

PRODUCTION OF POTATOES
FOR PROCESSING

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At one time potatoes were grown almost solely for the housewife. She was accustomed to accepting a range in quality and adjusting her cooking methods accordingly. A range of varieties was grown and over the years, the majority of housewives were reasonably satisfied with what they bought. There were problems with damage and disease and poor storage, but these were problems of management rather than the variety and good farmers produced an acceptable products.

Of recent years, an increasing proportion of the crop has been sold for processing. This new demand has coincided with changes in farming systems which have affected older varieties, and the introduction of new varieties to which the farmer is not yet fully adapted. As a consequence there is difficulty in ensuring a regular supply of potatoes of the right quality throughout the season. Originally many processors thought in terms of buying any potatoes as a source of raw material but it is now realized that it is impossible to make a good product from poor raw material.

Processing then starts with the production of the crop and for convenience the whole operation can be divided up as follows:-

- (1) Producing the raw material
- (2) Harvesting and transporting
- (3) Storage
- (4) Processing
- (5) Distribution
- (6) Utilisation

Every stage is important in ensuring that the final product as eaten is up to standard, but this paper concentrates on producing the raw material and summarizes work at the Crop Research Division, D.S.I.R. Lincoln over the past 15-20 years.

In planning production it is helpful to know what characters are of importance to the processor. Some are of general importance and some are more important for a particular product.

(a) General

Medium to large size (except for canning), regular shape, shallow eyes. These reduce peeling losses. Absence of second growth, blemishes, diseases. Low sugar content. High dry matter content.

(b) Particular

(i) Crisps. Low sugar content (below 0.2%) is most important but in addition oil uptake should be low and crisps should be crisp without being too brittle nor too "woody".

(ii) Chips (French Fries). A little more sugar content (up to 0.4%) can be tolerated as some can be removed by blanching, but texture of the chip is very important. It should be crisp outside and firm inside, not limp and soggy.

(iii) Dehydration. Reconstituted mash should be a clean white or creamy colour with no greying and it should have a granular, not a gluey texture.

(iv) Canned Potatoes. Ideally these should be new potatoes $\frac{1}{2}$ " to $1\frac{1}{2}$ " in size, of a specific gravity less than 1.075. They should remain firm, free from greying and taste like new potatoes.

(v) Frozen Potatoes. Small older potatoes are used. They should stay white or cream and not fall to pieces on cooking.

How do we produce potatoes to suit these requirements?

The main factors involved are:-

- (a) Variety
- (b) Seed Treatment
- (c) Soil and fertilisers
- (d) Climate
- (e) Agronomic factors
- (f) Disease and Pests
- (g) Storage.

(a) Variety

Varieties differ in chemical composition, especially in dry matter and the content of free sugars. Some varieties, e.g. Ilam Hardy are not greatly affected by the growing conditions, whereas others, e.g. Sebago vary considerably. From tests at Lincoln varieties grown in New Zealand can be grouped as follows:

A. Dry Matter

i. High dry matter. Ono, Rima, Dakota Red, Wha, Whitu, Cliff's Kidney, Toru, Rua, Arran Chief, Aucklander Short Top.

ii. Medium high dry matter. Ilam Hardy, Katahdin, Sebago, Kennebec, King Edward.

iii. Medium dry matter. Arran Banner, Jersey Bennes, Majestic, Glen Ilam.

iv. Low dry matter. Tahi and Glen Ilam are frequently low, but both can be high when grown on lighter soils.

B. Sugars

i. Low sugar. Wha, Whitu, Ilam Hardy, Aucklander Short Top, Sebago, Dakota Red, Kennebec, Katahdin.

ii. Medium sugar. Rima, King Edward, Majestic, Rua, Arran Banner, Jersey Bennes, Ono.

iii. High sugar. Tahi, Glen Ilam, Arran Chief.

In addition varieties differ greatly in their reaction to irregular growing conditions. Aucklander Short Top, Dakota Red and Kennebec are very susceptible to second growth, whereas Rua and to some extent Ilam Hardy are more resistant.

Growing a crop to suit the processor then means avoiding the problems described.

