

# Global Distribution of Sweetpotato

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A georeferenced database of the global distribution of sweetpotato (*Ipomoea batatas* (L.) Lam) is described. The database was assembled from many country-level sources. To create a database representative for one time period, the proportion of national sweetpotato area in each production zone was multiplied by total national sweetpotato area for 1998-2000, as estimated by the Food and Agriculture Organization of the United Nations (FAO). Most sweetpotato is grown in the temperate zone, 70% of the area is between 20° N and 40° N. Sweetpotato is highly concentrated in some areas, notably in the lowlands of China and in the mid-elevations of the Lake Victoria area in Africa. About half the global sweetpotato area occurs where it is an obligatory seasonal crop because of low temperatures during part of the year.

Crop distribution data are useful for various purposes, particularly for targeting agricultural research and assessing the impact of agricultural technology (e.g., Hijmans et al., 2000). Country level crop distribution data are readily available through the database of FAO (2001). To study aspects related to the distribution of a particular crop at the global or lower aggregation levels, however, more disaggregated data are needed to account for the considerable differences within countries in crop distribution and other variables such as climate.

In this paper, we describe a new global georeferenced database of the distribution of sweetpotato and use it to provide a preliminary description of the current distribution of the crop. This database is an updated version of the one documented in detail by Huaccho and Hijmans (2000). The only previously existing map of global sweetpotato distribution (Bertin et al., 1971) focused more on historical aspects,

was outdated, and had insufficient detail for our purposes. Comparable work for potato (*Solanum tuberosum* L.) was reported by Huaccho and Hijmans (1999) and Hijmans (2001).

## Materials and Methods

### Georeferenced database

Sweetpotato production zones were delineated for each country with sweetpotato production. These zones generally followed administrative boundaries, but in some cases we used zones on existing national-level sweetpotato distribution maps or on maps of general crop distribution, including satellite-derived land cover data (USGS-EDC, 1998). Most data sources used to estimate within-country distribution of sweetpotato are listed by country in Huaccho and Hijmans (2000). We used ArcView-GIS version 3.1 (ESRI, Redlands, CA, USA), geographic information system software.

The fraction of the national sweetpotato area in each production zone was estimated, using national statistical data when

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available. This fraction was then multiplied by the FAO estimate of the average total national sweetpotato area for 1998–2000 (FAO, 2001) to create a consistent database representative for one time period. We used national-level estimates of total sweetpotato area for the countries for which FAO did not provide an estimate, namely: Colombia, Costa Rica, Guatemala, Guyana, and Nepal. For Malawi we assumed that the 80% of the total area reported as potato by FAO was in fact sweetpotato (Peter Ewell, CIP, 1999, pers. comm.)

### Data conversion and analysis

Relative sweetpotato area over total land area (RSA) was calculated for each production zone (polygon), using IDRISI software (Clark Labs, Worcester, MA, USA) to calculate the total area of each polygon.

RSA data were transferred to a 1 x 1 minute grid, which was aggregated to a coarser resolution grid (1 x 1 degree), calculating the average RSA for each cell. This two-step process prevented data loss from small polygons while creating a smoother grid. The 1 x 1 minute resolution seemed an adequate compromise between the desire for high resolution and the high uncertainty of some of the sweetpotato distribution data, which do not justify the use of a higher resolution. By multiplying the area of each grid cell by the RSA, the total sweetpotato area for a grid cell was calculated.

The sweetpotato area was summarized by bands of 1 degree of latitude wide; and by altitude (below and above 1,000 m), using the ETOPO5 database (USGS-EDC, undated).

A global grid of temperature (30-minute resolution) (New et al., 1999) was used to describe temperature of sweetpotato production areas. Months with an average temperature below 10°C were defined as *cold months*, in which sweetpotato is unlikely to be in the field.

## Results

The sweetpotato distribution database has a total of 1136 spatial units, with a mean of 8456 and a median of 1569 ha per map unit. Detailed results for first-level administrative subdivisions (e.g., state, department) are tabulated in Huaccho and Hijmans (2000). Figures 1 and 2 are derived from the database.

