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CIP

CIP Research Guide 19

EVALUATION OF POTATO AND SWEET POTATO GENOTYPES FOR DROUGHT RESISTANCE

1990

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CIP Research Guides (CRGs)

CIP Research Guides (CRGs) describe technologies that have been developed and used by CIP and National Potato Programs. The CRGs have been produced to promote exchange of information among scientists and are regularly updated to ensure that they describe the most recent advances.

Ekanayake, I.J.; 1990. Evaluation of potato and sweet potato genotypes for drought resistance. CIP Research Guide 19. International Potato Center. Lima, Perú. 16 pp.

EVALUATION OF POTATO AND SWEET POTATO GENOTYPES FOR DROUGHT RESISTANCE

Drought is a major environmental constraint to potato production in warm and hot tropics and for sweet potato in the traditional cultivation areas. The problem of drought stress can be alleviated by manipulating cultural and management practices and by using adapted genotypes with drought resistance.

At CIP, we have developed a two-phased approach to screen potatoes and sweet potatoes for their drought-resistance ability. In this publication, the methodologies used in the first phase to select for drought resistance based on rooting ability are described for wider adoption and testing. Adapted cultivars can be selected at a country-site level since drought is extremely site-specific.

1 GENERAL BACKGROUND AND DEFINITIONS

1. What is drought?

A field definition for drought is a period without rain, of sufficient duration to cause injury to the crop and significantly reduce the economic yield. Drought begins when the readily available soil water in the root zone is exhausted (Kramer, 1983).

Drought can be permanent, periodic, or random, occurring early, late, or in the middle of the crop season. Drought also can be cumulative or specific and short.

2. What is drought resistance?(1)

A genotype is drought resistant when it produces an economic crop, within the limits of its production potential under conditions of limited water availability. We use this as a working definition to separate it from a more specific concept of drought resistance.
A genotype can be drought resistant due to the following mechanisms:

drought escape,
drought tolerance,
drought avoidance, and
drought recovery

These mechanisms are not mutually exclusive and provide the crop with the ability to resist drought at any given period during its growth cycle.

(1) For more details, refer to the CIP research guide no. 30 and the reference list in the back.

Step 1: Checks

Select and use an adapted or commonly cultivated genotype as the point of reference (check clone). Also, try to use a resistant and a sensitive clone as an upper-and lower-level reference; these genotypes can be temporary references which can be changed as more information becomes available and as more genotypes are tested.

Step 2: Simulated drought screening nursery

1. Rationale:

For various reasons, at the beginning of a screening program, lack of planting materials (potato tubers or sweet potato stem cuttings) of each genotype usually limits field experiments. The approach outlined here takes this problem into account and is designed to be tested with a minimum number of planting material of the individual test clones, i.e. 30 potato tubers or 60 sweet potato stem cuttings.

To compensate for both the extremely site-specific nature of drought resistance and for the low test population, check clones should be planted as many times as possible (using the local variety as the check enables you to have more planting materials).

2. Statistical design:

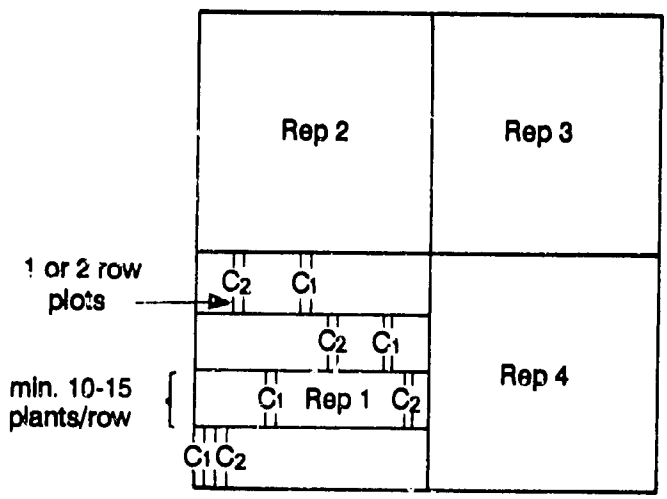
A randomized complete block design with genotypes as treatments is recommended (Figure 1a). A minimum of 3 replications are needed; for sweet potato, due to the large genotype x environment interaction, at

least 5 replications and larger plot sizes (with more number of plants) are preferred. A more complex but suitable design where few tubers are available for planting can also be used (Figure 1b).

