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Test Procedures
for
Measuring the Quality in Sugar Beet Production
-
Seed Drillability, Precision Seeders, Harvesters, Cleaner Loaders

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Credits:

Test Procedures for Measuring the Quality of Sugar Beet - Seed, Drillability, Precision Seeders, Harvesters, Cleaner Loaders

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1. Growth and morphology of sugar beet

1.1. Growth and morphology

Sugar beet (*Beta vulgaris* L. ssp. *vulgaris* var. *altissima*) belongs to the family Chenopodiaceae. The cultivated fodder and sugar beets originate from the Middle East and Mediterranean areas. It is a biennial plant, which is essentially vegetative during the first year of growth and requires over - wintering to induce reproductive development in the following year.

The sugar beet seeds used today are essentially monogerm. They need to be fully viable to ensure that an adequate plant population is established from the sown seed, and need to be accurately placed within the rows to ensure stands are regular and even. There is also a need for good seed vigour to ensure rapid seedling growth to avoid pest and diseases and allow the crop to compete effectively with weeds. Rapid seedling development is also important to establish leaf area, provide early leaf cover to fully intercept incident radiation and maximize crop dry matter and sugar production. High sugar yields depend upon maximum interception of the available solar radiation and its efficient use in dry matter and sugar production. The growth and development of the leaf canopy needs to be maintained by optimal use of fertilizers and irrigation. Its photosynthetic activity needs to be sustained with effective control of diseases.

The majority of beets require a period of cold vernalization and appropriate day length to flower. These are usually provided by over-wintering and increasing daylength in spring. Occasionally, and especially if sown too early under cold conditions, some plants will flower and set seed in the first year (i.e. 'bolt'). Normally beets are harvested at the end of the first growing season.

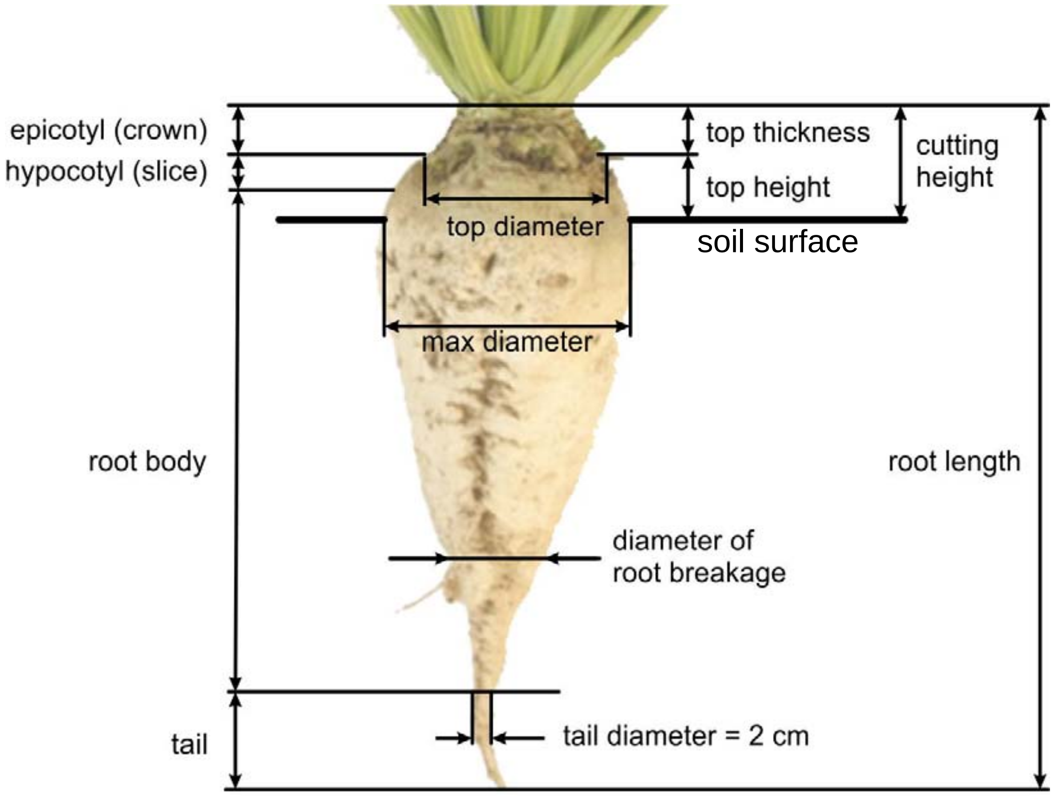

Figure 1 Morphological data of sugar beets

The shoot of the mature, vegetative sugar beet plant consists of a rosette of leaves, borne on erect petioles subtended from a compressed stem. In commercial practice, the compressed stem is referred to as the crown. The upper part of the root is derived from the seedling hypocotyl and the lower part, the true storage root, is developed from a series of secondary cambial rings that arise in the root pericycle (Artschwager, 1926). The true storage root contains the highest concentrations of sucrose (*c.* 16-20%), and concentrations progressively decline in the hypocotyl (*c.* 15%) and the lower (*c*. 13%) and upper (*c*. 7-9%) parts of the crown. The decrease in sucrose concentration is accompanied by increases in the concentrations of potassium, sodium, amino-nitrogen compounds and invert sugars (Harvey & Dutton, 1993). These melassigenic substances interfere with the crystallisation of white sugar in the factory.

The harvesting of sugar beet is now fully mechanised. Plants are topped or defoliated in the field to remove as much green shoot material as possible, but some crown tissue is left to avoid over-topping beet and removing part of the storage root. This is to ensure that the full yield of roots is delivered to the factory. The proportion of crown left on the beet after machine topping, the crown tare, depends on variation in plant size, the initial size of the biological crown, harvesting conditions, and the skills of the operator in setting up and using the harvesting machinery. Machine topping of field-grown beet is rarely uniform, so delivered loads contain different proportions of over-, under- and correctly-topped beet, and different amounts of crown, leaf material, dirt and stones.

1.2. Morphological data of sugar beets

The morphological attributes of the clean sugar beet vary with the location of growth, variety, weather and cultivation techniques.

PROPERTIES	UNIT	TYPICAL VALUE	VALUE RANGE
Technical length	mm	220	100 - 340
Weight	kg (50 t/ha)	0.8	0.14 - 3
Weight of the parts:			
Top	%	6	5 - 7
Root neck	%	12	6 - 18
Root	%	82	77 - 86
Maximum beet diameter	mm	120	40 - 300
Top diameter	mm	80	40 - 160
Vertical height	mm	45	0 - 150
Top thickness	mm	30	5 - 100
Beet Density	kg/dm^3	1.07	1.00 - 1.14
Bulk Density	kg/m^3	635	580 - 690
Bulk Angle	degree	40.5	35 - 46
Dry matter parts	%	22	18 - 26
Surface area	cm^2	350	10 - 700

Table 1 Biotechnical characteristics of the sugar beet

The physical properties are summarized in annex A.

2. <u>Seed quality</u>

Since the sugar beet seed used today is almost exclusively a monogerm seed, the seed provided for growers needs to be of the highest biological quality and uniformity.

Types of seeds, due to ISO/DIS 7256/1, are specified for single-purpose and multi-purpose drills. For multi-purpose drills they are differentiated between

type a: medium round seed 3 ± 0.75 mm in diameter;

type b: small seed of regular shape of diameter less then 3 mm;

type c: large irregular seed of diameter greater then 6 mm;

type d: most difficult seed permitted by the manufacturer (e.g. unpelleted genetically monogerm beet seed).

The seeds should not have been subject to any treatment which could change their physical property, except that incorporated in the coating.

The dimensional characteristics, purity and water content of the batch used should be mentioned in the test report.

The hygrometric levels should be observed and noted in the test report.

2.1. Calibration

Drilling is a highly mechanized process. In drilling to a stand, the correct placement of single seeds is of paramount importance, and precise calibration is essential with both naked and pelleted seed to ensure precision of placement within the row, avoidance of doubles, and the correct planting depth. In Europe the industry has decided on a calibration limit placed between 3.25 and 4.75 mm, based on an agreement between the seed producers and single-seed drill/ precision drill manufacturers. Drill cells need to be calibrated to ensure that single seeds are delivered to the coulter and missing cells or double seeded cells are avoided.

To ensure that drill calibration is effective, the seed size range (naked and pelleted seed for drilling) needs to be carefully controlled. The sieve size is determined with the help of samples taken from the total seed mass. Each sample should weigh approximately 50 grams and be tested with two replications. The screening process is done with a standardized sieving machine (see annex B) first with a round hole plate and then with a slit hole plate. The class width of the sieve amounts to 0.25 mm. The amount of remaining seed is quoted in mass percentage.

Normal limiting values due to sieving with round holes e.g.:

Class <3 mm:	≤1.5 weight %
Class >5 mm:	≤1.5 weight %
Class 3.00 > 3.25 mm:	max. 4.5 weight %
Class 4.75 > 5.00 mm:	max. 4.5 weight %

There is a desire to have an European standard calibre, however some countries may have a different standard, e.g. in Belgium: < 3.50 mm plus > 4.75 mm must be less than 6% number of seeds.

2.2. Sphericity

Index of sphericity I.S. = d/D The index of sphericity I.S. is the quotient of seed diameter (e.g. measured by the slit hole plate) and the seed length (e.g. measured by the round hole plate), see also annex B. The I.S. data may also be gained by an image analysis system, Tits & Leveque 2001; IRBAB 1999.

2.3. Definitions and formulas

Application rate is the amount of seeds expressed as a number, mass or volume of seeds per unit of length or surface.

Spacing is the distance between two successive seeds in the row.

Misses (Voids) are the absence of a seed where there should be one theoretically, in practice all the spaces larger than 1.5 times the theoretical seed spacing.

Multiples (Doubles) are the presence of two or more seeds where there should only be one, in practice all spacings less then 0.5 times the theoretical seed spacing.

Germinating power (GP): is the number of germinated seeds relative to the total number in the test sample.

$$GP = \frac{n_{gkK}}{nK} \times 100\% \quad (1)$$

n_{gkK} : number of germinated seeds with a plumule and a radicle (i.e. a shoot and a root axis)
nK: total number of seeds in the sample

<u>Method</u>: Two samples, each of 50 pelleted seed, are placed in a Petri dish or similar, lined with a moistened paper filter at room temperature. The number of germinated seeds is counted after 3 and 7 days.

