text{S.E. of Mean} = \sqrt{\frac{E_3 M.S.}{40}} = \sqrt{\frac{17.88}{40}} = 0.67$$

$$d.05\ (.01) = t.05\ (.01)\ E_3\ d.f. \times \sqrt{\frac{2 \times (E_3 M.S.)}{40}}$$

$$= 1.980\ (2.617) \times 0.95 = 1.9\ (2.5)$$

APPENDIX VII

Total yield, tons/acre.

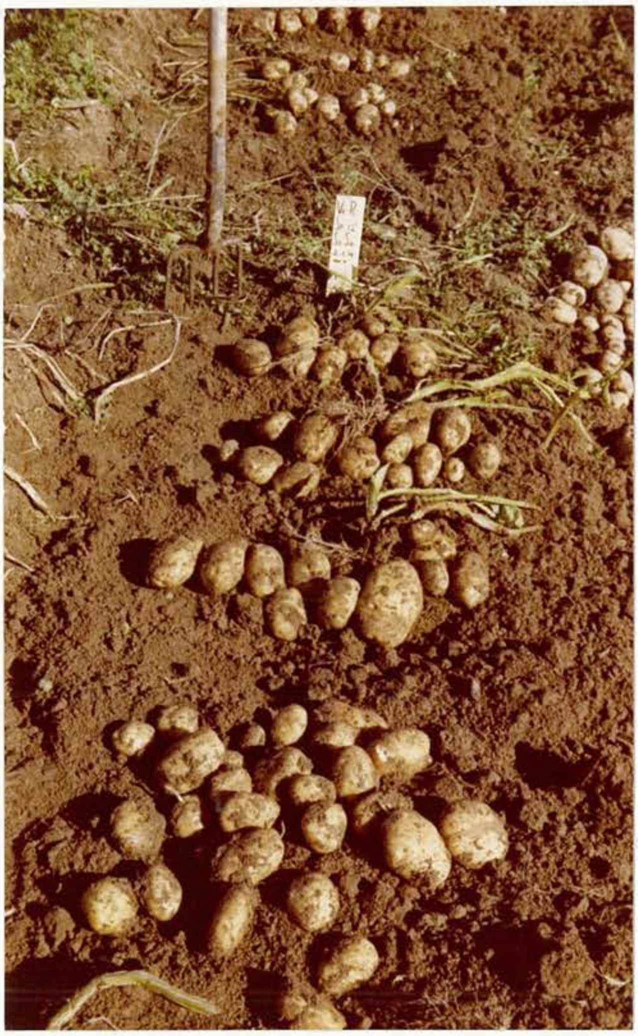
Seed Size		1 oz				2 oz				4 oz			
Spacing		6"	12"	18"	24"	6"	12"	18"	24"	6"	12"	18"	24"
Variety	Repl.												
I.Hardy	I	35.72	27.53	32.08	21.92	39.62	23.16	23.45	23.64	24.34	22.54	38.23	15.81
	II	19.34	17.87	20.19	31.32	24.49	17.56	19.77	18.02	16.85	20.90	21.26	19.38
	III	28.39	23.79	25.54	22.90	28.24	27.93	27.61	17.09	33.07	25.04	17.79	16.70
	IV	39.00	28.24	23.61	19.62	33.23	26.91	23.45	27.88	36.35	18.56	19.08	24.30
	V	18.10	23.79	21.37	18.33	32.45	31.04	24.91	22.90	21.68	24.34	24.13	14.08
	VI	26.83	21.85	23.91	24.34	29.17	26.13	17.63	28.62	35.41	21.68	21.32	20.60
	VII	29.80	18.56	34.89	19.42	37.60	25.50	24.43	21.61	37.44	14.20	18.51	21.03
	VIII	26.99	29.10	20.33	23.21	30.42	22.78	25.95	21.69	40.56	28.31	28.08	12.56
	IX	29.80	22.78	28.49	21.06	32.76	19.43	22.83	24.49	45.55	22.46	24.33	20.82
	X	23.40	22.08	22.15	20.94	42.74	22.23	27.20	18.54	21.09	18.17	20.70	13.80
Rua	I	22.15	23.55	20.44	15.83	31.67	30.12	23.40	22.66	43.68	25.66	22.73	18.84
	II	31.36	16.77	21.95	14.63	24.96	24.03	24.92	25.86	40.40	20.90	26.21	28.28
	III	23.72	18.96	21.69	11.60	23.87	23.71	25.27	14.66	40.09	31.04	25.53	20.16
	IV	36.04	25.04	7.49	14.74	35.09	22.30	25.43	27.85	41.81	27.69	22.42	25.42
	V	22.00	19.97	14.97	17.32	29.99	21.92	19.29	22.97	32.29	28.47	19.33	22.04
	VI	16.69	9.52	12.74	7.18	26.05	17.32	13.16	17.90	37.28	18.57	21.06	22.31
	VII	25.11	15.21	9.98	5.38	34.16	21.37	21.01	15.95	34.32	22.39	23.71	19.97
	IX	22.78	23.09	24.53	11.27	36.35	19.89	16.43	17.47	37.60	24.89	24.44	26.52
	X	12.32	18.41	4.73	16.22	29.04	21.07	20.01	16.61	30.89	25.43	21.06	23.01

APPENDIX VIII

Table Potato Yield, tons/acre

Seed Size		1 oz				2 oz				4 oz			
Spacing		6"	12"	18"	24"	6"	12"	18"	24"	6"	12"	18"	24"
Variety	Repl.												
I.Hardy	I	28.08	22.85	26.26	17.00	32.45	16.22	18.46	18.41	16.85	18.40	29.85	12.25
	II	14.82	14.04	15.50	26.13	19.19	13.34	15.76	13.92	12.95	16.22	15.34	14.43
	III	23.87	17.24	18.88	18.84	18.25	19.97	23.87	12.64	25.74	21.06	14.14	11.35
	IV	28.70	22.70	18.82	15.91	25.43	19.19	18.10	22.11	24.49	12.87	12.06	17.86
	V	14.04	20.28	17.16	13.42	23.40	24.18	17.68	17.47	15.29	16.77	17.89	10.80
	VI	20.28	14.12	18.88	19.19	21.06	18.72	11.70	23.24	28.08	15.83	15.81	14.66
	VII	20.59	13.26	25.06	12.71	24.18	20.28	19.34	17.86	20.75	8.74	12.84	15.25
	VIII	20.28	22.78	14.82	14.51	17.94	13.57	17.58	16.97	28.39	14.66	19.71	7.80
	IX	19.50	16.15	20.80	15.68	24.80	14.12	14.77	18.95	27.77	17.00	17.16	13.49
	X	17.32	17.16	15.08	15.60	29.33	15.29	18.56	13.85	14.20	9.20	14.20	9.20
Rua	I	18.41	20.90	11.34	9.87	23.24	23.95	15.65	18.41	32.45	19.34	19.81	13.61
	II	27.46	15.21	17.37	10.73	19.66	20.28	20.18	19.50	32.76	18.41	21.48	21.18
	III	20.44	11.70	15.24	6.98	19.66	20.20	18.56	11.35	30.26	25.66	17.42	16.22
	IV	30.11	21.22	4.63	11.19	29.95	16.30	20.28	18.25	26.21	22.07	17.37	21.41
	V	16.38	14.12	10.92	12.91	25.00	19.97	16.22	15.80	26.52	26.52	14.98	16.89
	VI	9.36	8.97	11.96	5.54	22.62	13.26	10.14	12.64	30.42	14.98	16.48	16.54
	VII	18.72	9.67	7.75	4.49	25.27	16.38	18.20	13.61	24.96	17.63	20.54	14.12
	VIII	14.66	10.69	9.88	7.06	22.78	10.61	13.83	11.58	20.59	15.83	16.07	10.61
	IX	12.79	17.55	15.39	7.80	24.80	14.04	11.70	12.60	24.96	18.88	20.90	19.73
	X	9.98	13.73	4.42	12.09	19.50	16.15	13.78	12.17	23.87	20.51	15.08	17.51