3. Field plot layout:

Single-row plots of 10 plants each for potatoes, and two-row plots with 10 plants per row or 20-plant single-row plots for sweet potatoes can be used. Plant spacing depends on the local recommendation; at CIP headquarters, plant spacings of 30cm x 70cm for potatoes and 30cm x 90cm for sweet potatoes are normally used.

Figure 1. Detailed field plan with proposed guidelines.

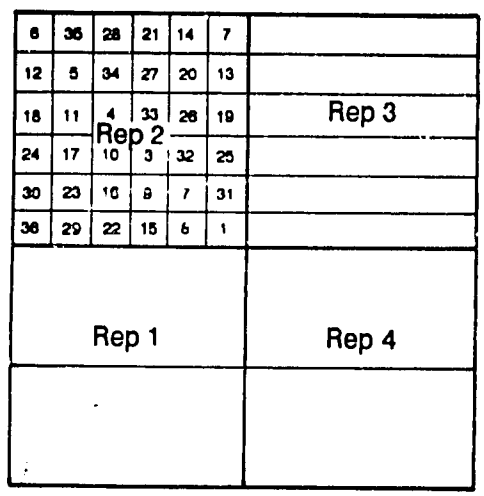


C_1: check 1

C_2: check 2

(If needed additional checks can be added)

a) Randomized complete block design.



6x6 Triple Lattice

Rep 1-3: for yield analysis

Rep 4: for root-pulling

b) Other field designs

A single sprouted potato tuber (physiologically-young sprouted tubers are recommended) per hill or a single sweet potato stem cutting approximately 25cm long can be planted per hill.

Checks should be repeated at least once (preferably more than once) in each block.

4. Drought simulation:

Based on the priority drought period in the region, and the identified sensitive growth stage, the drought treatment can be applied to coincide with the establishment stage or tuber/tuberous root-initiation stage and then to continue until harvest. Planting can be adjusted to maximize the occurrence of predictable drought at the specific location. Our approach is to initiate the stress at approximately full canopy cover development and to expose to a continuous drought.

Intensity of drought applied can also depend on the needs of the crop and growing area: mild, moderate, or severe stress. We have used 60% of the potential evapo-transpiration for a moderate drought stress treatment, or alternate irrigation cycles of the optimum water requirement to induce the field drought stress throughout the growing season. Water management practices used must be adjusted according to the total volume of water needed by the individual crop; method of irrigation (furrow, sprinkler or sub-surface); and the stage of crop development.(2)

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(2) The proper uses of irrigation practices are described in CIP Research Guide No.30, and in Haverkort, A.J., 1982 Technical Information Bulletin 15, CIP Lima, Peru.

3 SUGGESTIONS FOR DATA COLLECTION

1. Emergence, crop cover, tuber initiation

The effects of the drought treatment are dependent on the growth stage it coincides with. When the drought treatment should begin can be determined by crop emergence. Weekly counts of emerged plants can be gathered on a per-plot basis. Crop cover also can be measured using a standard grid[3] at weekly intervals. Sample data collecting sheets are given in Appendices 2 and 3 for potatoes and sweet potatoes, respectively.

Tuber initiation of potatoes and root thickening (bulking) for sweet potatoes can be determined by scraping around the base of the stems of the border plants of the plot. For potatoes, these data can be collected from 3 weeks after planting at bi-weekly intervals. For sweet potatoes, it can be done from 5 weeks after planting, also at bi-weekly intervals.[4]

2. Root-pulling resistance

Root resistance to pulling can be recorded up to 45 days after planting for potatoes (i.e. 2 to 3 weeks after beginning a drought period imposed at maximum crop cover) and up to about 60 days after planting sweet potatoes.

Pulling of individual plants can be done by wrapping a piece of cloth around the base of the plant and tying it to a rope, which is then attached.

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[3] For detailed instructions on how to gather crop-cover data, refer to the CIP Research Guide No.30, and in Midmore, D.J. 1986 CIP Circular 14(1):79.

[4] A data-collecting format can be obtained from the data sheets given in CIP Technology Evaluation Series No. 1982-4.