Expected Field Emergence FE: Germinating power corrected for the expected field emergence. For sugar beet typically 15% of the sown seed are not expected to emerge.

$$FE = GP - A \text{ (\%)} \quad (2)$$

GP: germinating power (%)
A: proportion of seed not expected to emerge (%) (sugar beet approx. 15%)

Spacing (Seed distance) $\mathbf{S_{KA}}$: Planting distance within the row

$$S_{KA} = \frac{FE \times 10^6}{PD \times S_R} \times 100 \text{ (cm)} \quad (3)$$

FE: field emergence in %
PD: plant density in plants per ha
S_R: row distance in cm

Application Rate (Seed Density) $\mathbf{n_K}$**:** Number of sugar beet seed sown per hectare.

$$n_K = \frac{PD}{FE} \times 100 \text{ (seeds/ha)} \quad (4)$$

PD: plant (sugar beet) density (plants/ha)
FE: field emergence (%)

3. Precision seeder

3.1. Test procedure (according to ISO 7256/1 - 1984(E), annex B)

The following measurements are made on spacing (seed distribution within the row, distances in mm) and all benchmarks and calculations are related to this basic raw data. The accuracy at the test stand should be 5 mm and in the field (4 leaf stage) 10 mm. In fields with a poor or irregular emergence the test can not be used.

Target spacing is the final spacing required within the established crop. This may be a commercial or experimental requirement. In practise it is varied by adjustments to the settings of the seed delivery mechanism.

Actual spacing: The actual spacing X_{IST} is obtained from the DRS (distance recording system, annex D) which measures average seed distance between consecutive seed drops, not considering misses and doubles (weighted average of the normal distribution at the given distance or the class of dominant distance).

Actual field emergence: The actual field emergence calculates the total number of the plants emerged n_e per theoretical number of the plants (application rate) times a hundred (%).

$$FE = \frac{n_e}{n_k} \times 100\,\% \qquad (5)$$

n_e: number of plants after field emergence
n_k: theoretical number of applied seeds

Method: Calculation of the field increments of the emerged seeds from the number of accrued plants and number of the non emerged seeds.

Desired spacing: The desired spacing is the part of the seed in an experiment that lies in the area 0.5 times to 1.5 times actual distance.

$$0.5X_{IST} \leq X_i < 1.5X_{IST} \qquad (6)$$

Doubles: The doubles are the portion of seeds in an experiment that lay in an area <0.5 times the actual distance.

$$0 \leq X_i < 0.5X_{IST} \qquad (7)$$

Misses: The missed application parts are subdivided into the 1 times and over 2 times missed applications. The 1 times missed application is the part of the seed in an experiment, where the area lies 1.5 times the actual distance. The over 2 times missed application part is the part of the seed in an experiment, where the area lies > 2-5 times the actual distances.

$$1.5X_{IST} \leq X_i \qquad (8)$$

Spacing accuracy of seeds and plants A_I (%): The number of seeds or plants f_i, described by their actual spacing, placed within tolerance bands around the actual distance X_{IST} versus the entire numbers n of spacings of seeds or plants counted, multiplied by 100.

$$A_i = \frac{f_i}{n} \times 100 \qquad (9)$$

$$f_i = sum\left(X_{IST} \pm tolerance\right)$$

X_{IST}: actual, measured distance

Tolerance range for sugar beets: laboratory test (seed spacing) and field test (plant spacing):

+15 mm.

Mandatory: tolerance of plant spacing (field test) ±25 mm

Spacing accuracy as standard deviation s_X of the distance of X (mm):

$$s_X = \sqrt{\frac{\sum (X - X_{IST})^2}{(n-1)}} \qquad (10)$$

X_{IST}: actual, measured distance

Variation coefficient of the desired spacing: The variation coefficients are specified for the area (scope) 0.5 times to 1.5 times the actual distance. The variation coefficient is the relative variability:

$$VAR = \frac{S}{X} \times 100 \qquad (11)$$

Field emergence increase (speed of field emergence) v_{FE}: The field increment describes the change in the field increments between the counting dates.

$$v_{FE} = \frac{FE_{(t2-t1)}}{z_{t2} - z_{t1}} \text{ (\%d)} \qquad (12)$$

$FE_{(t_2-t_1)}$: field emergence increase is the difference between first and the following date of field measurement (%)

z_{t1}: date t_1, as the day in the year (d)
z_{t2}: date t_2, as the day in the year (d)

Method: The field emergence increase describes the speed of field emergence between at least two counting dates, that is the change of the field increase between at least two counting dates. The following counts are e.g.:

1. Date = 10% of the expected field emergence is obtained on 2/3 of the test plot.
2. Date = on 2/3 of the plot the field emergence stays constant

Actual plant density (PD): The actual plant density is defined as the number of the plants per hectare at harvest

$$PD_P = \frac{nP \times 100}{l \times R} \text{ (plants/ha)} \qquad (13)$$

nP: number of plants
l: row length (m)
R: row distance (cm)

Method: The plants at harvest are counted at row length of 10 m.

4. Harvester

4.1. Prerequisites

A prerequisite of this test is that the plant density should be regular and be between 50,000 and 120,000 beets per hectare. Roots of less than 4.5 cm diameter are ignored both in the plant counts and the losses assessments. The plant density should be in the range of ±20% of the regionally advised plant density.

4.2. Agronomic information

Basic information about the site, the crop and its agronomy are essential to meaningfully interpret the results. The following field details should be given:

- Soil type (e.g. peat, clay - loam, etc.)
- State of soil (e.g. wet, stony, etc.)
- Cultivation technique (ploughing, no-ploughing, strip-till, …)
- Cultural practices (crop drilled to stand or thinned)
- Primary tillage, last crop rotation
- Variety
- Type of seed (e.g. pelleted, monogerm, etc.)
- Seed spacing (cm)
- Row width (cm)
- Plant density (plants/ha)
- Plant population
- Diameter of the beets
- Potential yield of clean beets (t/ha)
- Other details (e.g. bolting, disease, top size, etc.)

4.2.1. Plant distribution

The distance between plants within a row is measured at 4 rows of 10 m length random locations across the field. The measurements are summarized as relative frequency distribution curves, as shown in Figure 2**.**

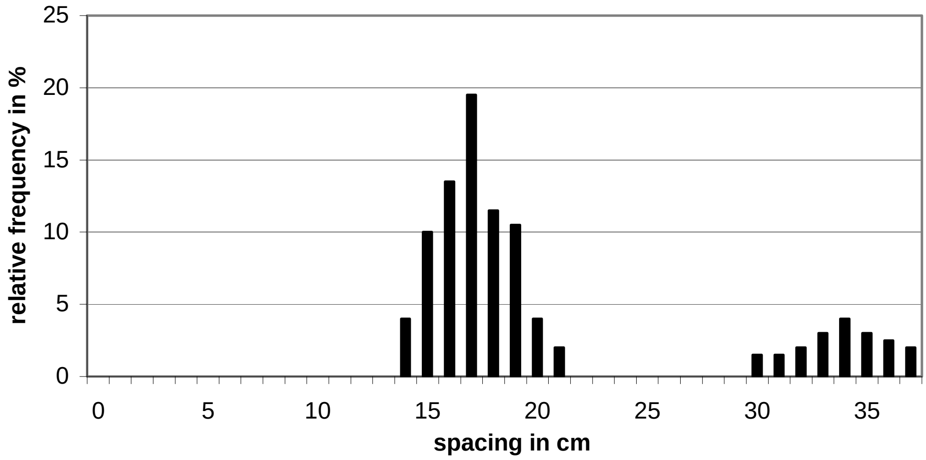

Figure 2 Pattern of a graph showing the plant distribution

4.2.2. Root diameter

The maximum diameter is highly correlated with the beet root mass. Therefore the measurement of the root diameter is optional.

Mandatory Test: The maximum diameter of each root in a 500 - root sample is measured. The distribution of frequencies of the largest sugar beet diameter can be shown in the form of a diagram as in Figure 3 and the diameters classified into the following categories, 4.5 - 7 cm, >7 - 9 cm, >9 - 11 cm, >11 - 13 cm, >13 - 15 cm and >15 cm to provide frequency distributions as shown in Figure 3. These measurements may be done on the same bulk of roots taken for the determination of root breakages.

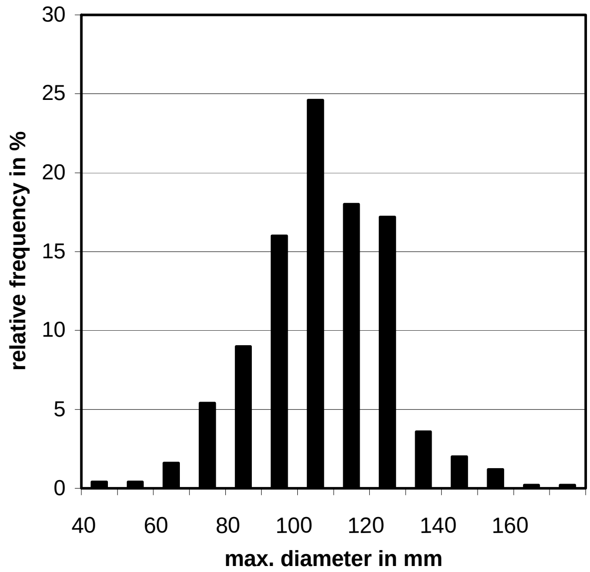

Figure 3 Relative frequencies of maximum beet root diameter

4.3. Description of the harvester

The test report should include

- Name and address of the manufacturer
- Test person and/or team
- Harvester characteristics (topping, lifting, conveying, cleaning)
- Overall dimensions
- Tyre dimensions, make and type, inflation pressure as recommended in tyre tables
- Weight gross and net), axle and wheel load with lifted and unlifted header, fuel tank full and without driver- other specifications e.g. empty weight, tank capacity

4.4. Performance assessments ('harvesting quality')

The test is performed in a regular crop stand prepared for 2 test passes. After the first test run a representative of the manufacturer decides wether the first run is accepted or whether a second test run will be necessary due to unforeseen occurences.

Measurement of speed: The speed of harvesting is measured on the total test run. The organizer of the test can decide wether a minimum speed depending on test conditions is defined.

