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Technical Information Bulletin 1

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Effect of Stem Density on Potato Production

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Potato tubers producing different numbers of stems

INTERNATIONAL POTATO CENTER (CIP)

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Effect of Stem Density on Potato Production

Objectives. Study of this bulletin enables you to:

- define stem density,
- describe effects of stem density,
- calculate stem density,
- list factors determining stem density,
- discuss recommended stem density,
- calculate planting distance and amount of seed tubers required.

Study materials

- Potato plants with different numbers of stems.
- Plots with different stem densities.

Practicals

- Count and calculate stem densities in the field during crop growth and harvest. In different varieties, compare yield, tuber size, and multiplication rate at different stem densities.
- Calculate planting distance and amount of seed tubers required for production of seed tubers and consumer potatoes.

Questionnaire

1 Of which components consists the density of a potato crop?

2 Why does "stem density" describe the density of a potato crop better than "plant density"?

3 How is stem density commonly expressed?

4 How does stem density influence yield, number and size of tubers, and multiplication rate?

5 How can you determine stem density in a growing crop?

6 How would you calculate the example in Section 3, assuming that the distance between rows was 100 cm?

7 How do seedbed conditions influence stem density?

8 How can minor or heavy damage to sprouts influence the number of stems?

9 How is the physiological age of seed tubers related to the number of sprouts?

10 How are the growing conditions related to stem density?

11 How is the stem density for seed tuber production in comparison to consumer potato production?

12 How is the stem density for certified seed production in comparison to basic seed production?

13 What is the best way to determine the recommended stem density?

14 Assume that recommended stem density is 30 stems/m^2 and row distance 75 cm. Calculate distance within rows and amount of seed tubers required according to the example in Section 6.

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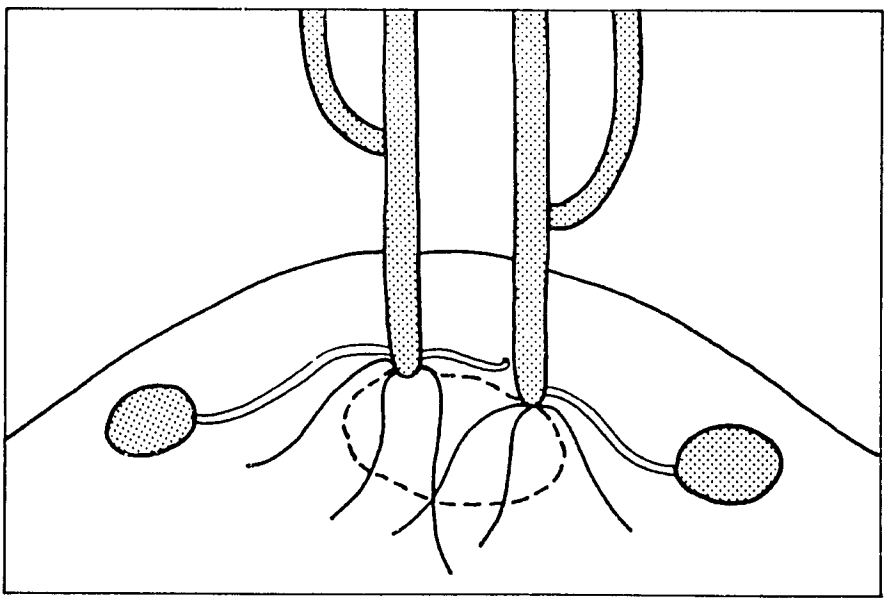
Effect of Stem Density on Potato Production

1 Definition
2 Effects of stem density
3 Calculating stem density
4 Factors determining stem density
5 Recommended stem density
6 Example: Planting distance and amount of seed tubers required
7 Additional study

The density of a potato crop consists of two components: plant density and number of stems per plant. "Stem density" combines both and describes the density of a potato crop better than the traditional term "plant density." Stem density influences number of tubers, size of tubers, and multiplication rate and is determined by the number of main stems that emerge and survive. The recommended stem density depends on the environment, purpose of the crop, and potato variety.

