# Supporting Emergence or Reference Drought Tolerance Phenotyping Centers - Drought Phenotyping Network

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# Contrasting Environment Targets Characteristics: Development of the Drought Phenotyping Network

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## Introduction

The drought process studies require knowledge of some target environment factors and how these factors interact with plants genotypes performance under water constraint condition. In Brazilian Northeast, Southeast, Mid-North, and Central-West tropical regions, drought is considered the main environmental stress source of grain yield instability of cereals and legumes crops. Among several responsible factors for the cereals and legumes production risk, soil and rainfall spatial variability are the most important, because they influence nutrients and water availability directly to the genotypes. Generally the rainfall presents two distinct periods, dry and rainy seasons, offering great risk for the agriculture practice.

Thus, it is necessary a good characterization of the environment, requiring the registration and acquisition of several soil, water, plants, and atmosphere attributes. Problems related to soil water dynamics variability at the plants effective root depth region, in the soil profile, and to some other soil chemical and physical properties, have contributed to the difficulties of the drought tolerance studies in different environment. For this reason a standard breeding program methodology should require a good understanding of environment characteristics for genotypes evaluation and selection under water constraint condition.

The Embrapa's researchers have established and described the procedures and practices to develop the "drought phenotyping network" (DPN) in Brazil, by means of selecting, installing, and characterizing the precision specific sites experimental areas, in contrasting environment targets, according to geographical coordinates, elevation, climatic condition, and soil physical and chemical properties.

### *Specific Sites Selecting Criteria*

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The choice of the specific sites experimental areas at Embrapa Units in Brazil for the DPN studies took into account the sites representativeness with regard to the regions geographical coordinates, economic and social aspects, agriculture and cropping systems information, climatic condition characterization (according to weather data historical series of at least 15 years and hydrological soil water balance), soil physical (texture, structure, porosity, apparent and real density, soil moisture retention curves, water infiltration rate) and chemical (fertility, organic matter, macro and micro nutrients) properties. Some important soil attributes variability were determined and evaluated by means of topographic survey and division of the sites areas in a grid size (25 m x 25 m), utilizing an accurate survey laser total station, on SAD-69 datum and UTM projection (south zone 23, 48 to 42 W), and a differential global position system (DGPS). Soil samples were collected at the grid intersections for soil physics and chemistries properties analyses. In each selected site area, the water table was deep in order to avoid soil water capillarity effect in the genotypes root systems, and it was identified high and low points in order to avoid drainage problems.

Table 1 presents the selected specific sites localization per Embrapa Unit, in Brazil, with their geographic coordinates, altitudes, crops species, and type of phenotyping strategy and genetic material for drought tolerance studies. They are the following: 1) Embrapa Maize and Sorghum - Sete Lagoas and Janaúba at Minas Gerais (MG) state, 2) Embrapa Rice and Beans - Santo Antônio de Goiás and Porangatu at Goiás (GO) state, 3) Embrapa Mid-North - Teresina at Piauí (PI) state, 4) Embrapa Savannah - Planaltina at Federal District (DF) Brasília, 5) Embrapa Wheat - Passo Fundo at Rio Grande do Sul (RS) state, and 6) Embrapa Semi-Arid - Petrolina at Pernambuco (PE) state. Figure 1 shows the localization of these specific sites for crop drought tolerance phenotyping in the map of Brazil for the different Embrapa Units and regions. Each specific site presents its own direct administrative and technical research support.

## *Soil Characteristics for Establishment of a Specific Site*

Some of the important agronomic attributes are not usually displayed in the soil maps, such as soil compaction and soil water availability. It is important to take into account the differential influence of the experimental areas past use and management, such as residual effect of fertilizing among plots in the trials, common in experimental stations.