The driver decides when his bunker is filled completely.

Only members of the testing team and the driver can be on or around the machine during the test run.

The harvesting quality of each machine is based on the following criteria:

- Harvesting losses (lifting, cleaning and conveying losses)
- Root breakage
- Topping quality
- Soil tare
- Superficial damage

4.4.1. Lifting, cleaning and conveying losses

The lifting losses include all whole roots left above and under the ground, as well as the upper parts of all broken roots with a diameter larger than 4.5 cm that are left on and in the soil. The lower parts of broken roots are not included because these are recorded in the root breakage assessments. The soil will need to be drag or spring-tine harrowed twice at a depth of 15-20 cm to recover roots left in the ground. Lifting losses should be measured on four areas that are e.g. 6 rows wide and at least 10 m long, to give a total sampled area of at least 100 m^2. The tines of the cultivator should work both in and between the rows.

The beetroots are collected, topped by hand and weighed to calculate the specific mass loss per hectare in t/ha (manually harvested yield as reference).

To calculate the specific mass loss of clean beets the collected beet losses may be cleaned by a washing process standardized and topped by hand for measuring the soil tare.

4.4.2. Root tip breakage

Root breakage assessments are made on 5 x 100 root samples taken from the beet lifted from the whole of the performance assessment area (minimum 6 rows, each 200 m long). A representative sample is taken

a. with a catch frame (annex E) holding bags or buckets of a capacity of at least 25 kg at least twice for each unloading of the tank of the harvester or the conveyor of a loader.

b. from the pile after unloading the harvested beets within the test area and increasing the sample number to 10 x 100.

The diameter of each root at the point of breakage (if any) is measured and recorded in the following diameter classes: 0-2 cm, >2-4 cm, >4-6 cm, >6-8 cm and >8 cm. For fangy beets the maximum root tip diameter is measured.

Mandatory: testing tank harvesters, samples should be equally devided during unloading process.

The calibration factor provides the relative weight of root lost within each breakage diameter class. Tables 2 shows examples for the calculations involved.

To reduce any subjective errors in these assessments, each replicate should be measured by the same trained persons. The test should be supervised by an expert in sugar beet outside characteristics assessment.

Number of categories I	1	2	3	4	5
Categories of diameter of root breakage cm	0-2	>2-4	>4-6	>6-8	>8
Relative frequency b_i %	-				
Factor of losses c_i * g	0	23	60	130	230
Relative yield losses Per category (b_i x c_i) g	-				

*centre of classes 1, 3, 5, 7 and 9 cm

Table 2 Calculation of yield losses caused by root tip breakage from measurement and classification of breakage diameter

Plant density at harvest (PD_h) = ____________/ha

Root tips broken off in the sample (r_b) = ____________ g

Relative yield losses due to root tip breakage:

$$\sum_{i=2}^{5}\left(\frac{(b_i \times c_i) - r_b}{b_i \times 10^6} \times PD_h\right) = \_\_\_\_\_\_\_\_\_\_\_\_ \text{ t/ha} \qquad (14)$$

Yield of clean beets = ____________t/ha

Relative yield losses by root tip breakage:

(yield of clean beets in t/ha x absolute yield losses in t/ha)/100 = _____________ % (15)

4.4.3. Topping quality

A subjective assessment of topping quality is made at the same time as the root breakage measurements, using the same 500 - beet sample (or 10 samples of 100 roots, respectively). They are classified into one of the following six categories (see Fig. 4.):

Under topped subdivided into

- Untopped with petioles longer than 2 cm
- Under topped with petioles shorter than or equal to 2 cm

Well topped

- Under topped with no petioles
- Correctly topped

Over topped

- Over topped with under half of maximum diameter of bundle rings visible
- Angled topped

For beets defoliated with a- flail topper the categories are similar:

Defoliated with petioles > and < 2 cm
Well/correctly defoliated without lesions
Completely defoliated with lesions

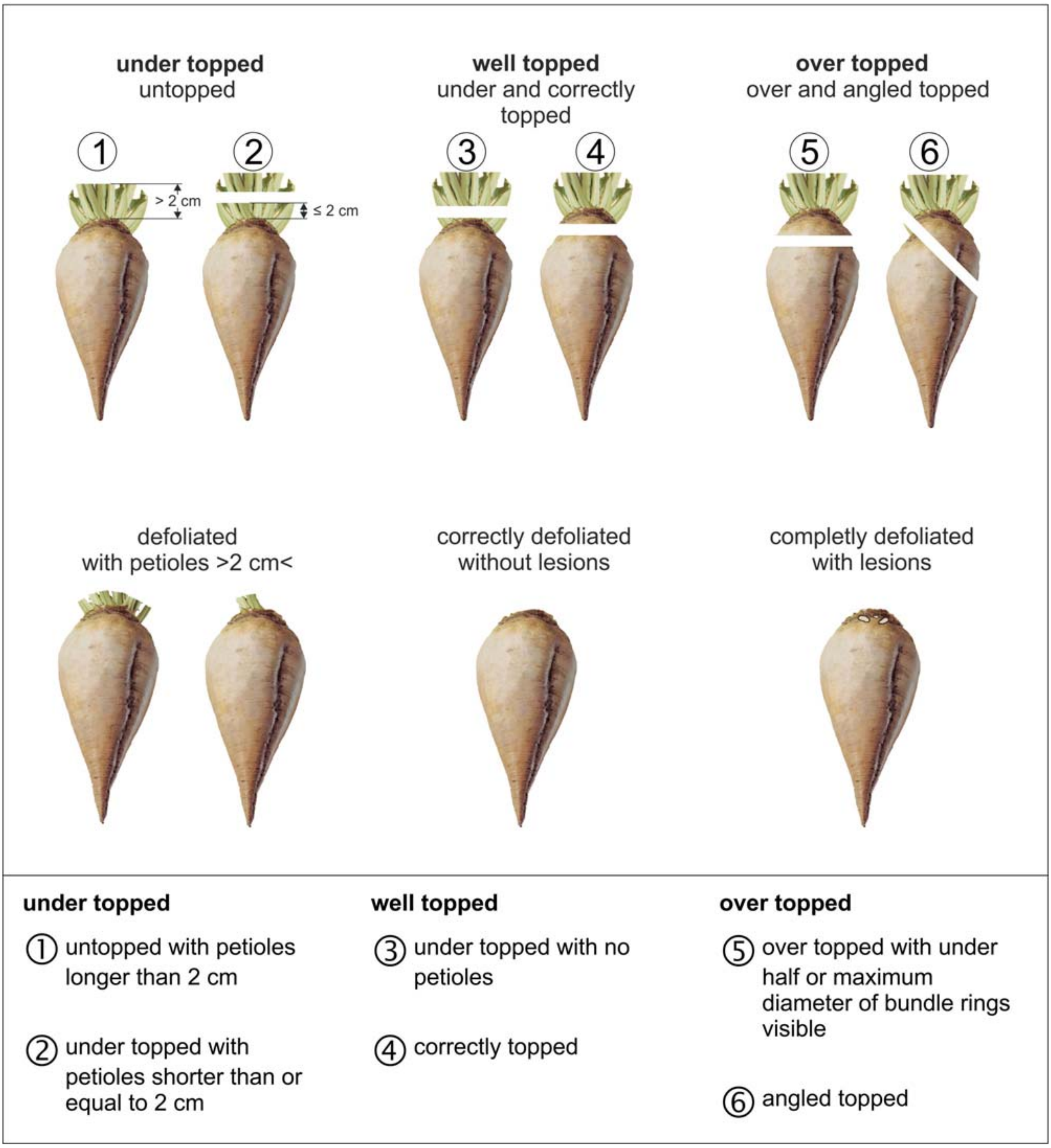

Figure 4 Assessment classes for topping and defoliation quality

Optionally, top mass loss can be estimated, but only on over topped beets.

The numbers of roots within each topping category should be recorded as shown in Table 3.

Number of categories	1	2	3	4	5	6
Categories of topping quality, parts of petioles left	Untopped >2 cm	Under topped ≤ 2 cm	Under topped no petioles	Correctly topped	Over Topped, with bundle rings visible	Angled topped
Relative frequency %						

Table 3 Form for declaring the topping quality of harvesters

Each country should indicate what it considers to be an acceptable topped beet, possibly including the categories 3 and 4.

4.4.4. Soil tare

Soil tare (i.e. the soil adhering to the roots, loose soil and stones) should be measured and included in the report. This is an assessment carried out on an extra sample of 5 x 100 beets, taken according to the sample taken for root breakage.

The mass of soil is measured by a washing process described in annex C or the determination is based on tare house washing with regular settings of the existing washing equipment. The soil tare is calculated by the equation shown below. An average is calculated for at least 500 kg and a sufficient number of repetitions.

$$\text{Soil tare} = (\text{gross beet weight} - \text{washed beet weight}) / \text{gross beet weight} \quad (16)$$

A true soil tare may be calculated by dividing the single mass of dirty samples minus mass of washed (clean) beets by the mass of washed (clean) beets.

$$\text{Soil tare}_{\text{clean beet base}} = (\text{gross beet weight} - \text{washed beet weight}) / \text{washed beet weight} \quad (17)$$

4.4.5. Superficial damage

The recording of superficial damage to the roots is not a mandatory element in performance assessments, but it is important since it provides information on the way in which roots are handled as they pass through the harvester.

The damage is classified into the four classes

- Non-damaged,
- Wounded (significant mass loss),
- Bruised (scratched surface, visible crack with no mass loss),
- Wounded and bruised.

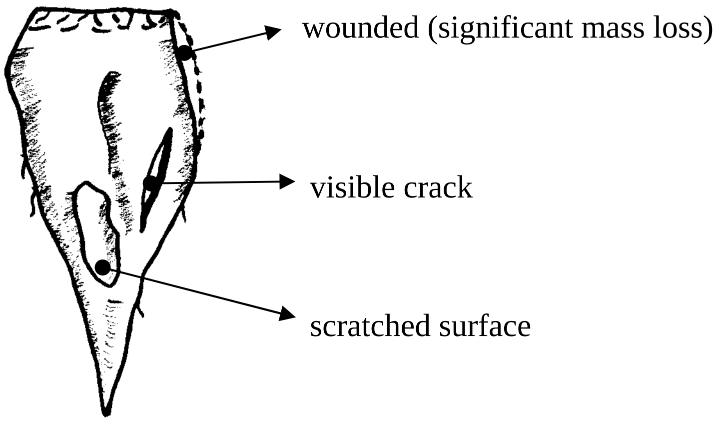

Figure 5 Classes of superficial damage

The number of roots occurring in each category of damage should be recorded using the same procedure as for topping quality. The superficial damage is declared by the relative frequency in each category.

