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Population characteristics of giant reed (*Arundo donax* L.) in cultivated and naturalized habitats

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ABSTRACT

In the present study, we analyzed the variability among naturalized and cultivated giant reed (*Arundo donax* L.) populations in terms of density, morphology and primary production along the prevailing environmental gradient in Nile Delta, Egypt. For this purpose, a sampling was carried out in homogeneous and monospecific *A. donax* stands in Nile Delta. The samples were collected to represent the cultivated populations (planted habitat) and the naturalized populations in four habitats (canal banks, waste lands, road and railway sides). Each habitat was represented by 3 stands; and in each stand, density, morphology and biomass were recorded using five randomly distributed quadrats (each of 0.5×0.5 m). The results had indicated a significant variation in density, morphological and biomass parameters between naturalized and cultivated populations. Generally, naturalized populations along the railway and road sides (the less moist habitats) had the minimum values for most measured population parameters, while the cultivated populations (the moistest habitat) had the maximum. The dependence of shoot height, number of branches and panicle length on shoot density indicated the density-size effects. Density, morphology and biomass of *A. donax* were correlated significantly with some soil properties such as salinity, pH, organic matter and nitrogen. The regression technique was applied to develop equations for predicting the biomass of *A. donax* shoots from more easily determined shoot height and shoot basal diameter. These methods were time-saving, so the equations might be useful in evaluating management techniques which were used for monitoring *A. donax*.

1. Introduction

Giant reed (*Arundo donax* L.) is a robust erect perennial rhizomatous grass species reaching up to 14 m height under optimal growth conditions and grows in many clumps (Alshaal et al., 2015). It is characterized by rapid growth rate up to 10 cm per day (Perdue, 1958); thus it is the fastest growing herbaceous grass on the earth (Palmer et al., 2014). It has also a high biomass production, a tendency toward community dominance in many habitats and there will be a tolerance to a wide range of environmental conditions (Dudley, 2000). *A. donax* is usually found along river banks, creeks and generally in moist soils, but it grows also successfully on relatively dry and infertile soils such as road sides (Günes and Saygin, 1996; Sharma et al., 1998). *A. donax* was introduced to Egypt in 1761 (c.f. Shaltout, 2014). Nowadays, it is recorded as a naturalized species along canals, road sides, railways and waste lands in the Nile region, oases of the Western Desert, Mediterranean coastal strip, Sinai and all the desert of Egypt (El-Sheikh, 1996; Boulos, 2009). Many studies are carried out on its ecology, biology, primary production, nutrient dynamics, phytoremediation, physiology, invasion, bioenergy, reproduction, modeling, demography and soil condition. However, to the authors' knowledge, so far no studies have been carried out to analyze the variability among its naturalized and cultivated populations in terms of their density, morphology and primary production.

Density, morphometric and biomass analyses are important parameters in evaluating the plant growth and development (Watson, 1990; Eid et al., 2010a,b, 2012; Shaltout et al., 2010). The above analyses are also useful for evaluating population dynamics and rates of spread in response to environmental factors for a clonal species such as *A. donax* (Decruyenaere and Holt, 2005). Environmental factors are of paramount importance to plant establishment and can vary widely even within a specific habitat type (Quinn and Holt, 2008). Some previous studies have focused on the effect of some soil properties such as nitrogen, pH, salinity, organic mat-

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ter and moisture on the structure of *A. donax* stands (Varanini and Pinton, 2001; Coffman, 2007; Palmer et al., 2014).

The present study aims at comparing between naturalized and cultivated giant reed populations in terms of their density, morphology and primary production. It aims at developing regression equations for predicting *A. donax* phytomass and it also aims at evaluating which ones of soil properties which are more effective in its growth. Our hypothesis is: density, morphology and biomass of *A. donax* vary between the cultivated and naturalized populations along the prevailing environmental gradient in Nile Delta, Egypt.

2. Material and methods

2.1. Study area

The study area is part of Nile Delta that is bounded by the two branches of the Nile (Rosetta to the west and Damietta to the east). According to the map of the world distribution of arid regions (UNESCO, 1977), the north part of Nile Delta lies in the arid region, while the southern part lies in the hyper-arid region. The climatic conditions are warm summers (20–30 °C) and mild winters (≥10 °C). The long-term annual mean air temperature of Nile Delta decreased from 20.7 °C at the north to 19.9 °C at its middle. The relative humidity is decreased in the same direction from 69 to 65%. The average daily evaporation is varied between 4.6 mm day^{-1} at the north and 6.8 mm day^{-1} at the middle. This is associated with an inverse gradient of annual precipitation which varied between 175.2 mm year^{-1} at the north and 56.9 mm year^{-1} at the middle (EMA, 1980).