Appendix VIII (continued)



Yield per plant from Rua

APPENDIX IX

Yield of Large Table Potato, tons/acre

Seed Size		1 oz				2 oz				4 oz			
Spacing		6"	12"	18"	24"	6"	12"	18"	24"	6"	12"	18"	24"
Variety:	Repl.												
I.Hardy	I	0.00	2.26	2.81	3.28	0.00	2.57	2.34	1.95	0.00	0.00	3.54	1.29
	II	0.00	0.00	2.29	2.18	0.00	0.00	0.47	1.17	0.00	0.00	1.82	2.26
	III	0.00	0.00	2.70	1.40	0.00	0.00	0.94	1.44	0.00	0.00	0.00	1.95
	IV	0.00	0.00	1.72	1.01	0.00	0.86	0.00	2.34	0.00	0.00	1.56	2.34
	V	0.00	0.00	0.62	1.95	0.00	0.00	1.72	3.32	0.00	0.00	0.00	0.78
	VI	0.00	1.72	1.14	1.17	0.00	0.00	1.40	2.03	0.00	0.00	0.00	2.00
	VII	0.00	0.00	5.25	4.29	0.00	0.00	0.57	0.51	0.00	0.00	0.00	2.03
	VIII	0.00	0.00	0.00	4.37	0.00	1.72	1.14	1.56	0.00	3.28	0.00	0.47
	IX	0.00	2.96	4.51	2.34	0.00	0.00	2.96	1.52	1.87	0.00	0.57	1.17
	X	0.00	0.00	1.77	0.78	0.00	0.00	2.24	0.00	0.00	0.00	1.14	0.00
Rua	I	0.00	0.00	6.14	5.46	0.00	3.28	5.51	2.57	0.00	0.00	0.00	4.10
	II	0.00	0.00	2.50	2.50	0.00	2.81	1.72	3.71	0.00	0.00	1.92	5.81
	III	0.00	5.93	4.00	2.96	0.00	0.94	3.69	2.11	0.00	0.00	2.13	2.42
	IV	0.00	0.00	2.08	2.73	0.00	2.96	3.38	7.45	0.00	1.95	1.25	0.47
	V	0.00	3.51	2.70	3.28	0.00	0.00	1.82	4.84	0.00	0.00	1.30	3.35
	VI	6.55	0.00	0.00	1.17	0.00	0.94	1.77	3.04	0.00	0.00	1.82	3.74
	VII	3.12	5.07	1.66	0.00	0.00	1.40	1.30	0.00	0.00	0.00	0.68	2.93
	VIII	0.00	0.00	2.34	0.00	0.00	6.86	0.88	5.73	1.87	1.72	1.35	1.21
	IX	6.86	3.28	6.86	2.03	7.49	2.81	3.22	3.90	0.00	0.00	1.30	4.41
	X	0.00	2.73	0.00	2.07	4.99	3.28	4.78	2.34	0.00	0.00	2.60	3.32

APPENDIX X

Yield of Seed Potato, tons/acre

Seed Size		1 oz				2 oz				4 oz			
Spacing		6"	12"	18"	24"	6"	12"	18"	24"	6"	12"	18"	24"
Variety	Repl.												
I.Hardy	I	6.24	1.95	2.39	1.25	5.30	3.59	2.08	2.73	4.68	3.28	3.90	1.68
	II	3.28	2.89	1.98	2.50	4.06	3.28	3.02	2.42	2.81	3.67	3.22	1.91
	III	3.43	4.99	2.39	2.15	8.11	6.40	2.18	2.46	5.93	3.12	2.86	2.93
	IV	8.11	4.29	2.60	2.11	5.46	5.77	4.52	2.81	9.36	3.74	4.42	3.55
	V	3.12	3.12	3.17	2.57	7.02	5.46	4.63	1.72	4.84	6.63	5.36	1.91
	VI	4.68	4.84	3.01	3.20	6.24	5.85	3.85	2.73	5.62	4.52	4.21	3.16
	VII	8.11	4.52	3.80	2.03	10.45	4.21	3.64	2.65	14.04	4.06	4.78	3.20
	VIII	5.46	5.07	4.42	3.63	9.20	5.62	6.45	2.50	9.05	8.58	7.59	3.12
	IX	7.96	2.89	2.50	2.38	5.93	4.06	4.68	3.59	12.01	4.52	5.30	5.15
	X	4.52	3.59	3.90	3.55	9.67	5.30	5.10	3.71	4.39	5.85	3.74	3.04
Rua	I	3.74	2.03	2.65	0.51	8.43	2.50	2.24	1.40	8.89	4.68	2.50	0.86
	II	3.59	1.40	1.77	1.29	4.84	0.78	2.29	2.38	5.93	2.18	2.34	1.09
	III	3.12	1.33	2.29	0.94	3.90	2.18	2.81	1.01	7.18	4.21	5.41	1.25
	IV	4.68	3.35	0.52	0.82	4.21	2.26	1.51	1.68	13.73	3.67	3.28	2.57
	V	3.90	2.34	1.25	0.86	3.74	1.95	1.14	1.87	4.99	1.56	2.76	1.56
	VI	0.78	0.39	0.78	0.47	2.65	3.12	1.04	2.11	5.30	3.12	2.18	1.76
	VII	2.97	0.31	0.36	0.78	7.02	2.65	1.04	2.11	7.96	4.21	2.13	2.61
	VIII	3.12	3.59	1.14	0.78	7.18	1.79	3.38	1.76	8.27	4.06	3.95	1.60
	IX	3.12	2.26	1.92	1.37	3.28	2.81	1.35	0.98	10.93	5.07	1.98	1.83
	X	2.34	1.64	0.32	1.91	4.39	1.17	1.35	1.95	6.71	4.45	2.86	2.00