4.4.6. Storage trials

Optional tests: The superficial damage can be measured by outcomes of respiration or storage trials of the beet harvested by the harvesters in test, including one ‘standard’ of manually harvested beets.

In assessments of superficial damage, linear measurements could be made of the length and width of the damaged area (Figure 6). The product of the two measurements gives the damaged area. The measurements should be made on ten samples of 100 roots, and the results expressed as the total area (cm^2) per 100 roots.

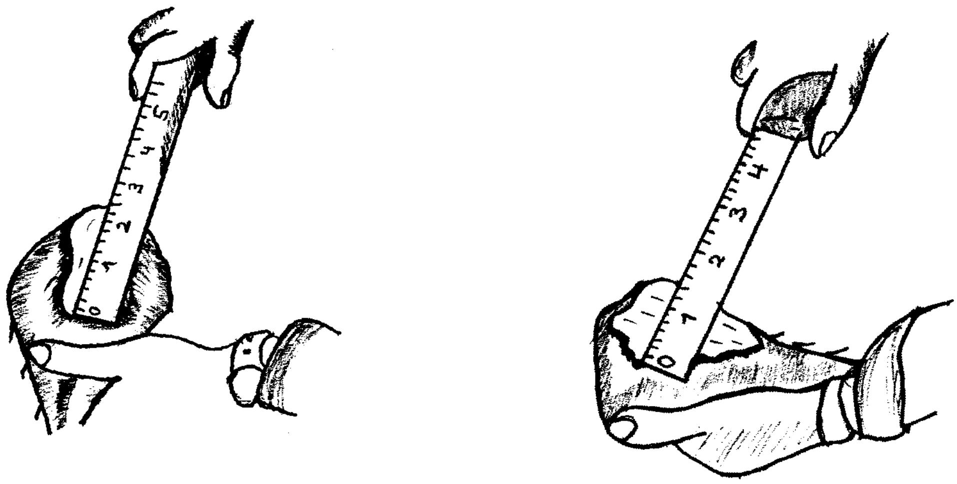

Figure 6 Measurement of superficial injuries

The assessments of root breakage, topping quality and superficial damage should be made on the same five samples of 100 roots taken with the catch frame or on the same ten samples of 100 roots taken from the heap (pile) of harvested beet.

4.4.7. Example of a control on working quality for harvesters

Test sheet of harvesters

location: ***Seligenstadt*** ……. test team: ***university*** ………. date: ***10/11/2012*** ……
machine: ***n° 6*** ……………… plant density : ***90.000*** ..plants/ha
yield potential (clean beets): ***70,000*** …………t/ha working speed: ***5*** …….km/h

Losses

root tip breakage category	rel. frequency %	factor of losses g/100 beets	rel.losses kg/100 beets
0 - 2 cm	***29,0***	0	------
>2 - 4 cm	***63,0***	23	***1,440***
>4 - 6 cm	***7,0***	60	***0,420***
>6 - 8 cm	***1,0***	130	***0,130***
>8 cm	***0,0***	230	***0,000***
total per 100 beets			***2,000***

root tip breakage losses: ………………. …………***2,57*** ….% ………***1,800*** …..t/ha
lifting, cleaning and conveying losses: . …………***0,77*** ….% ………***0,500*** …..t/ha
total losses: ……………………………. …………***3,34*** ….% ………***2,300*** …..t/ha

Topping and defoliation quality

category	Topping quality rel. frequency %	Defoliation quality rel. frequency %
1	***2,0***	**7,6**
2	***8,0***	
3	***24,2***	**75,0**
4	***37,4***	
5	***23,4***	**17,4**
6	***5,0***	

Soil tare: …***11,1*** .. %, number of samples: ……***20*** …, per …**25**... kg of harvested beets

Additional information
trial identification: ***2012/06/JPG*** ……………………………
weather conditions: ***good*** …………………………………
soil type: ***loam*** ………………………………………………
regularity of crop: ***very good*** ………………………………
presence of fangy beets, optional: ***1 %*** ……………………………
miscellaneous: ***no further comment*** ………………………………………………………

Table 4 Example of a control on working quality for harvesters

5. Cleaner loader

5.1. Prerequisites

The prerequisites should be listed according to the test standard of harvesters, see section 4.

5.2. Conditions

The tests should be done on a typical sugar beet crop, i.e. with plant densities and root yields in the range of ± 20% of the regional average.

The sugar beet used in these tests should be a uniform sample, and avoid beets of diameter less than 4.5 cm. The beet must come from the same stand, variety, location, soil type and harvest date specified.

A review of specifications of cultivation practices is found in Table 5.

General information			
location	Peterborough	row width (cm)	50
soil type	sandy loam	plant spacing (cm)	19.5
variety	sweet		
weather condition	normal		
harvest date	12/10/16		
cleaning date	12/11/16		
Measures and analysis			
plant density (pl/ha)	90,016	sugar content (°S)	17.6
top thickness (avg., mm)	22	potassium (mmol/1000 g beet)	31.6
beet high (avg., mm)	62	sodium (mmol/1000 g beet)	6.3
beet diameter (max, mm)	104	Amino-N (mmol/1000 g beet)	12.2
beet mass (max, g)	760		
calculated beet yield (t/ha)	68,400		

Table 5 Example of specification of cultivation practices

5.3. Description of the cleaner loader

Sugar beet cleaner loaders should be in a good condition and have been used to load a minimum of one days capacity harvested beet. The required machine details are:

- Name and address of the manufacturer
- Test person and/or team
- Cleaner loader characteristics, e.g. type, technical specifications
- Overall dimensions
- Other specifications, e.g. wheel load, tyre dimensions

5.4. Description of the sugar beet crop

The performance of the cleaner loader depends on the condition of the sugar beet, and the amount of loose and attached soil. Some definition is needed of the location and conditions under which loading is done.

The assessment of the test results requires the following information:

Sugar beet in the heap

- Sugar beet size distribution
- Soil tare
- Breakage status
- Topping quality status

Storage location and conditions

- Heap size
- Nature of storage base
- Duration of any covering of the heap
- Duration of storage
- Soil type and moisture content of the loose soil (optional)
- Moisture content of soil beneath the heap (optional)
- Storage climate, e.g. air temperature, temperature in the centre of the heap (optional)
- Storage management, e.g. type of cover

Root diameter:

The frequency distribution of the maximum root diameter of sugar beets taken randomly from the sugar beet heap is used to characterize the size of the sugar beets. The 500 sugar beets are measured and grouped according to diameter size used for harvesters testing, using the following size categories: <4.5 cm., >4.5 - 7 cm., >7 - 9 cm., >9 - 11 cm., >11 - 13 cm., >13 - 15 cm., >15 cm, and the average weight of a single sugar beet is calculated.

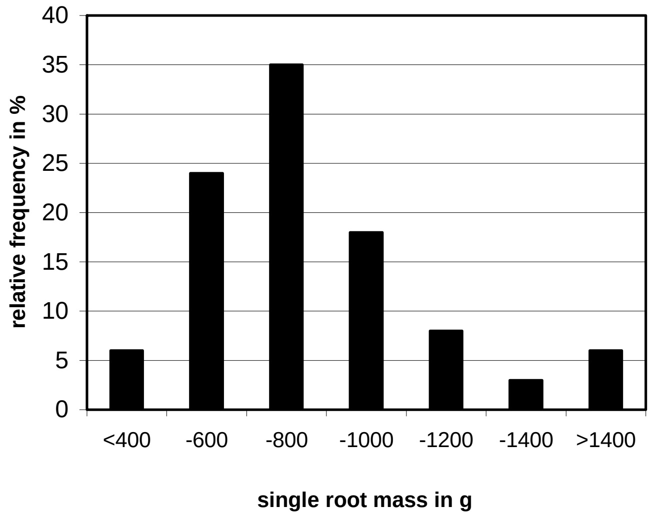

Figure 7 Example of single root mass frequency

Soil tare:

This is the accompanying soil (attached soil, loose soil, stones) which is included in the overall dirty weight of topped and harvested beet. Soil tare is generally determined by a standard washing test (annex C) or according to the local standards applied in the tare house used for the test.

The calculation of soil tare (%) is done according to formula (16) and the calculation of true soil tare according to formula (17).

The representative sample has to be taken of at least 500 kg with sufficient numbers of repetitions to determine the soil tare status in the heap.

a. By using the catch frame according to the harvester test, see annex E.

b. By using a probe sample device (horizontal Rupro), see annex G.

The samples are taken along the heap or during unloading of the harvester.

Root breakage status:

The status is in general given at the measures of the harvester test with the frequency distribution in the categories nondamaged, wounded, bruised, wounded and bruised.

Mandatory: The diameter of the root tip at the point breakage is measured (using the sugar beet samples taken for the sugar beet size studies) and grouped into size categories shown in Table 6 (0 - 2 cm., >2 - 4 cm., >4 - 6 cm., >6 - 8 cm., >8 – cm, alternatively 0 - 3 cm., >3 - 6 cm, > 6 cm). As far as is possible, the tests should be done on five samples each of 100 beet and, if possible, by five trained people. The results are expressed as a size frequency distribution as in figure 7.

Number of categories I		1	2	3	4	5
Categories of diameter of root breakage	cm	0-2	>2-4	>4-6	>6-8	>8
Relative frequency b_i	%	-				
Factor of losses c_i *	g	0	23	60	130	230
Relative yield losses Per category (b_i x c_i)	g	-				

*centre of classes 1, 3, 5, 7 and 9 cm

Table 6 Calculation of yield losses caused by root tip breakage from measurement and classification of breakage diameter

Superficial Damage (optional): Measurements of surface damage are optional. In assessments of superficial damage, linear measurements should be made of the length and width of the damaged area (see figure 6). The product of the two measurements gives the damaged area. The measurements should be made on five samples of 100 roots, and the results expressed as the total area (cm^2 per 100 roots).