The localization of the specific site areas for breeding and phenotyping experiments require maximization of the abiotic factors uniformity that may result in the influence of data acquisition, in order to reduce experimental errors. The selection of the place for the experimental specific site should consider the representation of field reality regarding to local uniformity and resources and infrastructure availability. The specific site concept was developed for commercial crop production systems, aiming to use technological resources, mainly after the introduction of the DGPS and others modern electronic devices for data collection, transference, and storage. At the end, all the acquired data are incorporated and processed by means of a geographical processing system (GIS) software.

Table 1. Localization of the specific sites at Embrapa Units in Brazil with specification of state, city, geographic coordinates, altitudes, crops species, and type of phenotyping strategy and genetic material for drought tolerance studies.

| State[(1)] of Brazil | Specific site[(2)] localization | Longitude (W) | Latitude (S) | Altitude (m) | Crop species | Phenotyping strategy[(3)] / Genetic material[(4)] |
|---|---|---|---|---|---|---|
| MG | Sete Lagoas (E) | 44.2467 | 19.4658 | 731 | Maize, sorghum | P, I, A /Access and elite |
| MG | Janaúba (R) | 43.3089 | 15.8025 | 533 | Maize, sorghum | P, I / Access and elite |
| DF | Planaltina (R) | 47.6142 | 15.4528 | 944 | Wheat | P, I / Access and elite |
| GO | Santo Antônio de Goiás (E) | 49.1711 | 16.2811 | 823 | Rice, common bean, wheat | P, I, A / Access, elite, segregation |
| GO | Porangatu (R) | 49.1486 | 13.4408 | 396 | Rice | P, I / Access and elite |
| PI | Teresina (R) | 42.8019 | 5.0892 | 72 | Maize, sorghum, cowpea | P, I / Access and elite |
| PE | Petrolina (R) | 40.5008 | 9.3986 | 376 | Sorghum, maize, cowpea | P, I / Access and elite |
| RS | Passo Fundo | 52.4067 | 28.2628 | 687 | Wheat | P, I / Access and elite |

[(1)] MG= Minas Gerais, GO= Goiás, DF= Federal District, PI= Piauí, PE= Pernanbuco, RS= Rio Grande do Sul.

[(2)] E= Site of Excellence, R= Site of Reference.

[(3)] Type of phenotyping strategy: P= Preliminary, I= Intermediary, A=Advanced.

[(4)] Cereals and Legumes Supporting Breeding Programs at Embrapa.

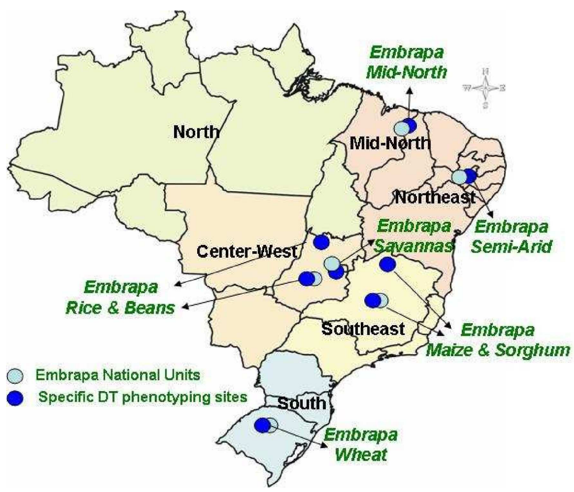


Figure 1. Localization of the specific site areas of the drought phenotyping network for crop drought tolerance studies in different Embrapa Units and regions of Brazil.

The procedures described below allow accessing the minimum information required for the specific site selection and placing in the field.

*Main Steps and Recommendations for a Specific Site Selection and Placement*

1. Choice of the site. The site should be chosen according to the availability of area and infrastructure, usually restricted to the experimental station, or in an area where rigorous control can be achieved. This place should be, as much as possible, representative of the agricultural areas where the genetic materials would be cultivated.

2. Bibliographic revision of local knowledge, including all the thematic maps, aerial photos, images, scientific papers, theses, dissertation, and technical reports referred to that region. The compilation of the bibliography should include, at least the soil and land use maps, the geologic and geomorphologic surveys, the topographic maps, and the photos or rectified images of the local.