APPENDIX XI

Yield of Small Potato, tons/acre

Seed Size		1 oz				2 oz				4 oz			
Spacing		6"	12"	18"	24"	6"	12"	18"	24"	6"	12"	18"	24"
Variety	Repl.												
I.Hardy	I	1.40	0.47	0.62	0.39	1.87	0.78	0.57	0.55	2.81	0.86	0.94	0.59
	II	1.24	0.94	0.42	0.51	1.25	0.94	0.52	0.51	1.09	1.01	0.88	0.78
	III	1.09	1.56	0.57	0.51	1.87	1.56	0.62	0.55	1.40	0.86	0.78	0.47
	IV	2.18	1.25	0.47	0.59	2.34	1.09	0.83	0.62	2.50	1.95	1.04	0.55
	V	0.94	0.39	0.42	0.39	2.03	1.40	0.88	0.39	1.56	0.94	0.88	0.59
	VI	1.87	1.17	0.88	0.78	1.87	1.56	0.68	0.62	1.71	1.33	1.30	0.78
	VII	1.09	0.78	0.78	0.39	2.97	1.01	0.88	0.59	2.65	1.40	0.88	0.55
	VIII	1.25	1.25	1.09	0.70	3.28	1.87	0.78	0.66	3.12	1.79	0.78	1.17
	IX	2.34	0.78	0.68	0.66	2.03	1.25	0.42	0.43	3.90	0.94	1.30	1.01
	X	1.56	1.33	1.40	1.01	3.74	1.64	1.30	0.98	2.50	3.12	1.62	1.56
Rua	I	0.00	0.62	0.31	0.00	0.00	0.39	0.00	0.27	2.34	1.64	0.42	0.27
	II	0.31	0.16	0.31	0.12	0.46	0.16	0.73	0.27	1.71	0.31	0.47	0.20
	III	0.16	0.00	0.16	0.12	0.31	0.39	0.21	0.20	2.65	1.17	0.57	0.27
	IV	1.25	0.47	0.26	0.00	0.93	0.78	0.26	0.47	1.87	0.00	0.52	0.98
	V	1.72	0.00	0.10	0.27	1.25	0.00	0.10	0.47	0.78	0.39	0.31	0.23
	VI	0.00	0.16	0.00	0.00	0.78	0.00	0.21	0.12	1.56	0.47	0.57	0.27
	VII	0.31	0.16	0.21	0.12	1.87	0.94	0.47	0.23	1.40	0.55	0.36	0.31
	VIII	0.00	0.78	0.26	0.00	1.56	0.31	0.52	0.27	2.65	0.00	0.68	0.39
	IX	0.00	0.00	0.36	0.08	0.78	0.23	0.16	0.00	1.71	0.94	0.26	0.55
	X	0.00	0.31	0.00	0.16	0.16	0.47	0.10	0.16	0.31	0.47	0.52	0.59

APPENDIX XII

The effect of spacing, variety, and seed size on the Percentage of Yield Distribution.

Mean of 10 replicates.

Treatments.		Ilam Hardy				Rua			
		Large Potato	Table Potato	Seed	Small Potato	Large Potato	Table Potato	Seed	Small Potato
1 oz	6"	0.0	74.8	19.8	5.4	7.2	77.6	13.6	1.6
	12"	2.9	76.6	16.3	4.2	11.0	77.5	10.1	1.4
	18"	9.1	76.0	12.0	2.9	18.6	71.6	8.5	1.3
	24"	10.2	75.7	11.4	2.6	18.3	73.0	8.0	0.7
2 oz	6"	0.0	71.4	21.6	7.0	4.1	76.8	16.4	2.7
	12"	2.1	72.1	20.4	5.4	11.4	77.3	9.6	1.7
	18"	5.8	74.1	16.9	3.2	13.5	76.4	8.8	1.3
	24"	7.0	78.2	12.2	2.6	17.7	72.5	8.6	1.2
4 oz	6"	0.6	68.7	23.3	7.4	0.5	73.4	21.5	4.6
	12"	1.5	69.7	22.2	6.6	1.5	81.0	15.1	2.4
	18"	3.7	72.4	19.5	4.4	6.3	78.8	12.9	2.0
	24"	8.0	71.0	16.5	4.5	14.4	76.2	7.8	1.6

APPENDIX XIII

Dryweight Yield of Table Potato, tons/acre

Seed Size		1 oz				2 oz				4 oz			
Spacing		6"	12"	18"	24"	6"	12"	18"	24"	6"	12"	18"	24"
Variety	Repl.												
I.Hardy	I	4.97	3.79	4.65	3.04	5.78	2.77	3.21	3.15	2.98	3.40	5.16	2.08
	II	2.52	2.44	2.85	4.83	3.30	2.23	2.82	2.42	2.15	2.69	2.79	2.55
	III	4.34	3.05	3.30	3.17	3.16	3.53	4.17	2.16	4.56	3.64	2.30	1.95
	IV	4.94	3.97	3.27	2.77	4.48	3.22	3.13	3.83	4.36	2.23	2.00	3.16
	V	2.53	3.49	2.95	2.27	4.42	4.52	3.16	3.09	2.74	3.02	3.17	1.86
	VI	3.63	2.54	3.29	3.59	3.75	3.39	2.19	4.56	5.05	2.83	2.70	2.71
	VII	3.64	2.25	4.51	2.17	4.28	3.49	3.27	3.07	3.84	1.42	2.20	2.59
	VIII	3.45	4.28	2.58	2.57	3.18	2.39	3.11	3.00	4.85	2.57	3.59	1.28
	IX	3.45	2.94	3.70	2.78	4.41	2.50	2.41	3.34	4.89	3.18	3.00	2.40
	X	3.05	2.87	2.65	2.76	5.13	2.69	3.21	2.44	2.46	1.60	2.41	1.62
Rua	I	3.59	4.35	2.13	2.07	4.88	4.55	2.96	3.76	6.81	3.79	3.80	2.50
	II	5.30	2.86	3.65	2.11	3.42	3.97	3.73	3.82	6.65	3.46	4.32	4.45
	III	3.88	2.39	2.87	1.27	3.72	4.04	3.60	2.19	6.20	5.29	3.33	3.31
	IV	5.57	4.31	0.87	2.37	5.99	3.23	4.02	3.56	5.45	4.22	3.21	4.35
	V	3.44	2.98	2.19	2.56	4.95	4.15	3.36	3.11	5.30	5.33	3.01	3.18
	VI	1.95	1.89	2.44	1.21	4.59	2.65	2.00	2.53	6.11	2.98	3.18	3.31
	VII	3.46	1.98	1.53	0.88	5.03	3.26	3.82	2.65	4.97	3.49	4.19	2.80
	VIII	2.93	2.08	1.88	1.33	4.33	2.16	2.67	2.30	3.87	3.17	3.01	2.12
	IX	2.61	3.60	3.03	1.50	5.41	2.79	2.32	2.39	5.14	4.00	3.91	3.69
	X	1.97	2.81	0.84	2.32	4.02	3.29	2.81	2.29	4.85	4.10	2.94	3.33