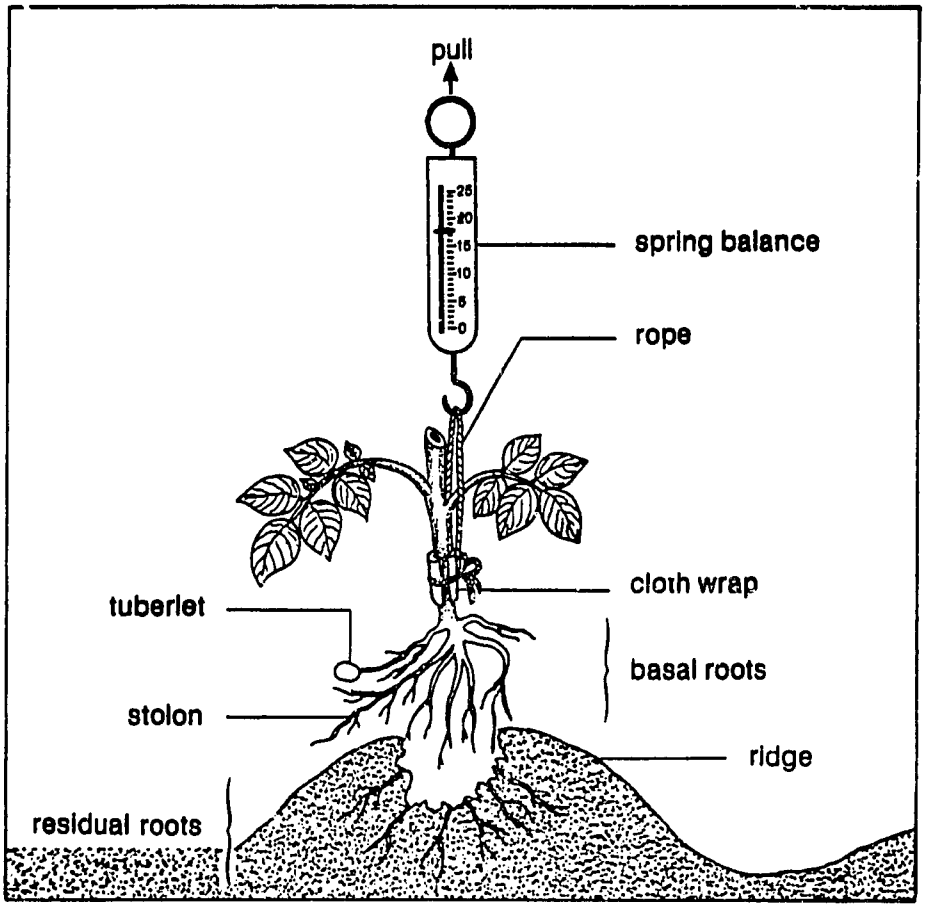

Figure 2. Root-pulling device and a modified approach used for pulling potato plants

to a simple scale or a dynamometer. This simplified approach was shown to be highly related to the use of a pulling device (Figure 2). As the plant is pulled out of the soil surface, the force required (resistance to pulling) is measured on the scale. It has been observed that for ease of manual pulling, sampling should be done when the individual plant resistance is less than 35 kg. Two workers are needed, one to pull and the other to record the data. Obviously, where growth analysis data on the pulled plants are to be recorded, more manpower is required. Recording time is about 2 to 3 minutes per plant. A minimum of 2-3 plants should be pulled separately in each plot. Sample data sheets are given in Appendices 2 and 3.

For the best results, no inter-row cultivation practices which could disturb the root zones should be done prior to pulling.

3. Yield

Per-plot yields can also be obtained on the same plots at maturity. The number of surviving plants, and a count of plants with tubers (or thick roots) can be done. Harvested tubers or roots can then be separated into size classes. Fresh weights per plot can be taken to calculate production per unit land area. If desired, sample dry weights can be obtained to calculate tuber or tuberous root dry-matter contents.

4. Other observations

Insect, fungus, and virus disease symptoms should be evaluated at least twice during the season; meteorological data obtained from the same site can help the researcher to interpret the data.

5. Selection

On the basis of tuber-yielding ability and root-pulling resistance, a preliminary selection and categorization of genotypes can be done: resistant - higher yields and higher pulling resistance than the check;

moderately resistant - higher yields or higher pulling resistance relative to the check; and susceptible - lower yields or lower pulling resistance than the check.

Since drought-resistant traits are largely influenced by the environment, genotypes should be tested in more than one season or location. The selected genotypes can be further tested on a large scale for their commercial acceptability and can be used in a breeding program.