The high concentration of sweetpotato area in China, which has about 65% of the world's sweetpotato area, is the most striking aspect of the crop's distribution (Figure 1). In addition to China, there are considerable concentrations of sweetpotato in Cuba and Haiti in the Caribbean region; in Java (Indonesia), the island of New Guinea (both in Indonesia and in Papua New Guinea), and Vietnam in Asia; and in Africa, particularly in the Lake Victoria area (Burundi, Rwanda, Uganda, and the Dem. Rep. of Congo), and in Ghana, Nigeria, and Madagascar. Sweetpotato is an important staple for many Oceania island countries such as Papua New Guinea, the Solomon Islands, Tonga, and New Caledonia. They are not shown on the map, however, because of the 1-dot-equals-1000-ha scale used.

Because of the high concentration of sweetpotato area in China, we include a separate map for that country (Figure 2). In China, there are three areas of very high concentration of sweetpotato: 1) Sichuan and Chongqing provinces, with about 1,000,000 ha (the Sichuan Basin); 2) the east central provinces of Shandong, Henan, and Anhui, each of which has over 600,000 ha; and 3) the southeastern coast. Each of four Chinese provinces has more sweetpotato area than Uganda, which, with 546,000 ha, is the second largest sweetpotato producing country.

There is a bimodal distribution of sweetpotato area by latitude (Figure 3). Seventy percent of sweetpotato is grown between 20°N and 40°N. This peak includes nearly all the area in China,