APPENDIX XIV

Leaf area per Plant (dm^2)

(Average of two plants)

Var.	Harv. Date.	Sd. Sz. Spac. Repl.	1 oz 6"	1 oz 12"	1 oz 18"	1 oz 24"	2 oz 6"	2 oz 12"	2 oz 18"	2 oz 24"	4 oz 6"	4 oz 12"	4 oz 18"	4 oz 24"
I.Hardy	23/12	I	0.37	26.83	14.56	14.23	20.13	41.12	16.61	28.82	42.26	41.57	35.72	10.57
		II	21.97	23.50	16.44	16.12	32.01	36.03	37.30	31.06	9.68	63.16	34.47	39.48
	6/1	I	27.86	46.80	55.67	33.68	59.55	62.53	75.65	122.98	55.84	118.79	123.47	85.89
		II	46.06	49.53	71.35	70.97	26.92	65.70	33.78	53.31	25.96	52.25	19.15	103.16
	20/1	I	59.26	154.76	193.20	81.42	64.79	74.65	167.19	156.60	37.42	72.04	52.69	101.89
		II	55.70	83.69	116.86	91.66	66.42	94.22	131.45	108.58	87.06	139.67	169.07	106.49
	2/2	I	31.38	95.47	168.38	208.19	96.33	109.20	145.72	185.77	52.64	52.98	77.29	206.05
		II	53.57	120.96	208.13	187.98	40.80	135.17	131.31	173.34	58.01	94.26	169.43	95.23
	17/2	I	18.26	138.36	169.82	269.22	47.05	61.55	126.86	42.96	100.84	55.12	108.86	109.30
		II	56.99	59.82	86.20	395.55	40.00	133.96	97.73	265.11	0.00	54.43	159.67	119.41
	3/3	I	21.61	50.77	91.36	58.59	37.44	71.49	62.01	102.40	27.26	125.30	154.40	80.04
		II	55.40	28.83	119.20	193.71	53.93	63.53	55.92	95.81	158.60	41.84	144.23	109.60
	17/3	I	33.52	40.88	70.01	63.87	15.94	21.26	32.04	27.46	12.26	31.89	104.50	42.40
		II	0.00	21.67	43.18	38.96	0.00	38.02	35.57	38.32	0.00	5.72	39.39	51.30
Rua	23/12	I					13.26	9.23	0.00	14.91	23.97	25.12	0.00	17.15
		II					11.48	6.79	11.50	0.00	13.87	61.89	23.23	29.21
	6/1	I					42.12	61.80	37.84	0.00	42.19	78.59	79.87	30.90
		II					60.30	12.26	38.77	30.27	36.88	28.34	44.64	45.58
	20/1	I					120.44	119.95	115.14	66.98	103.32	130.74	105.96	55.32
		II					65.26	90.86	126.73	133.31	59.75	123.12	105.76	129.36
	2/2	I					145.96	143.91	80.76	221.32	46.87	70.47	144.67	81.67
		II					40.32	78.23	161.80	51.69	67.75	102.70	103.79	149.27
	17/2	I					57.17	116.01	161.03	126.85	32.95	80.24	157.95	224.26
		II					68.88	46.43	0.00	365.61	64.44	63.31	127.48	162.24
	3/3	I					17.86	71.99	93.41	170.93	50.16	125.92	96.85	89.04
		II					49.98	90.02	111.22	87.70	80.13	55.70	85.12	97.77
	17/3	I					26.75	52.06	50.05	105.38	47.09	82.44	124.72	190.42
		II					40.66	113.62	49.28	155.81	111.81	130.02	149.08	138.98
	31/3	I					0.00	61.82	82.94	320.16	42.98	103.59	233.41	245.14
		II					61.87	127.60	172.33	167.56	79.58	47.87	95.26	131.23

APPENDIX XV

The effect of harvesting date and spacing interaction on Leaf Area (dm^2), (transformed into loge.)

Spacing	Harvesting Date						
	23/12	6/1	20/1	3/2	17/2	3/3	17/3
6"	1.26	1.62	1.85	1.79	1.53	1.56	1.13
12"	1.45	1.70	2.01	1.97	1.85	1.88	1.62
18"	1.04	1.69	2.06	2.09	1.85	1.98	1.79
24"	1.18	1.55	2.00	2.12	2.24	2.00	1.87
	S.E. ± 0.12						

APPENDIX XVI

The effect of harvesting date - variety and harvesting date - seed size interaction, on Leaf Area per Plant (dm^2), transformed into loge.

Treatment	Harvesting Date 23/12	6/1	20/1	3/2	17/2	3/3	17/3	
Variety:								
I.Hardy	1.47	1.77	1.97	2.01	1.86	1.82	1.28	S.E.
Rua	0.99	1.51	2.00	1.98	1.88	1.89	1.93	± 0.09
Seed Size:								
2 oz	1.12	1.56	2.01	2.03	1.88	1.84	1.54	S.E.
4 oz	1.35	1.72	1.96	1.95	1.86	1.87	1.67	± 0.09