2.2. Plant sampling

Sampling was carried out at 9 sites in Gharbia Governorate during August 2014 and Kafr El-Sheikh Governorate during September 2014 (Fig. 1). Homogeneous and monospecific stands of *A. donax* were chosen to represent the cultivated populations (planted habitat) and the naturalized populations in four ruderal habitats (canal banks, road sides, waste lands, railway sides). Cultivated populations represented the planted population which was cultivated for roofing material, erosion control, windbreak, baskets and fishing canes. Its fertilizer application was 100/40/100 kg ha^{-1} N/P/K, irrigated twice monthly and harvested once a year during autumn. The 4 ruderal habitats were arranged according to their soil moisture availability as follows (El-Sheikh, 1996): canal banks > waste lands > road sides > railway sides. The habitats of road and railway sides provided an exceptional type of disturbed habitat which were subject to greater stress due to treading, soil compaction, mowing or crushing of tall vegetation, herbicide application, local pollution, soil and rock addition related to slumping and rock falls (El-Sheikh, 1996). Each habitat was represented by three stands and in each stand, density, morphology and biomass which were recorded using 5 randomly distributed quadrats (each of 0.5 × 0.5 m). All of *A. donax* shoots within a sampled quadrat were cut off at the ground level and weighted to give the total above-ground fresh weight (kg FW m^{-2}) (data not presented). The number of flowering and non-flowering *A. donax* shoots per m^2 and branches per shoot were counted. Ten shoots randomly chosen and taken from each quadrat (50 individuals per stand and 150 individuals per habitat) to represent the shoot height variations and transferred to the laboratory in polyethylene bags. Shoot height (stem height + panicle length), number of leaves, shoot basal diameter (at the first complete internode above the basal cut surface) and panicle length were measured. Leaf area (single sided) was measured using a leaf area-meter (Dynamax AM 300). After that, *A. donax* shoots were separated into panicles, leaves and stems, and were cut into fragments of 5 cm length and oven-dried at 105 °C for one week until constant weight. The average dry matter of the shoots was calculated (g shoot^{-1}) and multiplied by the number of shoots per m^2 to give the total above-ground biomass (kg DM m^{-2}). Proportional biomass allocation was calculated as the biomass of a specific tissue divided by the total biomass. Flowering ratio was calculated as the number of flowering shoots divided by the total number of shoots (shoot m^{-2}).

2.3. Soil sampling

In each stand, a composite soil sample was collected as a profile from 5 holes, each of 30 cm depth. The soil samples were air dried and passed through a 2 mm sieve to separate gravel and debris before analyses. Soil-water extracts at 1:5 (w/w) were prepared for the determination of pH and salinity. Subsequently, P, Ca, Mg, Na, K, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn contents were extracted

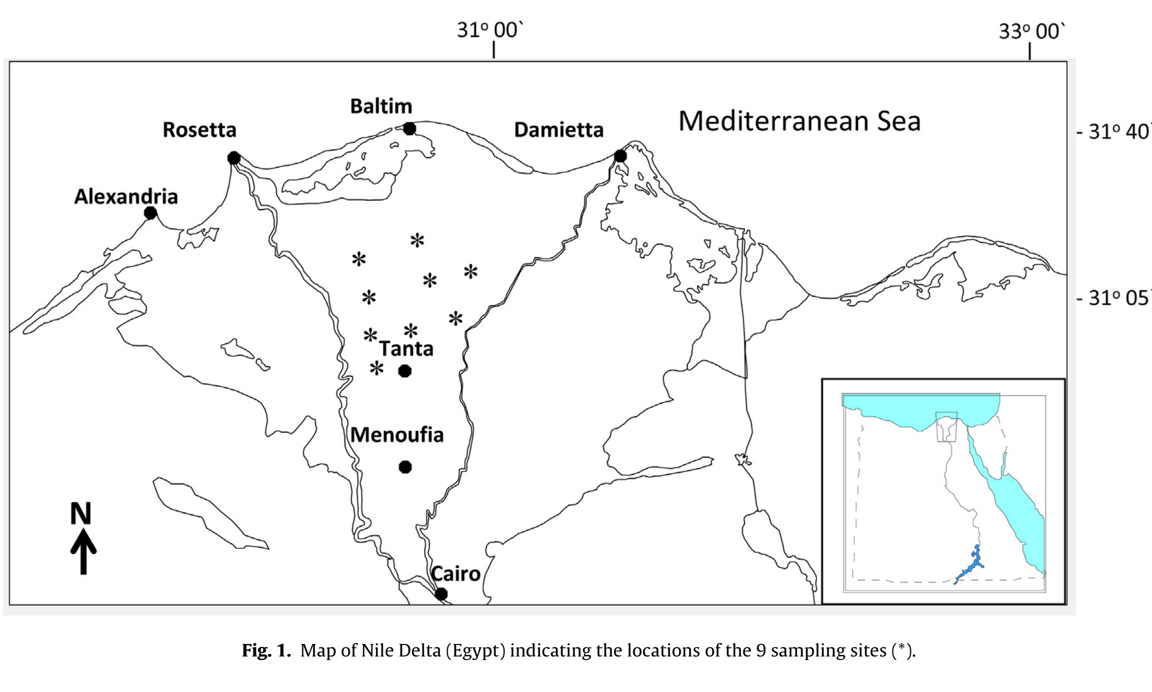

Fig. 1. Map of Nile Delta (Egypt) indicating the locations of the 9 sampling sites (*).