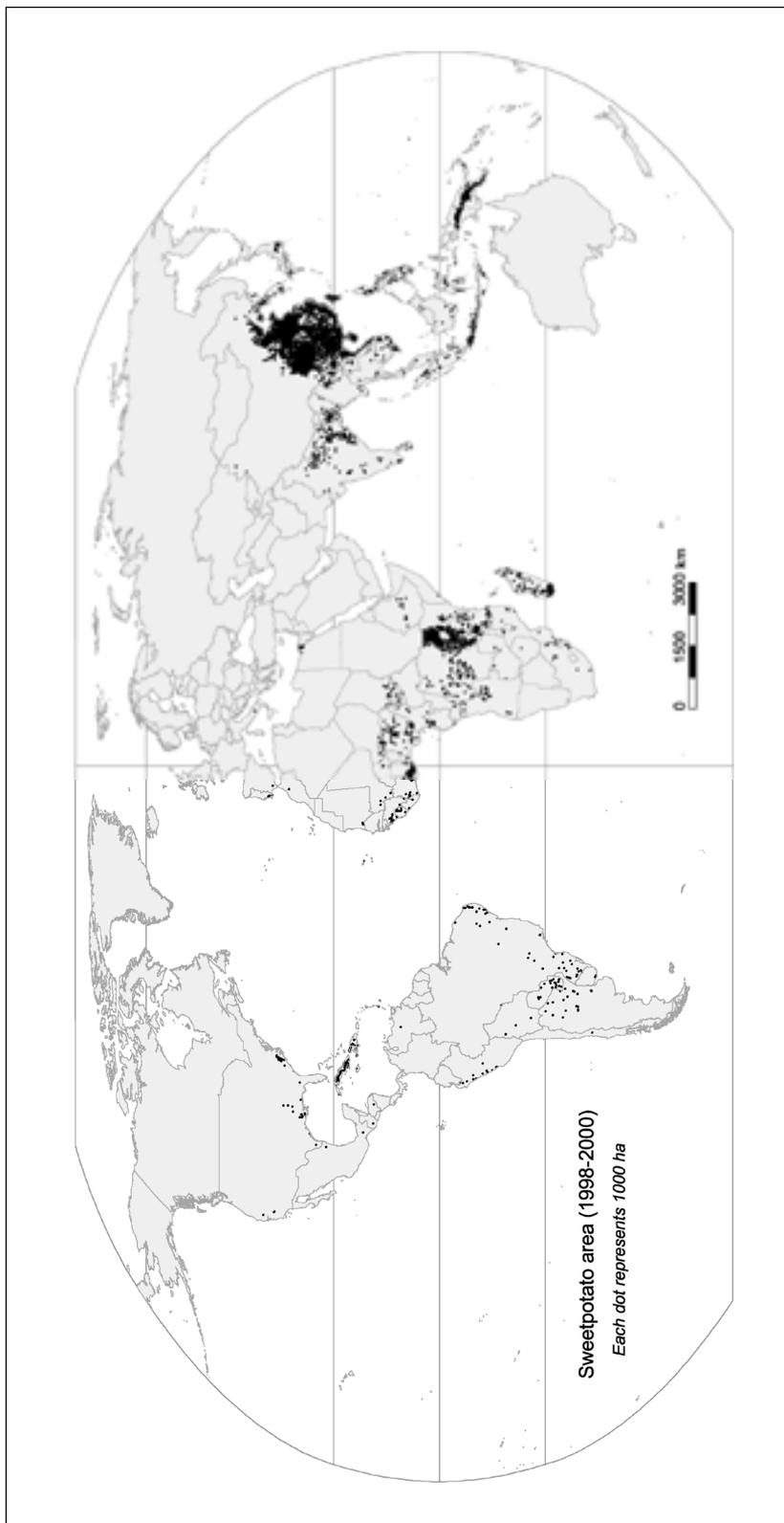


Figure 1. Global sweetpotato distribution (1998–2000).

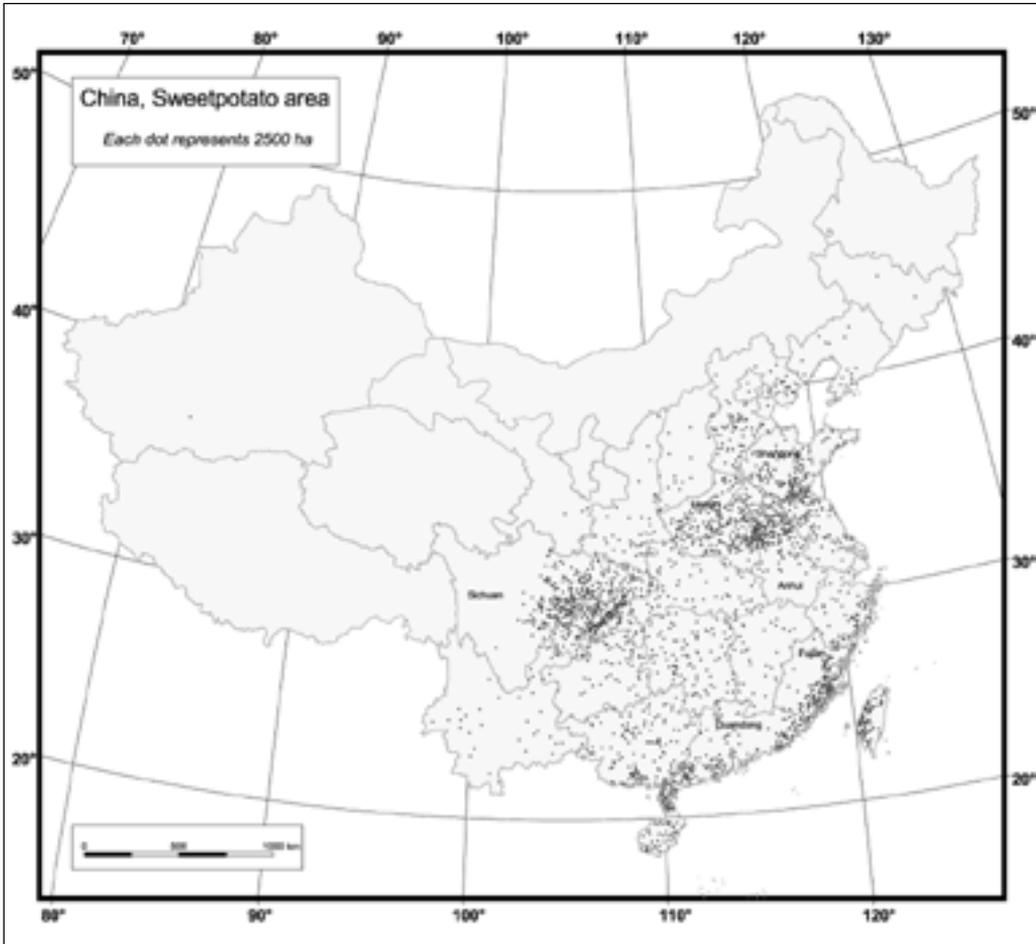


Figure 2. Sweetpotato distribution in China.