APPENDIX XVII

L.A.I. in all treatment combinations

Treatment	HARVESTING DATE																	
	9.12.65	S.E.	23.12.65	S.E.	6.1.66	S.E.	20.1.66	S.E.	3.2.66	S.E.	17.2.66	S.E.	3.3.66	S.E.	17.3.66	S.E.	31.3.66	S.E.
Ilam Hardy: 1 oz: 6"	0.09	±0.017	0.96	±0.18	3.18	±0.42	4.95	±0.73	3.57	±0.12	3.24	±6.56	3.32	±0.84	2.89	±0.40		
12"	0.03		1.08		2.07		5.13		4.66		4.27		2.19		1.35			
18"	0.04		0.45		1.97		4.45		5.40		3.68		3.04		1.62			
24"	0.01		0.33		1.13		1.86		4.26		5.80		2.72		1.11			
2 oz: 6"	0.04	0.007	2.25	1.27	3.72	2.01	5.65	3.28	5.91	3.13	3.75	2.16	3.93	2.25	1.38	0.19		
12"	0.10		1.66	0.96	2.76	1.60	3.64	2.09	5.26	3.32	3.78	2.27	2.91	1.68	1.28	0.62		
18"	0.04		0.78	0.41	1.57	0.85	4.29	2.42	3.98	2.30	3.22	1.83	1.69	0.58	0.97	0.56		
24"	0.02		0.64	0.37	1.90	0.99	2.85	1.66	3.86	2.24	3.32	2.43	2.13	1.24	0.71	0.40		
4 oz: 6"	0.01		2.24	1.01	3.52	1.90	5.37	2.85	4.33	2.75	4.34	0.45	1.86	1.04	1.06	0.17		
12"	0.09		2.26	1.33	3.68	1.96	4.56	2.49	3.17	1.98	2.36	1.53	3.11	1.81	0.81	0.35		
18"	0.02		1.01	0.48	2.05	0.81	3.18	1.57	3.54	1.90	3.85	2.19	4.29	2.49	2.07	1.06		
24"	0.02		0.54	0.25	2.02	1.17	2.24	1.30	3.24	1.74	2.46	1.42	2.15	1.21	1.01	0.58		
Rua: 2 oz: 6"	0.01		1.03	0.59	4.41	2.51	7.99	4.43	8.02	3.84	5.43	3.14	2.92	1.33	2.90	1.62	5.33	±0.40
12"	0.01		0.26	0.19	1.59	0.68	4.54	2.58	4.78	2.65	3.50	1.83	3.49	2.01	3.57	1.93	4.08	
18"	0.00		0.33	0.00	1.10	0.55	3.47	2.01	3.48	1.90	4.63	1.70	2.93	0.29	1.43	0.82	3.67	
24"	0.00		0.32	0.10	0.65	0.16	2.16	1.18	2.94	1.33	5.30	2.69	2.79	1.53	2.81	1.60	3.60	
4 oz: 6"	0.01		1.63	0.62	3.40	1.30	7.02	3.93	3.56	2.82	4.19	2.30	5.61	3.16	6.85	3.65	5.28	0.47
12"	0.03		1.87	1.42	2.30	1.10	5.47	3.16	3.73	2.12	3.09	1.77	3.91	2.09	4.57	2.59	3.27	
18"	0.02		0.67	0.13	1.78	0.99	3.04	1.76	3.57	2.04	4.10	2.36	2.61	1.51	3.93	2.32	4.71	
24"	0.02		0.50	0.28	0.82	0.46	1.99	1.05	2.49	1.37	4.46	2.38	2.01	1.26	3.55	2.03	4.05	

APPENDIX XVIII

Tuber Dryweight per Plant.
(Av.of two plant, gm)

	Harv.	Sd.Sz.	1 oz				2 oz				4 oz			
Var.	Date.	Spac.	6"	12"	18"	24"	6"	12"	18"	24"	6"	12"	18"	24"
		Repl.												
I.Hardy	6/1	I	3.8	4.3	2.8	0.3	3.8	1.7	3.6	10.0	7.7	15.8	7.4	3.9
		II	7.5	4.5	5.1	5.3	5.9	5.7	1.2	3.2	1.5	7.8	5.0	19.5
	20/1	I	48.2	50.3	72.3	30.9	21.4	39.5	33.2	30.1	50.5	44.5	30.0	65.8
		II	31.5	26.2	66.8	21.8	19.2	10.5	54.9	37.1	31.7	80.8	43.1	37.7
	3/2	I	68.7	86.9	43.0	72.6	63.4	61.1	58.7	115.4	86.2	73.8	68.7	109.9
		II	54.5	73.1	78.8	43.6	42.0	78.5	84.9	118.8	57.7	151.3	42.1	66.8
	17/2	I	15.9	107.8	244.0	164.2	89.5	137.0	266.7	161.5	74.2	133.3	37.8	103.0
		II	35.6	144.6	95.0	260.2	49.3	129.1	244.1	230.5	100.5	115.1	42.6	222.8
	3/3	I	43.6	144.6	289.9	257.1	91.6	104.2	278.0	292.6	38.8	202.6	315.1	102.7
		II	133.2	88.7	193.9	264.0	86.9	177.4	210.0	398.2	67.7	91.0	172.5	361.7
	17/3	I	152.6	107.9	152.8	420.9	79.9	30.0	260.8	252.7	135.9	97.6	266.7	236.3
		II	40.4	189.8	281.6	317.6	114.7	188.2	162.6	184.0	123.2	142.2	384.4	360.0
Rua	6/1	I					2.1	4.0	2.5	0.0	4.9	10.9	14.5	2.6
		II					8.7	0.0	0.6	1.4	6.2	0.3	1.2	12.1
	20/1	I					7.0	20.2	22.1	10.2	45.3	81.7	61.6	41.9
		II					52.7	91.5	24.3	90.4	42.7	61.1	47.1	19.0
	3/2	I					51.9	152.7	55.6	145.3	51.7	96.4	104.6	134.0
		II					110.1	56.3	32.7	70.5	104.9	74.0	155.2	200.5
	17/2	I					52.9	27.8	124.9	107.3	59.2	175.2	201.6	216.0
		II					102.0	120.1	0.0	121.8	64.8	156.0	168.0	272.9
	3/3	I					181.3	230.3	239.6	344.1	108.7	154.3	282.7	151.9
		II					107.0	119.8	196.5	253.6	162.9	159.7	145.6	280.7
	17/3	I					178.0	222.1	156.6	152.7	155.9	309.7	229.7	416.6
		II					132.4	213.1	284.5	369.4	205.7	246.4	283.1	377.9
	31/3	I					0.0	428.5	130.4	637.7	113.4	344.7	445.6	584.6
		II					130.9	280.6	657.3	409.8	105.5	288.0	435.3	347.7

APPENDIX XIX

The effect of harvesting-variety - spacing, and harvesting - variety - seed size interactions on Tuber Dryweight per Plant (gm), transformed into loge.