1 DEFINITION

The density of a potato crop is traditionally expressed as the number of plants per unit area. However, a potato plant commonly consists of various stems. Each stem forms roots, stolons, and tubers and behaves like an independent plant. Consequently, the density of a potato crop consists of two components.



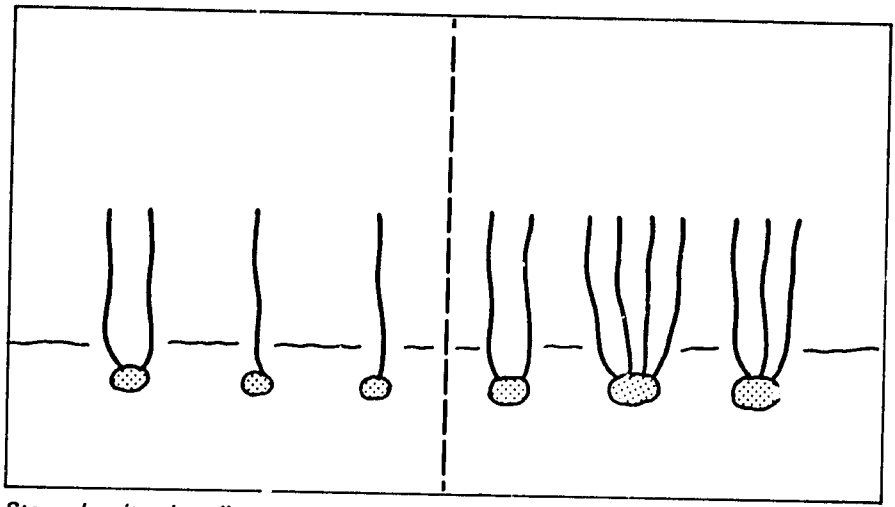
A potato plant commonly consists of various stems. Each stem forms roots, stolons, and tubers and behaves like an independent plant.

The first component is the number of potato plants, traditionally referred to as *plant density*. The second component is the number of stems per plant.

Thus, the real crop density –called *stem density* in this publication– is the result of:

plant density x number of stems per plant.

Stem density describes the density of a potato crop better than *plant density*.



Stem density **describes the density of a potato crop better than** *plant density.* **Three tubers may produce 4 stems (left) or 9 stems (right).**

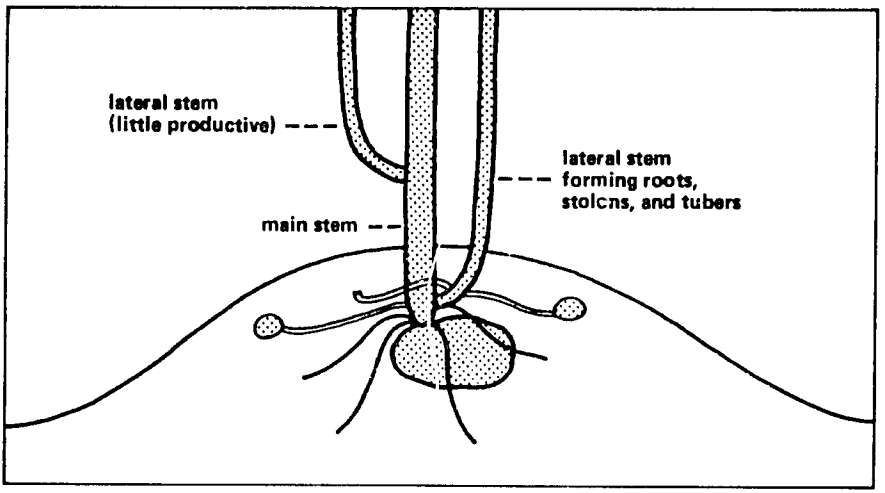
Stem density is commonly defined as:

main stems per square meter

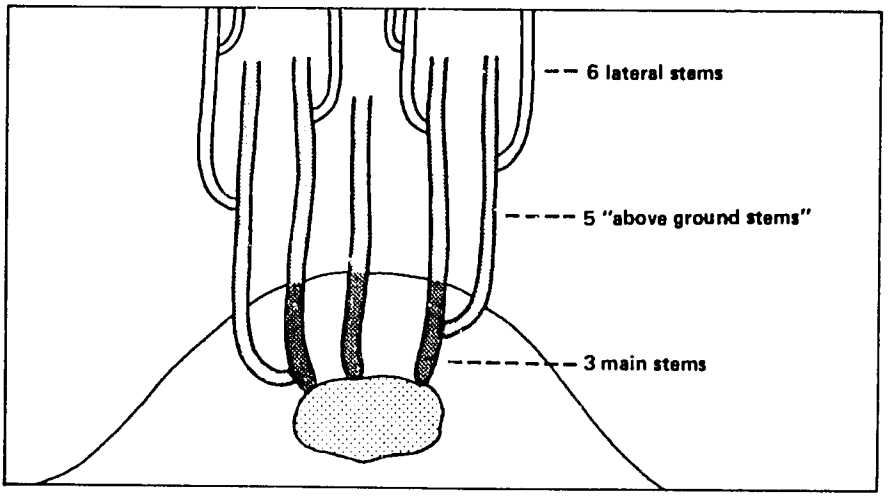
A main stem grows directly from the seed tuber. Lateral stems branching from main stems are generally little productive and are not considered when determining stem density. However, when lateral stems branch below soil level near the seed tuber, they may form roots, stolons, and tubers, as do main stems and may be as productive as main stems.

Main stems together with lateral stems branching below soil level are referred to as *above-ground stems.* The term *main stems per square meter* may be replaced by:

above ground stems per square meter



A main stem grows directly from the seed tuber. Lateral stems are generally little productive and are not considered when determining stem density, except when these stems branch below the soil surface near the seed tuber and form roots, stolons, and tubers, as do main stems.



Main stems together with lateral stems branching from main stems below the soil surface are referred to as *above-ground stems*. A potato plant may consist of 3 main stems, 5 productive above-ground stems, plus 6 less productive lateral stems.

2 EFFECTS OF STEM DENSITY

Stem density infiuences

- number of tubers,
- size of tubers,
- multiplication rate.

Number and size of tubers determine yield.

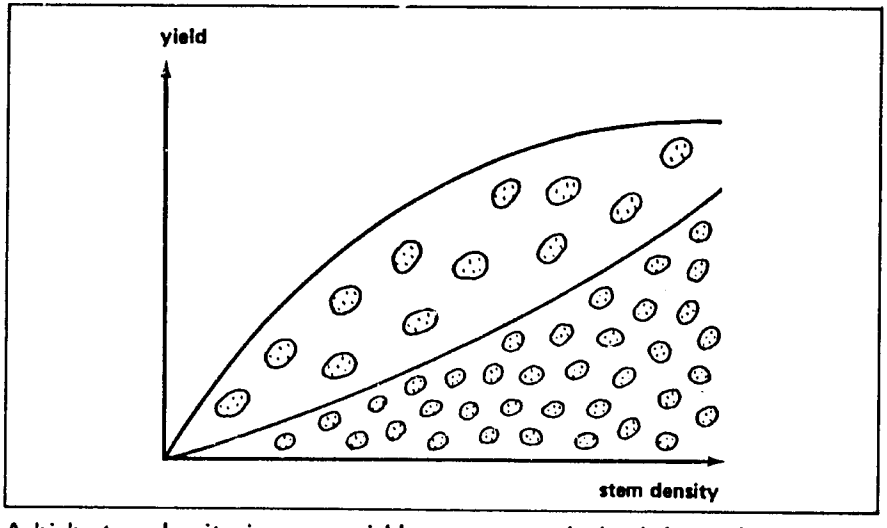
Number of tubers. The number of tubers produced depends on the competition among stems for growth factors, such as nutrients, water, and light. At lower stem densities competition is less, which results in a greater number of tubers per stem, but also in a smaller number of tubers per unit area. On the other hand, when stem densities increase, the number of tubers per stem decreases, but the number of tubers per unit area generally increases.

Size of tubers. Growth factors also affect tuber size, which is limited when competition among stems is high. At higher stem densities, the tubers produced remain smaller than at lower stem densities.