(a) Variety. Plant a variety which in the district has been shown to be satisfactory. Crop Research Division is breeding a range of varieties especially for processing. New hybrids are selected on the basis of their behaviour at Annat and Lincoln and subsequently grown in a number of other localities for several years. Samples are sent to Lincoln for cooking tests and those consistently good are selected. Cooking tests have shown Wha and Whitu to be consistently superior for frying over a wide area and range of conditions. Reasonable varieties are now available for most purposes except for canning.

In a trial at Lincoln in 1970-71, 18 varieties and hybrids were planted with whole and cut seed at 6", 9", and 12" apart in the rows. Harvests were made when tubers had reached canning size and at periods afterwards. The season was dry, tuber set was low and specific gravity increased rapidly so that few would have been suitable for canning beyond the first harvest. Tubers increased rapidly in size so that few gave as high a yield of canning size at second and later harvests. Close spacing had little overall effect. No variety gave over 4 tons an acre of canning size but Cliff's

Kidney and Red King Edward gave just under 4 tons, but would have had to be canned within a few days before dry matter rose too high. Further work will be necessary before a firm recommendation can be made.

(b) Seed Treatment

The establishment of the plant, the number of shoots and the number of tubers set depend greatly on the treatment of seed and in turn these factors influence yield, tuber size and maturity. The aim should be to encourage 3-5 sprouts per tuber at the usual planting distances. This will usually allow an adequate tuber set and hence few oversize tubers.

Care should be taken in killing the tops of seed crops as a too rapid kill may result in stem-end necrosis or net necrosis and lower vigour. Other factors reducing vigour of seed are excessive dryness during the growing season, careless handling, sweating in store through close stacking, lack of ventilation and too high temperature. Ideally, seed should be stored at around 38-40°F (3-5°C) with high humidity and good ventilation, until about 3-4 weeks before planting when it should be warmed to 55-65°F (13-19°C) to encourage sprouting. Varieties which sprout readily even though storage conditions have not been good are Ilam Hardy and Dakota Red. Varieties needing special care are Rua, Sebago and Katahdin. Poor sprouters may be helped by using seed dressing chemicals, especially if tubers are cut, but there may be little point in using them with good sprouters.

(c) Soils and Fertilisers

Soils are particularly important in association with climate, but there are some over-riding influences.

Dry matter tends to be high from medium to light soils and low from heavy wet soils. Peat soils tend to give the lowest dry matter. Although clay soils are heavy, well-drained clays can give potatoes with a high dry matter. Heavy soils can be improved by the incorporation of organic matter to improve the texture.

Although dry matter tends to be highest under poor growing conditions it is not necessarily so, and high yields of high dry matter can be obtained provided growth is evenly maintained through the season. In areas of reasonable rainfall, good crops can be obtained when potatoes are planted after a good grass pasture. The better texture allows better rooting and more even growth of the crop.

Fertilisers have an effect when in excess. Nitrogen lowers dry matter if used in large quantities. A light dressing of potash may raise dry matter, but high dressings, especially of potassium chloride, will lower dry matter. When phosphate is deficient, a dressing will improve dry matter, but higher amounts have little effect.

(d) Climate

There are three interacting factors:

- i. Day length
- ii. Temperature
- iii. Moisture

i. Day Length

The highest dry matter content tends to be present in potatoes maturing during the shorter days of autumn, early winter, rather than the long days of summer.

ii. Temperature

Dry matter is higher under moderate temperatures (13-21°C) rather than high (27-35°C). High temperatures when the crop is well grown may encourage second growth. If potatoes are left in the soil after soil temperatures fall below 10°C, the sugar content can rise considerably and make the potatoes unsuitable for frying. Consequently, potatoes for processing should be dug when they are mature rather than left until they are needed. Potatoes bruise more readily if dug when the soil is cold, especially if blackspot susceptible.

iii. Moisture

Moisture is important in two ways, the amount and the distribution. The amount largely determines yield while the distribution of rainfall as well as affecting yield greatly influences second growth, quality and some pathological and physiological diseases. For best quality water supply should be regular and even to give even growth. Quality can be as good at high levels of moisture as at low provided it is evenly distributed. Critical periods of moisture supply are firstly at tuber setting which usually corresponds to early flowering and about three weeks or so later when ample moisture is necessary for tuber growth. A moderate supply from then on is desirable for yield. In practice trials on maincrop varieties have shown that high yields of good quality potatoes can be obtained by irrigating (1½-2") at tuber setting, a further similar irrigation 3-4 weeks later and possibly a third irrigation another 3 weeks later. On sandy soils, heavier furrow irrigation may be used, but on alluvial and wind blown silts, spray irrigation is recommended. Care should be taken to avoid packing the soil and reducing the supply of air to the roots.