Treatment.	Harvesting Date						
	6/1	20/1	3/2	17/2	3/3	17/3	
Ilam Hardy:							
6"	0.60	1.45	1.78	1.88	1.83	2.05	
12"	0.77	1.54	1.93	2.11	2.13	2.19	
18"	0.55	1.59	1.79	2.00	2.37	2.36	
24"	0.84	1.61	2.00	2.23	2.41	2.40	S.E. ± 0.14
Rua:							
6"	0.68	1.67	1.87	1.83	2.13	2.22	
12"	0.28	1.74	1.94	1.99	2.21	2.39	
18"	0.35	1.55	1.86	1.65	2.32	2.36	
24"	0.41	1.46	2.11	2.22	2.39	2.42	
Ilam Hardy:							
2 oz	0.56	1.44	1.87	2.16	2.25	2.24	
4 oz	0.83	1.66	1.88	1.95	2.12	2.27	S.E. ± 0.10
Rua:							
2 oz	0.27	1.54	1.87	1.68	2.29	2.30	
4 oz	0.59	1.66	2.03	2.16	2.26	2.42	

APPENDIX XX

The effect of spacing, variety, and seed size on Tuber Dryweight per Unit Area (gm/sq.ft)

Treatment	Harvesting Date						
	6/1	20/1	3/2	17/2	3/3	17/3	31/3
Ilam Hardy:							
1 oz: 6"	4.56	31.92	49.31	56.98	94.37	102.96	
12"	1.79	15.33	32.00	50.50	58.74	59.56	
18"	1.06	24.74	26.84	45.21	64.52	77.17	
24"	0.54	5.28	11.63	42.45	69.49	73.86	
2 oz: 6"	3.84	16.21	42.17	55.50	71.40	77.84	
12"	1.96	9.99	27.92	53.22	75.08	83.92	
18"	0.85	11.74	19.15	68.10	65.15	56.46	
24"	1.32	13.42	23.36	39.20	69.12	48.62	
4 oz: 6"	3.68	32.95	57.58	93.14	85.18	138.18	
12"	4.72	25.06	45.00	49.68	78.29	78.32	
18"	2.19	9.74	14.77	14.30	103.00	86.81	
24"	2.34	10.34	23.56	43.44	61.91	59.63	
Rua:							
2 oz: 6"	5.78	37.58	86.35	75.13	115.33	124.12	104.18
12"	1.61	29.78	41.78	52.02	70.02	107.03	141.82
18"	0.84	12.37	13.69	33.30	58.14	58.82	105.03
24"	0.29	13.41	21.84	30.54	59.78	67.19	104.75
4 oz: 6"	4.42	34.96	83.52	115.78	144.83	144.62	87.55
12"	2.96	28.57	34.06	66.35	62.80	136.94	126.54
18"	2.09	14.53	34.70	49.28	57.11	68.33	117.45
24"	1.47	8.13	33.45	48.90	53.58	79.45	93.22

APPENDIX XXI

Dryweight of "Remainder"
(Av. of two plants, gm)

Var.	Harv. Date.	Sd.Sz. Spac. Repl.	1 oz 6"	1 oz 12"	1 oz 18"	1 oz 24"	2 oz 6"	2 oz 12"	2 oz 18"	2 oz 24"	4 oz 6"	4 oz 12"	4 oz 18"	4 oz 24"
I.Hardy	23/12	I	17.6	16.5	19.3	15.7	19.9	36.7	25.3	26.0	6.9	34.7	38.0	36.7
		II	13.5	19.6	12.5	8.7	21.2	20.5	27.5	26.9	17.5	16.7	31.6	28.6
	6/1	I	28.1	52.9	63.9	37.2	57.7	38.5	52.0	96.1	64.9	92.1	126.6	77.5
		II	45.3	57.8	56.3	42.1	23.9	34.0	42.8	67.8	20.6	57.8	71.3	86.8
	20/1	I	94.5	129.8	184.7	114.7	65.8	101.6	124.2	184.4	81.3	95.3	27.0	147.9
		II	57.9	97.1	162.2	97.4	90.0	88.7	117.8	125.7	93.5	122.2	145.0	134.2
	3/2	I	87.8	133.9	165.1	217.3	105.8	148.9	179.6	194.3	259.7	101.9	125.0	188.1
		II	98.9	112.1	170.1	261.6	86.6	130.8	184.4	209.1	130.2	127.0	213.1	63.4
	17/2	I	22.9	159.3	171.2	188.3	68.0	163.2	280.9	253.8	113.1	149.6	111.1	33.7
		II	45.3	121.4	145.8	369.5	27.7	103.0	70.0	172.4	63.0	101.4	311.9	243.5
	3/3	I	29.5	81.2	204.8	81.6	73.1	54.2	134.1	134.4	31.1	72.0	132.5	57.2
		II	90.3	30.5	320.3	103.7	82.5	100.2	120.7	163.2	12.4	47.2	91.9	191.8
	17/3	I	84.5	51.4	59.3	123.3	24.7	56.4	91.6	86.7	31.1	24.3	47.8	67.0
		II	0.0	50.6	94.6	145.3	0.0	99.2	82.2	101.7	0.0	14.9	88.6	167.9
Rua	23/12	I					5.8	10.7	10.2	19.5	16.5	23.1	0.0	0.0
		II					4.7	10.9	14.4	4.1	6.3	16.0	0.0	17.8
	6/1	I					36.4	40.6	16.5	0.0	41.7	83.1	74.4	45.9
		II					72.9	8.8	20.8	27.3	40.9	29.8	22.6	61.7
	20/1	I					101.9	104.8	95.7	59.6	74.1	108.7	83.7	48.8
		II					83.3	107.1	104.5	162.5	79.3	99.1	103.9	108.2
	3/2	I					57.3	140.9	121.9	193.5	49.4	91.1	167.3	129.8
		II					91.7	140.2	183.5	24.4	113.2	161.6	30.0	215.8
	17/2	I					44.0	44.5	185.9	228.8	28.1	134.5	198.9	235.4
		II					93.8	119.1	0.0	135.2	85.9	99.8	101.5	204.1
	3/3	I					86.8	198.2	219.5	286.2	103.7	127.6	222.4	198.8
		II					102.8	83.2	107.7	211.7	139.9	279.7	109.1	182.4
	17/3	I					26.9	105.8	67.4	78.4	72.4	125.4	156.2	324.7
		II					25.0	125.3	86.3	202.1	152.4	117.7	194.7	197.4
	31/3	I					0.0	130.5	83.3	227.2	51.1	197.6	220.9	174.0
		II					38.3	149.4	294.2	198.3	42.3	87.5	135.5	208.0

APPENDIX XXII

Dry Matter Partition in Tuber, (gm/sq.ft).

Treatment.		Harvesting Dates								
		9/12	23/12	6/1	20/1	3/2	17/2	3/3	17/3	31/3
Ilam Hardy:										
Spacing:	6"	-	-	3.76	24.58	49.87	74.32	78.29	108.01	
	12"	-	-	3.34	17.52	36.46	51.45	76.68	81.12	
	18"	-	-	1.52	10.74	16.96	41.20	84.06	71.63	
	24"	-	-	1.83	11.88	23.46	41.32	65.51	54.12	
Seed Size:	2 oz	-	-	1.99	12.84	28.15	54.01	70.19	66.71	
	4 oz	-	-	3.23	19.52	35.22	50.14	82.09	90.73	
Rua:										
Spacing:	6"	-	-	5.10	36.27	84.93	95.45	130.08	134.37	95.86
	12"	-	-	2.28	29.17	37.92	59.18	66.41	121.98	134.18
	18"	-	-	1.46	13.45	24.19	41.29	57.62	63.57	111.24
	24"	-	-	0.88	10.77	27.64	39.72	56.68	73.32	98.98
Seed Size:	2 oz	-	-	2.13	23.29	40.91	47.75	75.82	89.29	113.94
	4 oz	-	-	2.76	21.55	46.43	70.08	79.58	107.33	106.19

APPENDIX XXIII

Dry Matter Partition in "Remainder," (gm/sq.ft).