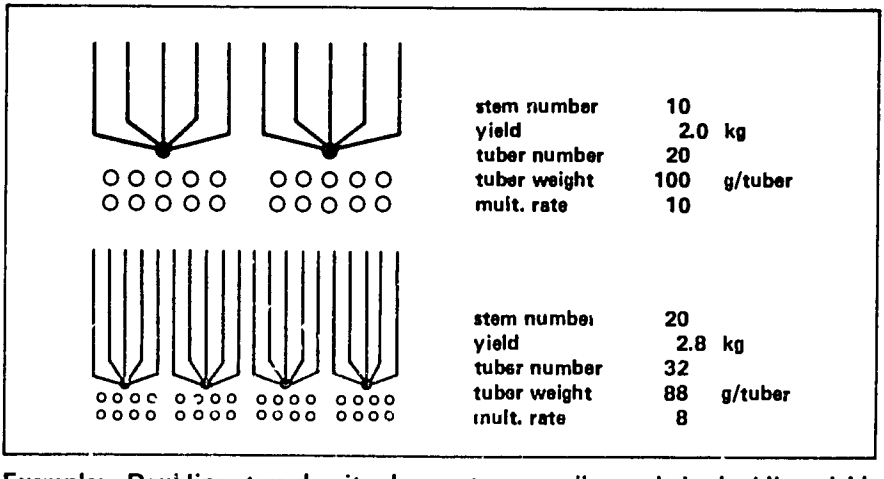
Multiplication rate. The multiplication rate is the number of tubers produced from one seed tuber. When stem density increases, fewer tubers are produced; the multiplication rate is reduced.

Thus, a high stem density:

- increases yield up to a certain level,
- reduces average tuber size,
- reduces multiplication rate.



A high stem density increases yield up to a certain level, but reduces average tuber size (higher proportion of small tubers).



Example: Doubling stem density does not necessarily result in doubling yield. Tuber number increases more than yield, resulting in smaller tuber size. When stem density increases, fewer tubers are produced from one seed tuber; the multiplication rate is reduced.

3 CALCULATING STEM DENSITY

Determination of stem density is more accurate at **harvest** when it is easier to separate main stems from lateral stems. However, determination of stem density is more practical in the **growing crop**.

To determine stem density count the number of main stems or above-ground stems per 10 meters of row at several randomly selected places. Then calculate stem number per square meter:

$$\text{Stem density} = \frac{\text{total stem number}}{\text{total row length} \times \text{row spacing}}$$

Example:

total number of stems at four randomly selected places	=	135 + 140 + 160 + 165	=	600	stems
total row length	=	4 x 10 m	=	40	m
distance between rows			=	0.75	m
stem density	=	$\frac{600 \text{ stems}}{40 \text{ m} \times 0.75 \text{ m}}$	=	20	stems/m^2

4 FACTORS DETERMINING STEM DENSITY

Stem density is determined by the number of main stems that emerge and survive.

Number of main stems depends on:

- Seedbed conditions: for good emergence, the soil should be moist and without clods. A dry and cloddy seedbed lowers stem density.
- Planting method: a minor damage to sprouts during planting reduces the number of stems. Heavy damage may cause new and more sprouts to grow, especially when the seed tuber is in good condition. This often leads to non-uniform emergence.
- *Number of sprouts planted* (with their corresponding seed tuber).

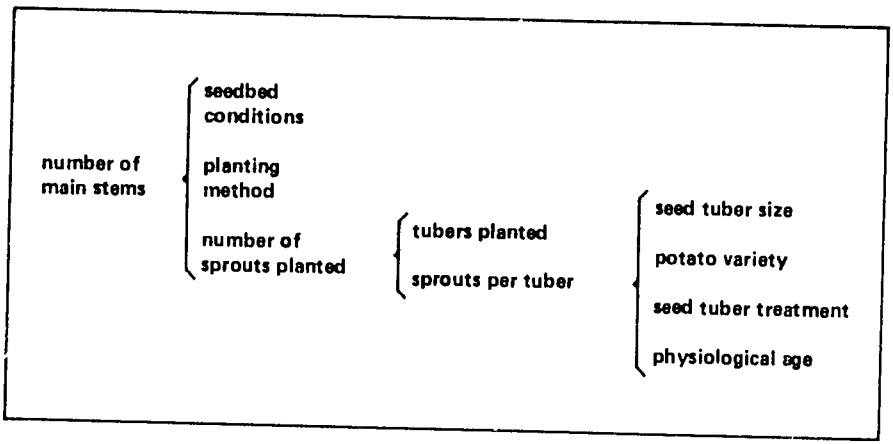
  Number of sprouts planted depends on:

  - Number of tubers planted.
  - *Number of sprouts per tuber.*

    Number of sprouts per tuber depends on:

    - Seed tuber size: larger tubers have more sprouts.
    - Potato variety: some varieties develop more sprouts than others.
    - Seed tuber treatment: treatment of the seed tuber before planting influences the number of sprouts. This includes: storage, de-sprouting, cutting, and pre-sprouting. Storage conditions that favor apical dominance limit the number of sprouts. De-sprouting and cutting of vigorous seed tubers often increase the number of sprouts. Pre-sprouting in diffused light allows sprouts to become well developed and firm, which reduces sprout damage during planting.
    - Physiological age: physiologically old tubers develop more sprouts than physiologically young tubers. If tubers are too old, sprouts become too weak for successful emergence.

Factors determining stem density



5 RECOMMENDED STEM DENSITY

Recommended stem density depends on:

- environment,
- purpose of crop,
- potato variety.

Environment. Poor growing conditions caused by low light intensity, low soil fertility, low soil moisture, and poor soil structure cannot support as many stems as good growing conditions. To produce an acceptable tuber size, stem density needs to be lower than under good growing conditions. High stem density under poor growing conditions may only decrease tuber size rather than increase yield.

Purpose of crop. In comparison with consumer potato production, seed potato production in general aims at reduced tuber size. In Holland, for example, at least 30 main stems per square meter are recommended for (certified) seed production, while 20 to 25 stems per square meter are recommended for consumer potatoes.

Seed potato production comprises two stages, each including a number of multiplications. The first stage leads to a high quality stock called **basic seed**. The second stage leads to **certified seed**, which is planted by the farmer to produce consumer potatoes. The level of tuber-borne diseases increases with each multiplication.

In production of **basic seed**, tuber health is more important than tuber size; thus, the number of multiplications must be kept to a minimum. This is achieved by maintaining a high multiplication rate through low stem density.

In production of **certified seed**, small seed size has higher priority because seed markets require small tubers. Thus, stem density for certified seed should be higher than for basic seed.

Note: A high multiplication rate is **not** compatible with small tuber size. A high multiplication rate is favored by **low** stem density; small tuber size is favored by **high** stem density. This implies that:

- stem density should be **low** when a high multiplication rate has priority,
- stem density should be **high** when small tuber size has priority.

Potato variety. Varieties that produce much foliage, such as some Andigena and late varieties, require a lower stem density than varieties that produce less foliage.

The best way to determine the recommended stem density is to experiment with different planting distances and seed sizes.

6 EXAMPLE: PLANTING DISTANCE AND AMOUNT OF SEED TUBERS REQUIRED

Assumptions:

recommended stem density	24	stems/m^2
row distance	80	cm
average tuber weight	40	g
average number of sprouts	4	sprouts/tuber

How to calculate distance within rows:

stems per m of row

$$= 24 \text{ stems/m}^2 \times 0.8 \text{ m} = 19.2 \text{ stems/m}$$

tubers per m of row

$$= \frac{19.2 \text{ stems/m}}{4 \text{ sprouts/tuber}} = 4.8 \text{ tubers/m}$$

distance within rows

$$= \frac{100 \text{ cm}}{4.8 \text{ tubers}} = \mathbf{21.0 \text{ cm}}$$

How to calculate the amount of seed tubers required:

seed tubers per m^2

$$= \frac{24 \text{ stems/m}^2}{4 \text{ sprouts/tuber}} = 6 \text{ tubers/m}^2$$

amount of seed tubers required

$$= 6 \text{ tubers/m}^2 \times 40 \text{ g/tuber} = 240 \text{ g/m}^2$$

$$= \mathbf{2.4 \text{ t/ha}}$$

7 ADDITIONAL STUDY

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