4 REFERENCES

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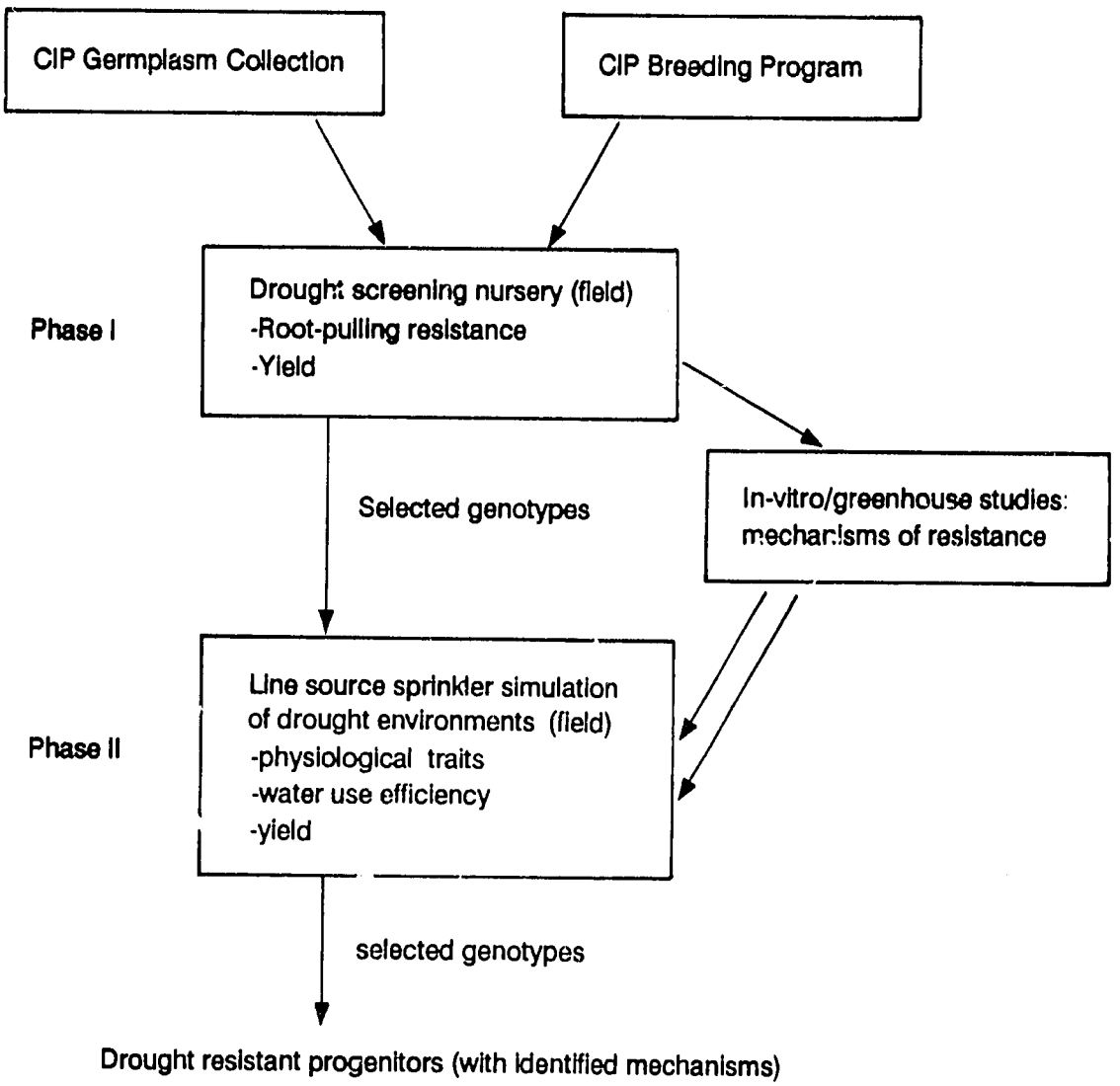
Appendix 1. Flow chart of the procedures used in screening for drought at CIP.



Appendix 2.

POTATO

GROWTH ANALYSIS AND PULLING RESISTANCE

Program: Location: Planting date: Plant age:

Person responsible: Season: Sampling date:

Plot	Plant	Plant	Foliage			Tubers						Roots		Pulling resist.
ID	No.	Ht.	Fresh	Sample		>3.5cm		<3.5cm		Sample		Fresh	Dry	Kg/plant
			Weight	Fr.wt	Dry wt	No.	Wt.	No.	Wt.	Fr.wt	Dry wt	wt.	wt.	

Appendix 3.

SWEET POTATO

GROWTH ANALYSIS AND PULLING RESISTANCE

Program: Location: Planting date: Plant age:

Person responsible: Season: Sampling date:

Plant ID	Plant Ht.	Number of							Root length	Dry weight of						Pulling Resist. (kg/p)
		stem	branch	inter.	leaf	flower	fib. root	tub. root		Aer. fol.	leaf	stem	flower	fib. root	tub. root	