Treatment.		Harvesting Date								
		9/12	23/12	6/1	20/1	3/2	17/2	3/3	17/3	31/3
Ilam Hardy:										
Spacing:	6"	2.98	14.75	33.43	66.32	96.48	72.83	48.54	16.08	
	12"	1.38	13.70	22.23	40.77	50.85	53.92	36.47	20.79	
	18"	1.03	8.16	23.09	35.46	46.81	67.65	46.91	20.68	
	24"	0.84	5.91	16.42	29.63	36.93	45.63	31.48	21.16	
Seed Size:	2 oz	2.02	10.76	19.01	41.01	55.35	49.67	41.79	23.21	
	4 oz	1.09	10.49	28.57	45.08	60.09	69.85	39.92	16.14	
Rua:										
Spacing:	6"	1.42	10.27	38.38	65.71	83.10	84.10	102.70	55.35	34.00
	12"	0.76	6.06	16.33	41.46	53.38	45.24	68.87	47.41	56.51
	18"	0.50	2.18	13.50	25.84	40.18	44.81	47.25	33.63	48.92
	24"	0.37	2.93	8.08	18.95	39.04	46.26	43.95	40.13	40.38
Seed Size:	2 oz	0.53	4.84	17.30	41.05	53.79	52.62	57.95	28.88	44.88
	4 oz	0.98	5.88	20.85	34.94	54.08	57.58	73.43	59.38	45.03

APPENDIX XXIV

Tuber Fresh Weight (gm, x 10^2)
(mean of 2 of plants)

Treatment		1 oz				2 oz				4 oz			
Var.	Harv. Date	6"	12"	18"	24"	6"	12"	18"	24"	6"	12"	18"	24"
I.Hardy	6/1	0.41	0.43	0.29	0.02	0.36	0.41	0.02	0.47	0.38	0.69	0.43	0.79
	20/1	2.49	2.39	4.35	1.62	1.26	1.56	2.65	2.09	2.57	3.91	2.26	4.22
	3/2	3.85	5.84	6.99	5.14	3.29	4.38	4.48	7.54	4.49	7.23	3.46	4.57
	17/2	3.15	6.91	9.65	13.38	3.90	7.48	13.15	12.24	4.82	8.05	7.88	11.34
	3/3	5.32	7.37	14.39	13.69	5.78	8.05	14.22	22.11	3.40	9.18	14.34	15.19
	17/3	5.89	9.63	14.17	20.18	5.55	12.64	12.98	14.85	8.27	8.16	19.50	18.71
Rua	6/1					0.39	0.15	0.12	0.06	0.40	0.44	0.60	0.60
	20/1					1.49	3.34	1.39	4.01	2.61	4.28	3.24	1.82
	3/2					5.52	7.23	4.31	5.39	4.98	4.37	8.45	8.56
	17/2					4.50	6.97	7.24	7.93	3.81	9.97	11.11	14.74
	3/3					7.19	8.89	13.66	18.02	8.39	10.88	12.75	16.32
	17/3					7.65	12.69	13.21	16.89	11.56	14.96	18.54	25.06
	31/3					6.07	19.75	19.16	26.19	7.03	16.27	22.68	26.70

APPENDIX XXV

No. of Tubers/2 Plants

	Harv.	Sd.Sz.	1 oz				2 oz				4 oz			
Var.	Date	Spac.	6"	12"	18"	24"	6"	12"	18"	24"	6"	12"	18"	24"
		Repl.												
I.Hardy	6/1	I	11	17	7	3	15	8	12	23	24	34	13	14
		II	22	19	20	23	15	14	7	18	10	28	27	50
	20/1	I	25	25	24	14	15	24	19	29	23	25	20	35
		II	12	15	13	15	10	20	29	25	19	42	28	26
	3/2	I	21	23	13	11	19	29	26	23	31	18	26	24
		II	14	18	16	15	18	18	22	31	26	29	26	11
	17/2	I	7	20	22	19	10	9	30	31	7	20	21	12
		II	6	15	13	25	8	26	40	27	14	19	24	38
	3/3	I	6	20	30	29	14	10	26	32	5	16	19	9
		II	18	9	10	16	8	18	21	33	10	11	22	47
	17/3	I	19	13	16	24	10	35	29	33	23	20	29	29
		II	9	22	23	23	14	16	21	26	9	26	39	36
Rua	6/1	I					16	14	8	0	19	52	37	18
		II					29	0	2	15	21	2	7	42
	20/1	I					16	16	9	9	13	33	34	26
		II					8	19	7	30	21	24	15	4
	3/2	I					12	30	9	24	10	31	18	16
		II					18	13	8	4	17	22	24	27
	17/2	I					12	4	24	13	8	13	30	21
		II					7	17	0	10	12	28	21	22
	3/3	I					18	15	28	25	13	19	32	24
		II					12	20	22	11	13	11	24	37
	17/3	I					13	22	19	18	22	23	28	54
		II					12	16	15	23	23	25	34	21
	31/3	I					0	23	13	31	13	30	28	42
		II					7	13	29	17	18	13	22	28

APPENDIX XXVI

The effect of harvesting intervals and harvesting - variety interaction on mean Number of Tuber per Plant

Treatment	Harvesting dates						
	6/1	20/1	3/2	17/2	3/3	17/3	
Overall mean	9.3	10.5	10.2	9.0	9.8	11.9	S.E. ± 0.8
Ilam Hardy	9.8	12.1	11.5	10.5	9.4	12.3	S.E. ± 1.2
Rua	8.8	8.9	8.8	7.6	10.1	11.5	

APPENDIX XXVII

No. of Main Stems/2 Plants.