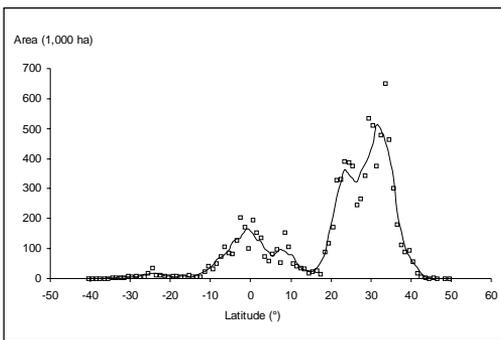


Figure 3. Distribution of sweetpotato area by latitude. Each dot represents one-degree latitude. Latitude in the Southern Hemisphere is indicated with a minus (-) sign. The line is the five-observations moving average.

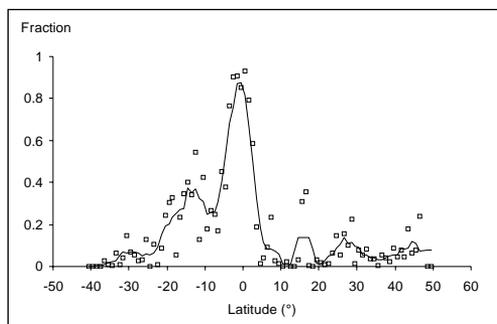
India, and North America. The sweetpotato area at these latitudes is virtually all in lowlands (with only 6% above 1,000 m; Figure 4). The second peak in sweetpotato distribution by latitude is between 10°S and 15°N, with 24% of the global sweetpotato area. This peak includes most of the sweetpotato area in Africa, and some areas in Asia and northeastern Brazil. A large part of the sweetpotato area at these latitudes occurs at mid-elevation (49% above 1,000 m; Figure 4). There is not much sweetpotato area south of 10°S, except for some areas on Madagascar. This is partly explained by the paucity of land, people, and agriculture in the Southern Hemisphere (Hijmans, in press).

Sweetpotato is grown in areas where it can be grown year-round, and in areas where it can only be grown in the summer (warm) season. Fifty-four percent of the sweetpotato area has more than one cold month (average temperature below 10°C; Figure 5). Hence, we estimate that about half the sweetpotato area is obligatory seasonal because of low temperatures during a part of the growing season. This area roughly corresponds with the coldest 49% of the growing area, which has an average annual temperature below 15°C (Figure 6). That is not to say that in other areas sweetpotato production is necessarily year-round. That depends on many other factors outside the scope of this paper, such as prevailing crop rotations and the presence of a dry season. In general, these two systems (seasonal vs year-round) have quite different production constraints. For example, fungal diseases are often very important in seasonal production areas, whereas insect pests are most severe in areas with year-round production. Whereas cold temperatures in the beginning and the end of the growing season are a limiting factor in seasonal systems, rare events of mid-season night frost in the tropical highlands of Papua New Guinea can have a devastating effect on production (Waddell, 1975).

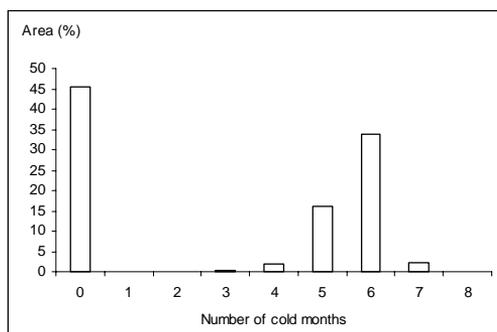
## Conclusion and Discussion

The georeferenced database presented here is the first detailed description of global sweetpotato distribution. It provides considerably more detail than the rather general map published 30 years ago by Bertin et al. (1971).