Performance assessments /Test procedure

There should be sufficient sugar beet present at the test site before the commencement of testing. A uniform test heap of 150 tonnes of beet for each machine under test is provided one week before the test. Special attention must be given to achieve uniform test heaps for each machine.

- 3 trucks are loaded, from each at least 10 samples are taken for soil tare determination. The entire procedure includes in addition 1 truck to adjust the loader and 1 truck to finish the pile.
- Capacity is determined by measuring the time to fill each truck (the average of 3 trucks). Weight (gross/net) is measured at the sugar factory.

5.4.1. Reduction of soil tare

Cleaning efficiency is assessed by measuring the soil tare of the beet that have passed over the cleaner loader and of the 'soil' (including green material) deposited from the cleaner loader.

Method for the measurement of the soil tare:

Soil tare in the heap before loading

- Deposition of an extra heap when harvesting the beets for the test piles. The extra heap is loaded and delivered either directly after beet harvest (tare status at harvest) or before the cleaner loader test (tare status after storage of one week) to the local sugar factory for soil tare determination in the tare house.
- Alternatively, samples for soil tare determination can be taken (500 kg with sufficient number of repetitions) using a horizontally driven cylinder (horizontal RUPRO) penetrating into the test heap
- Or samples are taken as defined under 4.4.2 from the harvester when unloading the beets.

Soil tare after loading

- From each of the 3 trucks loaded for performance test, at least 10 samples are taken for soil tare determination at the tare house of the local sugar factory, applying an approved method. Number of samples can be increased depending on the accuracy required.

The soil deposited from the cleaner loader is weighed and expressed as a percentage of the soil tare present in the test heap (optional).

Loose soil from the test heaps is taken randomly to measure the soil status (optional).

5.4.2. Beet weight loss (optional)

The beet losses through damage suffered during the cleaner loader operation are calculated from a random sample of 500 beets taken for soil tare analysis when the heaps are made. These are compared with a sample of beet taken after the cleaner loader process. Alternatively, the relative fractions from the cleaner loaded beet can be collected, sorted, and weighed.

Samples for the determination of the beet losses can also be taken from the transporting vehicle.

Optionally, all beet parts are gathered twice from representative strips 2 m wide of the middle of 3 loadings and are weighed. In combination with the pile length of the 3 loadings, and the weight in the trucks, the losses can be calculated.

5.4.3. Example of a control on working quality for cleaner loaders

Test sheet of cleaner loader			
location: ***Lelystad*** ……. test team: IRT…..		date: ***12/11/2015*** ……	
machine: **S3** ………………		plant density : ***90.000*** ..plants/ha	
yield potential (clean beets): ***70,000*** …………t/ha		cleaning speed: **200**…….t/h	
Losses			
root tip breakage category	rel. frequency % before / after	factor of losses g/100 beets	rel.losses kg/100 beets before / after
0 - 2 cm	***29/16***	0	------
>2 - 4 cm	***63/71***	23	***1,440/1,633***
>4 - 6 cm	***7/10***	60	***0,420/0,600***
>6 - 8 cm	***1/3***	130	***0,130/0,390***
>8 cm	***0/0***	230	***0/0***
total per 100 beets			***2,000/2,623***
		cleaning/before/after	cleaning/before/after
root tip breakage losses: ………………		***0,80*** / 2,57 / 3,37 %	***0,561*** / 1,800 / 2,361 t/ha
losses on soil (ruts, conveying,): ………		***0,17*** %	***0,120*** t/ha
total losses: ………………………………		***0,97*** / 2,57 / 3,54 %	***0,681*** / 1,800 / 2,481 t/ha
Soil tare before cleaning: *11,1* .. %, number of samples:***10*** , per **50** kg of harvested beets **Soil tare after cleaning: *7,2*** %			
Additional information trial identification: ***2015/06/JPG*** …………………………… weather conditions: ***good*** …………………………………. soil type: ***loam*** …………………………………………… presence of fangy beets, optional: ***1 %*** …………………………… miscellaneous: ***no further comment*** …………………………………………………………			

Include: capacity of the cleaner-loader (t/ha)

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Annex

A 1 Physical properties – definitions and test methods

The biophysical properties of sugar beets are presented as a data sheet which is intended as a guide for both the research worker and the design engineer of agricultural machinery. The information has been abstracted from a total of 25 publications from both European and North American sources. The physical properties have been categorized into the geometric, gravimetric and mechanical attributes.

Where large variation in the physical properties occurred, they have been attributed, where possible, to the influence of genetic, ecological, agrotechnical and technical factors. In most cases the information was obtained from freshly cut sugar beet or beet sections; those from Reference 9 were derived from beet models and those from Reference 5 from computer simulations.

Because of its morphological, anatomical and histological structure, beet is not a homogeneous organ. The mechanical properties given in the tables must therefore be interpreted as a mean value for the entire beet. Only with regard to its elastic properties can beet macroscopically be considered as statistically almost isotropic and homogeneous.

A 1.1 Geometric properties

GEOMETRIC PROPERTIES	UNIT	MEDIAN OR RANGE	REFERENCE
Length			
- beet	mm	169	16
		100 - 350	3, 12
		250	12
		72 - 350	2
		200 - 350	13
		245	10
- leaves		100 - 900	3, 12
		350	12
Diameter	mm	30 - 200	3, 12
		120	12
		108	5
		86	16
		60 - 120	6
		30 - 170	2
		40 - 160	23
Height of beet top	mm	≤16	24
		0 - 150	3, 12
		45	12
		107	5
		7 - 74	2
(variety)			
- Monohill		43	1
- Primahill		61 - 74	1
(distance between two beets)			
- 14 cm		55	17
- 26 cm		70	17
Collar height	mm	37	5
Average height of topped pieces	mm	10 - 40	3, 12
		30	12
(variety)			
- Monohill		20 - 27	1
- Primahill		31 - 32	1
- Kawemono		27 - 33	1
tall beets		47	7
small beets		29	7

A 1.2 Gravimetric data

GRAVIMETRIC DATA	UNIT	MEAN OR RANGE	REFERENCE
Weight	g	600 - 1800	6
		150 - 900	2
		600 - 800	12
		500	23
		634	4
(parts of beet)			
- crown		92	4
- slice		84	4
- root		505	4
- tail		50	4
Dry matter content	%	23.6	11
(at harvest)		18 - 26	24
		16 - 25	25
		20 - 26	6, 13
- leaves		11 - 19	13
Medulla content	%	3.75 - 4.7	25
(variety)			
- productive		4.77	22
- normal		5.09	22
- with high sugar content		5.67	22
			12
Mass ratio leaves to beet		0.3 - 1.2	12
		0.7	12
Unit density	kg/m^3	1000 - 1150	12
		1060	12
Bulk density	kg/m^3	520 - 600	12
		560	12
(weight of beet)			
- 300-500 g		640	23
- 100-300 g		590	23
- <100 g		550	23

A 1.3 Mechanical data

MECHANICAL DATA	UNIT	MEAN OR RANGE	REFERENCE
Coefficient of friction (static)			
(conducted on fresh cut sugar beets)			
- beet - machined steel			
(applied load 3 kg)		0.37	2
(applied load 12 kg)		0.32	2
- beet - sheet steel			
(applied load 3 kg)		0.44	2
(applied load 12 kg)		0.37	2
- beet - steel during topping		0.39	15
		0.28 - 0.45	15
(calculated)			
- beet - machined steel			
(applied load 33.8 kN/m²)		0.39	15
(applied load 99.3 kN/m²)		0.32	15
- beet - water - steel			
(applied load 33.8 kN/m²)		0.44	15
(applied load 99.3 kN/m²)		0.44	15
- beet - 10% teepol - steel			
(applied load 33.8 kN/m²)		0.28	15
(applied load 99.3 kN/m²)		0.24	15
- beet - HP 10 oil - steel			
(applied load 33.8 kN/m²)		0.38	15
(applied load 99.3 kN/m²)		0.33	15
- beet - PTFE			
(applied load 33.8 kN/m²)		0.22	15
(applied load 99.3 kN/m²)		0.17	15
Coefficient of friction (dynamic)			
(conducted on fresh cut sugar beets)			
- beet - machined steel			
(applied load 33.8 kN/m²)		0.38	15
(applied load 99.3 kN/m²)		0.15	15
- beet - water - steel			
(applied load 33.8 kN/m²)		0.26	15
(applied load 99.3 kN/m²)		0.25	15
- beet - 10% teepol - steel			
(applied load 33.8 kN/m²)		0.28	15
(applied load 99.3 kN/m²)		0.24	15
- beet - HP 10 oil - steel			
(applied load 33.8 kN/m²)		0.38	15
(applied load 99.3 kN/m²)		0.33	15
- beet - PTFE			
(applied load 33.8 kN/m²)		0.22	15
(applied load 99.3 kN/m²)		0.17	15

MECHANICAL DATA - WHOLE BEETS	UNIT	MEAN OR RANGE	REFERENCE
Force required to top beet	N		
(1.5 mm blade thickness,			
6-15º asymmetric wedge)		101 - 141	2
Horizontal component			
of cutting force - 'Blade angle'	N		
(52º)		110 - 320	17
(67º)		120 - 360	17
(82º)		155 - 420	17
Force required to top beet	N/mm		
(5mm blade thickness,			
at 2m/s)			
(20º asymmetric wedge			
standard topping knife new)		6.3 S.D. 1.0	15
(20º asymmetric wedge			
standard topping knife worn			
in field)		8.4 S.D. 2.4	15
(10º asymmetric wedge			
blade with 1 mm dia. edge)		4.6 S.D.	15
(4.5mm blade thickness)	N/mm	0.6	
(20º asymmetric wedge			
standard topping knife)			
Maximal cutting force permissible		5.0	15
before some beet overturning in wet			
sandy clay loam	N/mm		
-force acting on beet at:			
(soil level)			
(25 mm above soil level)		12	15
(50 mm above soil level)		9	15
Force required to overturn beet in		7.5	
ground			
(force in horizontal direction)			
- not loosened beet	N	50 - 600	12
(force acting on beet 5cm		250	12
above soil level)		50 - 600	12
		250	12
- height of beet top >5 cm	N		
		500 - 950	17
- diameter of beet top	N	800 - 1400	17
(5-10 cm)			
(10-16 cm)		43	5
Force required to crush beets in the			
ground (vertically)	N	1177.2	10
'Root holding power' in totally hard			
soil	N	34.3 - 73.6	11
Tensile force	daN		10
(vertical)			
(horizontal)			