3. Elaboration of a historical area use report, including the experimental data and the activities conducted in the site, works and any other change by use. The report should include the information since the beginning of occupation of the area, if possible, and may use oral reports from past habitants or workers of the area, but well documented registers are preferable.

4. Preliminary mapping of the area. This step should be done using the images or photos, trying to identify patterns in the ground and targets for sampling.

5. Planning and organization of the field work. This step includes the preparation of a work sketch, a work schedule and a check list of the materials and equipment required.

6. Planimetric and altimetric surveying of the site area, with contour lines in the topographic map within a vertical distance of at least one meter or better accuracy (sub-metric), if necessary. This work should be performed by a specialized team, using geodesic DGPS and a total laser station. Some permanent ground control points should be placed as a reference for future sampling work.

7. Highly-detailed soil survey, according to an up-to-dated version of the classification system in use. The survey should include the opening, description and sampling in opened representative trenches, as much as necessary for the best description of all the soil classes present, according to the current or best soil survey method (e.g. Soil Survey Division Staff, 1993). The mapping should be aided by auger sampling between the trenches, to check for the soil classes' borders or transitions and the spots of differing soils.

8. Detailed survey and description of important agronomic or experimental properties not included in the previous survey, as the soil's strength, water infiltration rate curves in the soil profile, average thickness of horizons, electric conductivity, etc. A sampling grid size of 25 m x 25 m is suggested as an initial guess for the soil sampling. The use of a DGPS for the geo-referencing of the sampling points is recommended, but if not available or for short distances, a metric tape could be used. In this case, the measurements should be referred to a control point in ground with known coordinates, preferably a geodesic reference point. For each point in the sampling grid, a compound sample should be collected, at least three simple samples for each compound sample, in a maximum radius of one meter from the grid node.

9. Soil chemical analyses should include standard fertility status (pH, $Ca^{2+}$, $Mg^{2+}$, $Al^{3+}$, H+Al, macronutrients N, P, K, Organic Matter, electrical conductivity - C.E.C.) and the micronutrients (Fe, B, Zn, Cu) , according to the current methods (Agronomy Society of America, 1982; Embrapa-CNPS, 1997). Environment with aluminum (Al) toxicity problem in the soil profile, soil acids, must have determined the Al saturation to correct the pH by means of lime application.

10. Soil physical properties should include the granulometry (texture and structure), particle density (apparent and real), macro and micro porosity, water infiltration rate, soil moisture retention curves (field capacity, permanent wilting points, and total soil water availability) determination.

11. Exportation and compilation of all the data into a geographic information system (GIS), production of the thematic maps and digital terrain models in the adequate scale for the site would be recommended. The choice of the software should be done to match the needs for data analysis and processing, data exportation and compatibility with other systems in use.

## *Climatic Characterization*

Environment climatic characterization is essential in drought tolerance phenotyping investigation to determine and quantify the crop water requirement or evapotranspiration (ETc), the irrigation water management, the control of partial reposition of ETc or different water regimes treatments, and the crop water stress levels. The main atmosphere climatic parameters which must be registered close to vegetated surface are: air temperature, global solar radiation, air relative humidity, wind speed, air water vapor pressure deficit, and precipitation. These parameters associated with other plants and soil water content registration attributes affect directly the genotypes adaptation to water deficit condition (Merva, 1995; Gomide et al., 2005).

The environment climatic characterization was accomplished with weather data acquisition by means of an automatic or a standard weather station. The use of an automatic weather station is better since it can be easily configured and programmed to acquire data at short time intervals (one hour, for example). Direct evaluation of plants parameters, associated with some measurements of soil water content and microclimatic attributes, at surface level, were performed to better quantify crops water deficit, and these procedures were the key to explain how certain genotypes adjust better to water shortage condition than others. Each specific site climatic characterization was done with a time climatic series database of at least 15 years acquired from standards or automatic weather stations.