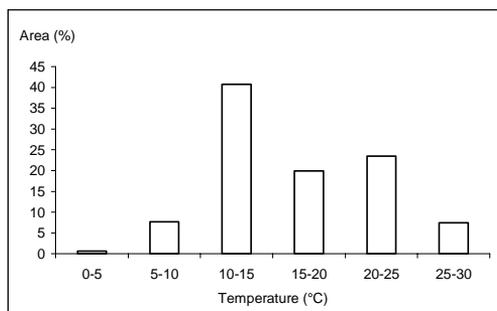
Sweetpotato distribution is characterized by a pattern of both concentration and dispersion. With 65% of global sweetpotato area, China is in a league of its own, and the area in China obviously dominates the distribution by latitude. There is also an area of high sweetpotato density in the Lake Victoria area in Africa. In most other countries, however, sweetpotato densities are low, yet the



**Figure 4.** Fraction of the sweetpotato area located above 1,000 m, by latitude. Each dot represents one-degree latitude. Latitude in the Southern Hemisphere is indicated with a minus (-) sign. The line is the five-observations moving average.



**Figure 5.** Global sweetpotato area by number of cold months. A cold month has an average temperature below 10°C.



**Figure 6.** Global sweetpotato area by average annual temperature.

crop is grown almost everywhere in the subtropics.

In China, the provinces of Sichuan, Henan, and Shandong have a very high rural population density and irrigable farmland is scarce. In these areas,

sweetpotato fits well in the intense cropping system of the uplands. Under certain circumstances, sweetpotato can produce more edible energy per hectare per day than any other major crop (De Vries et al., 1967). In eastern Africa, most of the production is concentrated at mid-elevation (1,000-1,600 m) in the densely populated Lake Victoria basin. Population pressure is the main reason for the crop's rising importance in this region, where it is often planted in more marginal fields with poor soils and limited water supply.

Sweetpotato appears to have a rather complementary distribution as compared to potato and cassava (*Manihot esculenta* (L.) Crantz) the other two root and tuber crops of global importance. Potato is a summer crop in the temperate lowlands, an off-season or mid-elevation crop of the subtropics, and is also grown in the upper parts of the tropical highlands (Hijmans, 2001). Sweetpotato is predominantly grown in warmer areas: the subtropical lowlands, and in mid-elevations of the tropical highlands. In contrast, cassava is mainly grown in the tropical lowlands.

China is the country with the world's largest potato and sweetpotato area. Nevertheless, most potato and sweetpotato production occurs in different areas: potato in the northern, northwestern and the southwestern highlands; sweetpotato in the eastern lowlands and in the Sichuan Basin. In the central African highlands, particularly in Rwanda and Burundi, there are high densities of cassava, sweetpotato, and potato, albeit mostly at different altitudes (cf. Hijmans, 2001; Carter et al., 1992).

The data sources used for the global sweetpotato distribution database differed greatly in detail and quality. The distribution in the countries with low sweetpotato production is, generally speaking, most uncertain. Given the paucity of data for many countries, we have probably missed

some production zones. The fact that the borders of countries are sometimes discernible from the sweetpotato distribution illustrates (in some cases, but not in all) weaknesses in the database.

Through a collaborative network of sweetpotato scientists in East Africa, we had access to good estimates for important sweetpotato-producing countries in that part of the world. We also had a high-resolution (at county-level) database for China for 1987 and 1988. The relative spatial distribution of the data seems to be quite accurate. However, the aggregated area exceeded FAO estimates by 1.5 million ha, representing about 17% of the world's sweetpotato reported by FAO for 1987. Although the higher estimate might actually be more accurate (Crook, 1993), we have used the FAO figure for the country aggregate, as we did for all other countries, and the county-level data for the within-country distribution.

Crop distribution maps are an important missing link for studies of global agriculture. Whereas there are prospects for using more remotely sensed data, it is currently difficult to use these to identify the spatial extent of global agriculture (Wood et al., 2000), let alone that of specific crops. At present, detailed census-type data are indispensable for the development of global crop distribution databases.

For this type of composite database, documenting the sources used for each country is very important, as this can guide efforts to update data and help users assess the data quality. The sources of a previous version of the database discussed here are documented in Huaccho and Hijmans (2000). Having the data in a digital format has the dual advantage of increasing its usefulness for research of global sweetpotato production, and making it relatively easy to update when newer or better data become available.

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