MECHANICAL DATA - WHOLE BEETS	UNIT	MEAN OR RANGE	REFERENCE
Force required to drag out:	N	≤196.2	
- a not loosened beet of a ‘medium			
binding’ soil at 15% moisture			
content			
- a loosened beet of a ‘medium		16 - 700	12
difficult soil at 15% moisture	28		
content			
Force required to break off tail		90 - 150	12
(tail of beet put in plaster, force acting			
on beet at 7 cm above plastered surface)			
- sectional area	N		
(>30 cm^2)			
(<30 cm^2)			
Force required to separate leaves from			
beet	N	0.5 - 0.25	11
		>0.25	11
Strength of epidermis	N		
Force of pressure that causes damages		80 - 700	12
of epidermis	N	450	12
Pressure force during rooting up that		3000 - 4000	12
causes damages of epidermis			
- bar - beet	N	2943 - 3924	10, 23
(30 mm diameter of beet)			
(80 mm diameter of beet)			
Effect of pressure force of different			
share types on beet during lifting beet		981 - 1962	23
out of soil		2746.8 - 4905	23
(80 - 100 mm diameter of beet at point			
of contact with shear)			
- tined shear	N		
- *‘Polderschar’*			
- *‘spoked discs’ Speichenscheiben*			
(at 0.32 m/s)		882.9 - 3041.1	10, 23
- *‘fork stub tines’ Gabelrodezinken*		2943	10
(in wet soil)			
- *‘spoked discs’ Speichenscheiben*		896.2 - 882.9	9
(vertical component of force, at 0.32			
m/s)		3100	12
Elongation at rupture			
Rupture force between steel plates			
(transverse)	N	539.5 - 686.7	9
Thermal capacity	kJ/kg K	24.5 - 37.9	8
(freezing-point - room temperature)			
		>980	2

MECHANICAL DATA - WHOLE BEETS	UNIT	MEAN OR RANGE	REFERENCE
Temperature code	cm^2/min		
(>50ºC)		0.197 - 0.204	23
(low temperature)		0.92 ± 0.008	23
(mean)		0.08	23
Quotient of permeability	10^4	0.076	23
Diffusion constant	cm^2/min	0.4 - 0.7	19
- of saccharose			
(beet of 16.5% sugar content exhausted under standard conditions)			
-root		3.7 - 6.8	19
-crown		3.08	19
(at 75ºC)		4.8 ± 0.95	23
-slice		3.25	23
-root		3.86	23
-tail		3.65	23
(at room temperature)		0.53	23
(in mechanically damaged cells)		0.42 - 0.74	23
- of water			
(inner tissue, at room temperature)	10^4 cm^2/min	2	23

MECHANICAL DATA - WHOLE BEETS	UNIT	MEAN OR RANGE	REFERENCE
Rupture force in bending	N		
(cross sectional area 1 cm^2)			
-cambium		314	11
-outer tissue		392	11
-inner tissue		157	11
(cross sectional area 9 cm^2)		530 - 880	8
Rupture stress in bending	Mpa		
(cross sec. Area 10 mm^2)		0.49	5
(cross sec. Area 50 mm^2)		0.16	5
Rupture stress			
(compression)	Mpa	1.96 - 2.45	13, 21, 23
		2.0 - 2.5	19
-extreme		1.57 - 3.53	21
-thawed frost beets			
(Höppler Konsistometer)		1.47 - 1.96	23
(Kitschigin)		1.57 - 3.53	23
(tension)	Mpa	0.52 - 1.89	21
		0.51 - 1.86	23
-normal beet		$\geq$ 1.18	21
-obdurate beet		0.49 - 1.18 or >1.18	21
(shearing)	Mpa		
(5 mm beet sections)			
(Stanek and Pawles)		0.29 - 0.78	23
		0.59	23
(Kitschigin)		0.29 - 1.45	23
(beet sections extracted at 80ºC)		0.06 - 0.30	23
		0.17	23
- at -13ºC quickly frozen beets			
non-frozen		0.09 - 0.16	23
		0.12	23
frozen		0.07 - 0.14	23
		0.10	23
- at -7ºC slowly frozen beets			
non-frozen		0.09 - 0.32	23
		0.22	23
frozen		0.06 - 0.14	23
		0.09	23
Cutting resistance	N/mm	1.08 $\pm$0.29	23
(cylindrical sections of tissue diameter 16 mm., 0.4 mm cutting wire)			
- tissue		<0.78	21, 23
(soft)		0.78 - 1.37	21, 23
(normal)		0.78 - 1.37	21
(obdurate)		1.37 - 1.77	23
(suberosed)		1.77 - 2.94	21, 23
(lignified)		>2.94	21, 23
(strongly lignified)			

MECHANICAL DATA - WHOLE BEETS	UNIT	MEAN OR RANGE	REFERENCE
- variety		1.26	19, 20
(Cesna R)		1.49	19
(Beta K 91)		1.28	20
	30	1.28	19
(Beta Poly 1)		1.1	20
		1.24	22, 23
(Beta Poly 4)		1.32	22, 23
(Ramon 06)		1.06	22, 23
(Monohill)			
-precipitation August-September		1.55	19
(36 mm)		1.33	19
(100 mm)		1.14 ± 0.0981	20
(3-48 mm)		1.13 ± 0.1275	20
(64-89 mm)		0.92 ± 0.0981	20
(107-205 mm)			
-method of cultivation		1.09	20, 23
(irrigated)		1.00	20, 23
(not irrigated)			
- period of rooting up		1.32	20, 23
(at the beginning of September)		1.40	20, 23
(at the beginning of October)		1.42	20, 23
(in the middle of October)		1.45	20, 23
(at the beginning of November)			
- parts of beet		1.29	20, 23
(head)		0.98	20, 23
(root)		1.13	20, 23
(tail)	Mpa		
Modulus of elasticity		2.81 - 3.36	8
(transverse sections)		5.37 - 8.75	8
		6.5 - 14.0	18
		10.75	15
(2.7 min^{-1} strain rate)			
-condition		6.38 - 13.77	19, 21
(fresh)		4.12 - 6.38	19, 21
(dried on)		1.77 - 4.12	19, 21
(faded)		<1.77	19, 21
(strongly faded)			
- tissue		<4.12	21
(soft)		3.92 - 8.83	21
(normal)		4.91 - 11.77	21
(obdurate)			
- conditions/turgor		6.87 - 13.73	23
(rigid/fresh)		4.12 - 6.87	23
(elastic/dry)		1.77 - 4.12	23
(soft/faded)		<1.77	23
(strongly soft/strongly faded)			

MECHANICAL DATA - WHOLE BEETS	UNIT	MEAN OR RANGE	REFERENCE
- variety (not significant)		6.18	20
(Beta K 91)		6.29	20
(Beta Poly 1)			
- method of cultivation		6.87	20
(irrigated)		7.43	23
		5.39	20
(not irrigated)		6.05	23
- parts of beet		10.30	20, 23
(head)		12.07	20, 23
(root)		11.77	20, 23
(tail)	Mpa		
(axial sections)		8.7	15
(5.3 min^{-1} strain rate)			
Poissons ratio			
(deformation up to an axial, natural strain of about 0.3)		close to 0.5	15

MECHANICAL DATA - BEET PILE	UNIT	MEAN OR RANGE	REFERENCE
Inner coefficient of friction		0.8	23
Natural slope	°		
(cleaned, average beets)		37 - 39	23
(dirty beets)		34 - 46	23
(data recommended for planning)	°	36 - 40	23
Gliding angle		30 - 35	23
(clean, dry beets - steel)		42 - 45	23
(dirty or frozen beets - steel)		< 30	23
(wet beets - steel)		15 - 20	23
(beet - rubber / conveyor belt)			
(beet - rubber / conveyor belt with cross-pieces)	°	30 - 35	23

MECHANICAL DATA - SLIVER PILE	UNIT	MEAN OR RANGE	REFERENCE
Natural slope	°		
(sweet slivers)		60 - 65	23
(exhausted, compressed slivers)		45	23
(exhausted, not compressed slivers)		60 - 65	23
Gliding angle			
(sweet slivers - steel)		47	23
(sweet slivers - rubber)	°	20	23

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B Mandatory Tests for Precision Seed Drills (ISO /DIS 7256/1)

B 1. Bench Tests

Table 1. Performance of bench tests

DESCRIP-TION OF TEST	TYPE OF TEST	N°.OF TEST	SLOPE	HOPPER LEVEL	THEORE-TICAL FORWARD SPEED	METERING MECHANISM SPEED	TYPE OF SEED
A.	Mandatory	Tests					
1. Effect of the level of seeds in the hopper	Static or mobile Without coulter if appropriate	101 102 103 104	none	1/1 1/8 1/1 1/8	high low high low	average average average average	c c d d
2. Effect of the speed of the metering mechanism	Static or mobile Without coulter if appropriate	201 202 203 204 205 206	none	½	low high low high low high	minimum maximum minimum maximum minimum maximum	b b c c d d
3. Effect of the slope	Static or mobile Without coulter if appropriate With coulter	301 302 303 304 305 306 307 308 309 310	20% when descending 20% slope to right 20% slope to left none	½	average	average	a c c a a c c a a c

4. Effect of the forward speed	Mobile or static With coulter	401 402 403 404 405 406 407 408 409 410 411 412	none	½	low average high low average high low average high low average high	maximum average minimum maximum average minimum maximum average minimum maximum average minimum	a a a b b b c c c d d d
5. Effect of unwanted movements of the seed	Mobile on bed of sand With coulter	501 502 503	none	½	average average average	maximum maximum maximum	a b c
6. Effects of separation	Fixed or mobile Without coulter if appropriate	601 602 603	none	1/8	average average average	average average average	a c d
B. Optional	Tests						
7. Effect of seed dressings	Fixed or mobile Without coulter if appropriate	701 702 703	none	1/2	average average average	average average average	optional

B 1.1. Nature of the test

Effect of seed dressings on the feed.

B 1.2. Test Conditions

The test should be carried out using a type of seed selected by the test centre (preferably with a rough surface to retain a maximum amount of the dressing product); the dressings used will be those most commonly used for the particular type of seed.