Var.	Harv. Date.	S.Sz. / Spac. / Repl.	1 oz 6"	1 oz 12"	1 oz 18"	1 oz 24"	2 oz 6"	2 oz 12"	2 oz 18"	2 oz 24"	4 oz 6"	4 oz 12"	4 oz 18"	4 oz 24"
I.Hardy	23/12	I	5	6	5	6	4	9	11	9	4	15	10	11
		II	6	4	4	4	6	6	8	11	7	8	13	8
	6/1	I	10	8	6	5	9	5	4	10	11	13	10	13
		II	11	8	7	6	6	7	6	8	6	5	6	9
	20/1	I	7	6	6	6	10	6	6	16	10	10	4	10
		II	6	4	8	2	12	8	8	8	6	14	5	4
	3/2	I	9	6	6	9	9	11	5	9	10	8	8	13
		II	10	6	7	9	8	6	7	8	9	10	8	4
	17/2	I	3	7	8	7	4	5	8	10	4	7	4	2
		II	2	3	6	7	5	7	9	6	8	9	5	9
	3/3	I	3	4	5	6	5	5	6	6	2	8	4	2
		II	6	2	6	6	5	5	4	6	2	3	5	12
	17/3	I	4	4	2	5	4	6	6	6	3	4	7	6
		II	0	5	7	7	0	5	7	7	0	2	10	9
Rua	23/12	I					4	5	8	10	9	8	0	0
		II					2	4	4	5	3	7	0	7
	6/1	I					6	7	2	0	4	10	9	5
		II					9	3	2	3	7	6	3	8
	20/1	I					4	6	4	4	12	8	4	4
		II					4	6	4	4	4	8	10	8
	3/2	I					3	7	4	10	4	6	11	4
		II					5	7	7	1	7	8	7	5
	17/2	I					4	1	7	4	2	3	10	6
		II					4	5	0	2	3	6	7	7
	3/3	I					6	6	5	4	4	5	11	9
		II					4	2	2	4	5	4	8	10
	17/3	I					3	4	5	3	7	4	7	9
		II					4	6	4	7	8	8	10	5

APPENDIX XXVIII

The effect of harvesting intervals and harvesting - variety interaction on the mean No. of Stem per Plant.

Treatment	Harvesting Date						
	23/12	6/1	20/1	3/2	17/2	3/3	17/3
Overall mean	3.4	3.3	3.6	3.6	2.7	2.6	2.8
Ilam Hardy	4.4	4.0	4.3	4.1	3.2	2.5	2.1
Rua	2.4	2.6	2.9	3.0	2.2	2.8	2.9

APPENDIX XXIX

Estimate Gross Margin per Acre of Potato (1966 - Manawatu)

Spacing (inch)	6"			12"			18"			24"		
Seed Size (oz)	1	2	4	1	2	4	1	2	4	1	2	4
Seed Rate (cwt/acr)	19.44	38.88	77.80	9.72	19.44	38.88	6.48	12.96	25.92	4.86	9.72	19.44
Table & Large Potato Yield (ton/acre)	20	24	24	17	18	17	17	18	18	15	18	17
Seed & Small Potato Yield (ton/acre)	5	7	9	3	4	5	2	3	4	2	2	2
Table Potato at £16.10. 0 (1966)	320. 0.0	396. 0.0	396. 0.0	280.10.0	297. 0.0	280.10.0	280.10.0	297. 0.0	297. 0.0	247.10.0	297. 0.0	280.10.0
Small Potato at £10. 0. 0 "	50. 0.0	70. 0.0	90. 0.0	30. 0.0	40. 0.0	50. 0.0	20. 0.0	30. 0.0	40. 0.0	20. 0.0	20. 0.0	20. 0.0
Gross Return : £	380. 0.0	466. 0.0	486. 0.0	310.10.0	337. 0.0	330.10.0	300.10.0	327. 0.0	337. 0.0	267.10.0	317. 0.0	300.10.0
Cost:												
Rent.	25. 0.0	25. 0.0	25. 0.0	25. 0.0	25. 0.0	25. 0.0	25. 0.0	25. 0.0	25. 0.0	25. 0.0	25. 0.0	25. 0.0
Cultivation	10. 0.0	10. 0.0	10. 0.0	10. 0.0	10. 0.0	10. 0.0	10. 0.0	10. 0.0	10. 0.0	10. 0.0	10. 0.0	10. 0.0
Plant	2.10.0	2.10.0	2.10.0	2.10.0	2.10.0	2.10.0	2.10.0	2.10.0	2.10.0	2.10.0	2.10.0	2.10.0
Seed (Cert. Mother Group 2) at £45. 0. 0	45. 0.0	90. 0.0	180. 0.0	27.10.0	45. 0.0	67.10.0	15. 0.0	30. 0.0	60. 0.0	11. 5.0	27. 0.0	45. 0.0
Manure	12. 0.0	12. 0.0	12. 0.0	12. 0.0	12. 0.0	12. 0.0	12. 0.0	12. 0.0	12. 0.0	12. 0.0	12. 0.0	12. 0.0
Spray: Blight X5 Material at 17/- - £4. 5. 0 Moth x 3 Material at 16/1 - £2. 8. 0 Application x 5 at 30/- - £7.10.0 £14. 3. 0	14. 3.0	14. 3.0	14. 3.0	14. 3.0	14. 3.0	14. 3.0	14. 3.0	14. 3.0	14. 3.0	14. 3.0	14. 3.0	14. 3.0
Weed Spray (not general perhaps for late digging) Material £6. 0. 0 Application 1.10. 0 £7.10. 0 Defoliation (10% growers) 2.10. 0	not included											
Digging	20. 0.0	20. 0.0	20. 0.0	20. 0.0	20. 0.0	20. 0.0	20. 0.0	20. 0.0	20. 0.0	20. 0.0	20. 0.0	20. 0.0
Picking-up £2/ton	40. 0.0	48. 0.0	48. 0.0	34. 0.0	36. 0.0	34. 0.0	34. 0.0	36. 0.0	36. 0.0	30. 0.0	36. 0.0	34. 0.0
Grading 3/- per ton	3. 0.0	3.12.0	3.12.0	2.11.0	2.14.0	2.11.0	2.11.0	2.14.0	2.14.0	2. 5.0	2.14.0	3.11.0
Sacks at 2/10, 16/tons £2.5.0/ton	45. 0.0	54. 0.0	54. 0.0	38.10.0	40.10.0	38.10.0	38.10.0	40.10.0	40.10.0	33.15.0	40.10.0	38.10.0
Twine 10/- per 10 ton	1. 0.0	1. 4.0	1. 4.0	17.0	18.0	17.0	17.0	18.0	18.0	15.0	18.0	17.0
Levy at £1. 5.0/ton	25. 0.0	30. 0.0	30. 0.0	21.10.0	22.10.0	21.10.0	21.10.0	22.10.0	22.10.0	18.15.0	22.10.0	21.10.0
Cartage at £1./ton	20. 0.0	24.0.0	24. 0.0	17. 0.0	18. 0.0	17. 0.0	17. 0.0	18. 0.0	18. 0.0	15. 0.0	18. 0.0	17. 0.0
TOTAL COST £:	262.13.0	334.9.0	424. 9.0	325.11.0	249. 5.0	265.11.0	213. 1.0	234. 5.0	264. 5.0	195. 8.0	231. 5.0	244. 1.0
GROSS MARGIN £:	117. 7.0	131.11.0	61.11.0	84.19.0	87.15.0	64.19.0	87. 9.0	92.15.0	72.15.0	72. 2.0	85.15.0	55. 9.0