Twenty ton crops have been obtained at Lincoln with as little as 12 inches of water (rain + irrigation) where rain was well distributed and individual falls were in useful amounts, but in most seasons a total of 15-18 inches is required.

A check to growth followed by rain, especially if warm, results in a change in growth rate of the tubers which may be manifest as second growth, hollow heart, growth cracks or tubers which though appearing normal break up on cooking. Such tubers although superficially appearing to be floury tend to absorb water when boiled giving a sloppy mash, or absorb fat when fried giving soft greasy French Fries. Good growing conditions followed by sudden dry weather may give brown fleck (internal rust spot) in tubers, whereas prolonged dry weather with the soil around wilting point produces tubers susceptible to blackspot and in severe cases, with internal breakdown. A wet autumn after a dry summer sometimes results in tubers which are soft and sappy and easily bruised and which never seem to ripen properly (e.g. Tahi). Any variation in growth rate appears to increase the sugar content.

(e) Agronomic Factors

Close spacing tends to give more but smaller tubers. Free soils give better shapes. Cloddy soils result in bruising during harvesting.

Potatoes which mature naturally are likely to be better quality than those ripened prematurely by haulm killing. Where haulm killing is done, the grower should aim at a slow kill over a period of 10-14 days to encourage ripening. A rapid kill may give stem-end necrosis, or internal necrosis, raise sugar content, or give tubers which break up.

Careless harvesting results in cuts and bruises which can harbour disease, raise respiration rates, as well as causing losses in preparation. Not only is there a loss in material cut away (as well as higher cost of labour) but also when the potato is cut into chips or crisps, there may be more short pieces to be rejected.

(f) Diseases cause losses as follows:-

- i. Yield reduction. Virus diseases, blight, wilt, blackleg, pink rot.
- ii. Tuber rotting. Blight, blackleg, pink rot, Fusarium soft rots, leak.
- iii. Tuber blemishes. Scab, corticium, skin spot, tuber moth, wire worm, slugs.
- iv. Lower quality. Tuber moth, brown fleck, leafroll, black spot, skin spot.

It goes without saying that diseases should be eliminated because of the damage they cause and the extra cost of sorting and thinning damaged potatoes.

(g) Storage

In New Zealand, storage is still largely a responsibility of the farmer, though in the future it will shift more to the processor as he realises the benefits of having his raw material under his control. The aim is to control storage diseases, weight loss, quality changes and sprouting. Factors of most importance are temperature, moisture and ventilation.

i. Temperature

Sprouting is reduced as the temperature drops below 50°F (10°C) and inhibited for long periods below 40°F (4.5°C). On the other hand sugars start to increase below 50°F and increase quickly below 45°F (7.2°C). A reasonable compromise is to store at 50°F with a sprout inhibitor for up to 3-4 months, at 45°F with a sprout inhibitor for 5-6 months and at 40°F for longer periods. In the latter case, potatoes may need re-conditioning before use by holding at 65-75°F (18-24°C) for 2-3 weeks.

ii. Humidity

At low humidities potatoes lose moisture whereas at high humidity some diseases may flourish. Provided the air is moving and there is no free water about, diseases and water loss can be controlled at around 95% RH.

iii. Ventilation

Air movement is necessary to avoid temperature gradients and free moisture. A minimum of 10 cfm per ton is necessary and under New Zealand conditions 20 cfm per ton is desirable with provision for faster flows (50-60 cfm/ton) when potatoes are put into storage in a wet condition.

There are evidences of different behaviour by different varieties (e.g. Ilam Hardy sprouts at a lower temperature) but these differences have not yet been worked out.

Potatoes may be stored in sacks, boxes or in bulk to suit the convenience of the farmer, so long as due allowances is made for different ventilation requirements, but for large scale storage, there are economies in bulk storage.