B 1.3. Test Procedure (Static test or mobile bench test)

The metering mechanism should be rotated at maximum speed for approximately 30 minutes to constantly fill the hopper with dressed seed. During this period three tests are to be done:

- one at the beginning of the period (test no. 701)
- one in the middle of the period (test no. 702)
- one at the end of the period (test no. 703)

B 2. Field tests

B 2.1. Scope

These cover:

a) the actual spacing of the seed on cultivated land;
b) the uniformity of the furrow depth;
c) the uniformity of the depth of the seed in the ground.

B 2.2. Test Conditions

The test site should be relatively level, cultivated land of a uniform soil type and texture. The rooting depth of the previous crop, the texture of the soil, its structure (size and position of the clods of earth as they appear in a vertical cut), and its water content should be noted in the test report.

The structure of the plot may be shown as a sketch attached to the test report. If possible, a soil penetrometer should be used to measure the hardness of the soil within the top 30 cm. The duration of the test should be sufficient to obtain meaningful results. The machine should operate under normal working conditions, from the start to the end of the test, i.e. it should not stop except for the half turns normally made at the ends of the plot.

The measurements should be made on at least five rows and be of sufficient length, within each row to cover at least 250 sown seed. The first measurements should be made at 20 m from the start of the drill bout and the last at least 20 m before its end.

The test centre should determine the seed to use in accordance with the manufacturer’s instructions.

If only one test is carried out, it should be performed at a forward speed of 2 m/s, or at the average rotary speed of the metering mechanism as defined for the mandatory tests.

The mandatory tests should relate basically to the precision of the placement and the quality of the seed flow provided by the metering mechanism. Each test should be carried out with three different units, either three units on one multi-row drill, or three independent sowing units if each has its own dispensing drive device.

Static tests - With the sowing unit stationary, the metering mechanism should be driven at a rotary speed equal to that normally used during actual work, i.e. taking into account the theoretical forward speed and the adjustment of the ratio between the speeds of the metering mechanism and the driving wheels. In order to bring about the relative drill/ground differential, an adhesive strip moving at the relative forward speed of the drill when travelling without slipping may be run underneath the seed drill. NOTE - The recording on to an adhesive strip may be replaced by any other recording method, such as an acoustic or optical method. The method used should be mentioned in the test report.

Mobile test - The sowing unit is fixed to a mobile trolley travelling at a constant speed without jolting over a stationary adhesive strip. NOTE - The recording on to an adhesive strip may be replaced by any other recording method, such as an acoustic or optical method. The method used should be mentioned in the test report.

Test on bed of sand - The sowing unit should travel over a bed of sand of specified characteristics (see the note) at a constant speed and without jolting. The coulter should penetrate the soil to at least the minimum working depth. For this test, the coulter may be equipped with deflectors which, without interfering with the placing of the seeds, prevents the sand from closing over the seed. It should be maintained at a constant depth. The forward speed should be equal to the actual speed of the seed drill at work. NOTE - Characteristics of the sand, should be recorded. It should be:

a) foundry sand that has

- a particle size of 85 to 120 µm,
- a clay content to provide sufficient binding (20 to 25%),
- a water content between 4 and 6%;

b) a pure sand (Fontainebleau sand to which a low viscosity oil is added in the proportion of 1%).

The theoretical quantity should be that deemed to be normal for the type of crop.

The depth of sowing should be that which is most suitable for sugar beet and should be noted in the test report. NOTE - This test should include a uniformity test after the seedlings emerge.

B 3. Measuring Conditions

For each row in the measurement length, the following should be measured:

a) the space between successive seeds or plants taken from centre to centre;
b) the average depth of the furrow, obtained from several sections through the plot;
c) the depth of the seed relative to the soil surface.

B 4. Results of Optional Tests

B 4.1. Results of the test of the effect of seed dressings

The presentation should be identical to that adopted for the mandatory tests for the seed drill.

The types of seed and the characteristics of the seed dressings (make, nature and if possible, physical characteristics) should be noted in the test report.

B 5. Test Report

Example of Test Report on Precision Drills

Name and address of seed drill manufacturer:

Tests carried out on seed drill by:

The samples undergoing test was selected by the manufacturer with the agreement of the test centre.

B 6. Specifications of the seed drill

Characteristics

Brand name:
Type:
Serial No.:
Towed, semi-mounted or mounted equipment:
Distributor and type of drive:
Number of gear ratios (speeds) and type of selection:
Maximum and minimum forward speeds: (km/h)
Maximum and minimum rotary speeds of the metering mechanism: (min^{-1})
Species and types of seeds sown:

Overall dimensions

Width

- when ready to operate: (m)
- when travelling on the road: (m)

Height when travelling on the road: (m)

Length when travelling on the road: (m)

Other specifications:

Load height: (mm)
Hopper(s) capacity: (l)
No-load mass: (kg)
Loaded mass (state the type of seed): (kg)
Tyre dimensions:
Radius of the tyres at half-load: (m)
Tyre pressure: kPa
Instrument numerical code (in accordance with ISO 7424):

C Standard Washing Process

A standard test involving the use of a modified vegetable washer (Type BISCO 630) is used to determine the dirt tare of sugar beet.

The washing is done in a two-sided open drum with a horizontal axle. The drum is 630 mm long with an inner diameter of 845 mm. The drum has slits of 84 mm length and 12 mm width. The drum is wheel friction driven by a torque electric motor of 0.55 KW output. On the inside of the drum surface are six blades which allow a mixing and forward pushing of the contents. On the upper inner side of the drum is a pipe with four nozzles with a diameter of 5.5 mm and a parallel pipe with seven nozzles with a diameter of 4 mm. The water flow is 55 L/mm with a pressure of $1.1 * 10^5$ Pa.

The dirty beet are placed in the rotating drum and sprayed with water. After washing the beet are released into a sieve and weighted. The difference between the weights of the dirty and clean beet represents the dirt tare.

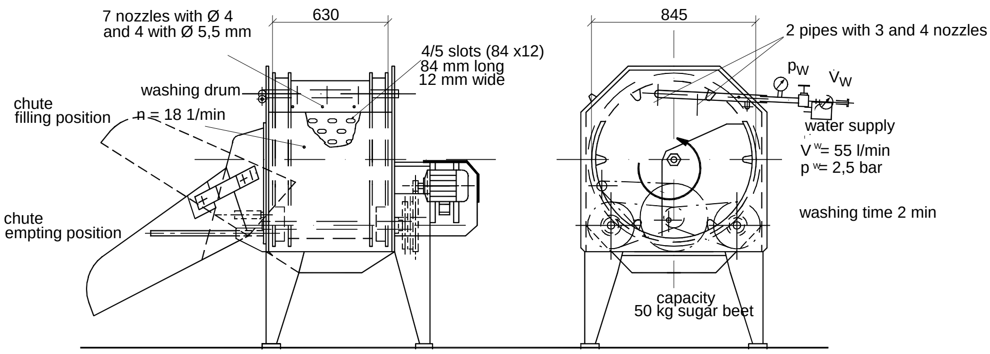

Figure 8 Outline of the washer BISCO Type 630 (after Bisco Bitter GmbH & Co)

D Distance - Recording - System (DRS)

D 1. Laboratory Measuring System

A light barrier frame with an optical-electronic sensor is mounted under the single compound machinery for help with the laboratory measurement. The distance between the mounting point and the light barrier frame is adjusted accordingly to be mounted at the same level as the seeding share on the normal equipment used in the field.

Release of the seeds is measured by the isolating impulse device in the light barrier frame. From the test-stand, impulses are formed dependent on the momentum from a direction-time-generator, the light barrier- and flap-steering-device. From the seed impulse, the light barrier frame and the direction-impulse then compute the grain distance in millimetres. With the help of a flap mechanism under half of the light barrier, the failed seed gathers in a bin, and can effect a correction of the light barrier frame not to count double application (seeds that happen to cover the optical light barrier). These corrections are made through the return of the collected seeds with a seed counting apparatus.

The door-times are selected, so that about 201 seeds or 200 distances (intervals) are included. These single measurements are repeated by 6 experts and summarized for each variety.

D 2. Field measuring system

The field measuring system consists of the distance-measurement equipment, the control unit, and a notebook with software. The position coverage of the plants effects the simultaneous corrections for the distances with the previous detection hidden-factor, and ascertains the exact actual distances.

E Catch frames used to take samples

Different catch frames are used to take beet samples. In Fig. 10, different systems used in Europe are illustrated.

IRS (Netherlands)

University of Bonn (Germany)

I

IRBAB (Belgium)

Figure 9 Catch frames used in IIRB countries

F Publication on root breakage

Study carried out on the appraisal method of the losses by breakage of roots (by J.-P. Vandergeten, IRBAB).

Meeting of the IIRB Study Group “Agricultural Engineering”, 14th of October 1997.

F 1. Measures done in laboratory

The analyzed roots are from different fields sampled in beginning of the campaign 1997. The beets were harvested by hand and only the whole roots were selected. The soil tare was removed and the roots were cut into 1 cm slices. Every cut slice was weighed separately.

Weight of beets in g	Breakage <=2cm	3 cm	4 cm	5cm	6 cm	7 cm	8 cm	Measures %
<400	9.6	21.9	38.3	68.3	95.5	137.3	189.9	9
400 - 600	10.0	21.3	38.6	62.8	94.0	136.0	199.8	19
600 - 800	9.2	22.2	40.8	66.0	98.0	136.2	191.2	19
800 - 1000	8.9	21.5	40.5	65.8	99.0	137.4	187.5	19
1000 - 1200	8.3	21.0	39.0	62.7	95.6	135.6	185.5	13
1200 - 1400	9.6	21.5	38.2	61.1	92.5	130.8	177.3	10
>1400	7.9	19.8	37.3	61.9	96.5	137.0	184.2	10
average	9.1	21.3	38.9	64.1	95.9	135.8	187.9	

Table 7 Losses (in g per root) by root breakage of beets according to the root weight (work in laboratory, campaign 1997)

There is no relation between the weight of the observed roots and the losses due to root breakage (different diameters of root breakage from 2 to 8 cm).

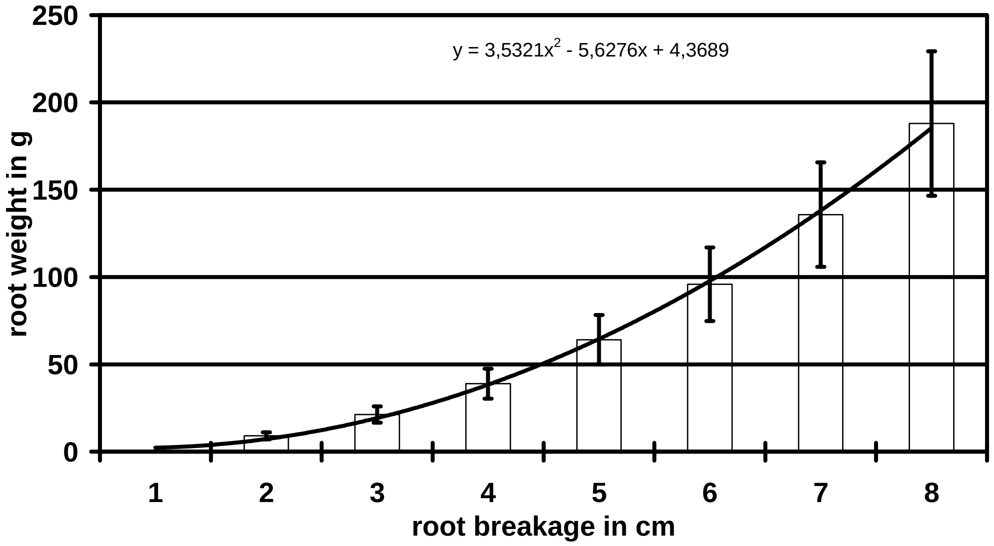

Figure 10 Yield losses (in g per root) according to the diameter of the root breakageof root the breakages

The losses by breakage of individual roots can be described by the formula $y = 3.53\ x^2 - 5.63x + 4.37$ where x represents the diameter of the breakage and y the yield loss. It is sufficient to distribute the beets according to the classes of diameter of breakage established by the IIRB methodology and to extrapolate accordingly to the population of the field.

F 2. Application to the example taken in 'Method for testing working quality of sugar beet harvesting machines in the IIRB countries'.

F 2.1. General data

Yield: 55,000 kg/ha

Population: 69,000 kg/ha

Speed of harvest: 4.0 km/h

F 2.2. Assessment of the losses by breakage of roots based on the IIRB example

Categories	Relative frequency %	Relative losses %
0 - 2 cm	66.2	
>2 - 4 cm	27.8	1.39
>4 - 6 cm	4.7	0.47
>6 - 8 cm	1.0	0.21
>8 cm	0.3	0.09

Table 8 Distribution of the beets and losses according to the diameters of breakage

The total losses of yield are valued to 2.11% or 1,188 kg.

	IIRB method: 69,000 and 100,000 plants/ha	Present method: 69,000 plants/ha	Present method: 100,000 plants/ha
Losses by breakage % or kg/ha	2.1% or 1,188 kg	1. 4% or 773 kg	2% or 1,120 kg

Table 9 Comparison IIRB method and method currently used, for a population of 69,000 and 100,000 plants per ha and a distribution of the breakages according to Table 8

F 2.3. Assessment of the losses by breakage of roots on basis of beets more strongly broken (simulation)

Categories	Relative frequency %
0 - 2 cm	0.3
>2 - 4 cm	66.2
>4 - 6 cm	27.8
>6 - 8 cm	4.7
>8 cm	1.0

Table 10 Distribution of the beets according to the diameters of breakage

	IIRB method 69,000 and 100,000 plants/ha	Present method 69,000 plants/ha	Present method 100,000 plants/ha
Losses by breakage % or kg/ha	7.4% or 4,057 kg	5.1% or 2,782 kg	7.3% or 4,032 kg

Table 11 Comparison IIRB method and method currently used, for a population of 69,000 and 100,000 plants per ha and a distribution of the breakages according to Table 10

F 3. Comments

The loss of yield calculated earlier by ITB (in g per root) is acceptable:

- 23 g for a diameter of root breakage >2 - 4 cm
- 60 g for a diameter of root breakage >4 - 6 cm
- 130 g for a diameter of root breakage >6 - 8 cm
- 230 g for a diameter of root breakage >8 cm

For the assessment of the losses the IIRB method doesn't take account:

- the population per hectare
- the roots topped to deep or split
- the fangy roots
- etc

G Use of Rupro to sample beet heaps

Horizontal Rupro

Description

The mobile horizontal Rupro is used by the IRBAB (Belgium) and by the ITB (France). The system constructed by IRBAB is inspired of an analogous system initiated by the ITB. The mobile Rupro is composed of three elements: a steel pipe, a hydraulic jack and a sub-frame.

The steel pipe is of square shape. It has a length of 4 m, a section of 300 mm and a thickness of 10 mm. The extremity of the pipe in contact with the heap ends bevelled to facilitate the sampling.

The hydraulic jack is double-effect. It is placed inside the sampling pipe. It has a diameter of 9 cm and a length of 2 m in extension. The jack is fixed to the structure and is provided to its expandable part of an ejector panel of 20 mm of thickness that slides inside the hose of sampling. The maximum length of sampling is of 2 m with a maximal volume of 180 dm³.

The sub-frame is triangle-shaped. It is composed of square tubes with a section of 100 mm and a thickness of 5 mm. It allows the anchorage of the whole the system to the 3 points of the tractor. The sampling pipe is fixed to the structure. The structure is reinforced by corner irons in the corners of the pipe and by an upright of 180 mm of width and 10 mm of thickness. This amount is welded on a length of 1.6 m on the pipe to the level at the third point level.

In front two telescopic skids support the structure. The rear of the pipe rests on a frame in tube squared of a section of 8 mm and 3 mm of thickness. This removable frame is only used for the transportation or for the storage.

Figure 11 Horizontal Rupro used in France (ITB) and Belgium (IRBAB)

Measurements and weight

The Rupro has a length of 4.50 m, a width of 0.70 m and a height of 1.30 m. Its weight is of 660 kg.

Working

The Rupro requires a tractor of 85 hp with 4 driving wheels with hydraulic links double-effect. It permits to sample the outside part of the heap on a depth of 2 m.

The Rupro also permits to sample the central part of the heap. In this case, the jack is manipulated in order to close up the pipe. The tractor moves back in the heap. When the yellow colored part of the pipe is not more visible, the jack is manipulated in order to open the pipe. A new receding of the tractor permits to sample the layer of beets included between 2 and 4 m in the heap.

Once the sample of beets has been taken in the heap, the jack is manipulated again to place the beets in plastic bags. The samples are transported then toward the laboratory for a determination of the soil tare by washing.

H Plain forms

Number of categories I	1	2	3	4	5
Categories of diameter of root breakage cm	0-2	>2-4	>4-6	>6-8	>8
Relative frequency b_i %	-				
Factor of losses c_i * g	0	23	60	130	230
Relative yield losses Per category (b_i x c_i) g	-				

Plain form 1 Calculation of yield losses caused by root tip breakage from measurement and classification of breakage diameter

Number of categories	1	2	3	4	5	6
Categories of topping quality, parts of petioles left	Untopped >2 cm	Under topped ≤ 2 cm	Under topped no petioles	Correctly topped	Over topped With bundle rings visible	Angled opped
Relative frequency %						

Plain form 2 Form for declaring the topping quality of harvesters

Test sheet of harvesters

location: …………………… test team: ……………….. date: …………………

machine: …………………… plant density : …………plants/ha

yield potential (clean beets): …………………t/ha working speed: ……….km/h

Losses

root tip breakage category	rel. frequency %	factor of losses g/100 beets	rel.losses kg/100 beets
0 - 2 cm		0	------
>2 - 4 cm		23	
>4 - 6 cm		60	
>6 - 8 cm		130	
>8 cm		230	
total			

root tip breakage losses: ……………… ………………….% ………………..t/ha

lifting, cleaning and conveying losses: . ………………….% ………………..t/ha

total losses: …………………………… ………………….% ………………..t/ha

Topping quality

category	rel. frequency %
1	
2	
3	
4	
5	
6	

Soil tare: ……….. %, number of samples: …………, per …….. kg of harvested beets

Superficial damages

category	rel. frequency %
non damaged	
wounded	
bruised	
wounded & bruised	

Additionnal information

trial identification: ………………………………………….

weather conditions: ……………………………………….

soil type: …………………………………………………

regularity of crop: ………………………………………….

presence of fangy beets: ……………………………….

miscellaneous: ……………………………………………………………………………..

………………………………………………………………………………………………

Plain form 3 Test sheet of harvesters

Test sheet of cleaner loader			
location: ....……………….. test team:.........…………..		date: .../…/............	
machine: …... ………………		plant density : ………...plants/ha	
yield potential (clean beets): …...…………t/ha		cleaning speed: …..…….t/h	

Losses

root tip breakage category	rel. frequency % before / after	factor of losses g/100 beets	rel.losses kg/100 beets before / after
0 - 2 cm	…../…...	0	------
>2 - 4 cm	…../…...	23	…../…...
>4 - 6 cm	…../…...	60	…../…...
>6 - 8 cm	…../…...	130	…../…...
>8 cm	…../…...	230	…../…...
total per 100 beets			…../…...
		cleaning/before/after	cleaning/before/after
root tip breakage losses: ………………		……./……./……..%	……./……./……..t/ha
losses on soil (ruts, conveying,): ………….		……. %	……./……./……..t/ha
total losses: ………………………………		……./……./……..%	……./……./……..t/ha

Topping quality

category	rel. frequency % before / after
1	…../…..
2	…../…..
3	…../…..
4	…../…..
5	…../…..
6	…../…..

Soil tare before cleaning: …... %, number of samples:….., per ….. kg of harvested beets
after cleaning: …... %, number of samples:….., per ….. kg of cleaned beets

Superficial damages

category	rel. frequency % before/after
non damaged	…../…..
wounded	…../…..
bruised	…../…..
wounded & bruised	…../…..

Additionnal information
trial identification: ……………………………………………
weather conditions: ……..…………………………………
soil type: ……..………………………………………………
presence of fangy beets: ………………………………….
miscellaneous: ……………………………………………………………………

Plain form 4 Test sheet of cleaner loader