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Biomass yields for upland and lowland switchgrass varieties grown in the Mediterranean region

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ABSTRACT

Switchgrass has been proposed as a perennial plant suitable for biofuel production. Cultivar selection has a major impact on the ultimate productivity, persistence and profitability of the crop. The purpose of this work was to evaluate 16 switchgrass varieties (upland and lowland ones) for 5 years in Greece and Italy. One single winter harvest was carried out every year when the moisture content was less than 20% and biomass yields were determined. At the end of each growing season, the stem height and the number of tillers per square meter were measured. It was found that all varieties performed high yields in both sites except for the varieties 9005439 (upland) and 9005438 (lowland), which produced only 5.6 and 6.9 t ha^{-1}, respectively. All varieties produced their best yields in the third growing season, 17.9 t ha^{-1} in Greece and 12.3 t ha^{-1} in Italy. Significantly higher mean yields were recorded in the Greek trial, apart from the lowland variety SL 93-3 that produced 20.8 t ha^{-1} in Italy and 18.1 t ha^{-1} in Greece. The lowland varieties (Cathage, Kanlow, SL 93-2 and SL 93-3) were found to be more productive compared to the upland varieties, averaged over the sites and the years. The best performing variety on every site (mean 1999–2002) was a lowland variety, Kanlow (17.1 t ha^{-1}) in Greece and SL 93-3 (20 t ha^{-1}) in Italy.

1. Introduction

Switchgrass (*Panicum virgatum* L.) is an erect warm-season (C_4) perennial grass that grows naturally from 55°N latitude to deep into Mexico, mostly as a prairie grass. Over the last two decades, it has become an important warm-season pasture grass for fodder production when cool-season C_3 grasses are less productive in summer [1]. Many reasons are given for using switchgrass as a biomass crop for energy and fibre production, including the high net energy production per ha, low production costs, low nutrient requirements, low ash content, high water use efficiency, large range of geographic adaptation, ease of establishment by seed, adaptation to marginal soils and potential for carbon storage in soil [2–4].

Two ecotypes are generally defined based on morphological characteristics and habitat preferences. Lowland ecotypes are found in floodplains, they are taller, coarser, have a more bunch-type growth habit and may be more rapid growing than upland types [5]. Upland types are found in drier upland sites, they are finer stemmed, broad based and often semi-decumbent. Lowland ecotypes are primarily tetraploid, while

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the upland ecotypes are hexaploid to octaploid, but the exact relationship between ploidy level and ecotypes remains unclear [6,7]. According to [5] upland and lowland types are genetically different. Artificial hybridization between the lowlands and uplands has largely been unsuccessful [8]. It is reported [9] that in southern USA lowland varieties, such as Alamo and Kanlow, generally yield more dry matter than upland varieties. It is suggested that lowland types may be better suited as biomass fuel plants [10].

In Europe, research on switchgrass as a biomass crop for energy and fibre has started in 1998 in the framework of a European network (FAIR5 CT97 3701). Experimental fields of switchgrass were established in five European countries, two in the south Europe (Greece and Italy) and three in the north (Germany, Netherlands and UK). Earlier, some research on switchgrass had been conducted in the UK and Germany [2,11]. It is estimated that in Europe there are some 4 ha of experimental switchgrass fields, the 2.5 ha of them have been established and funded in the frame of the switchgrass productivity network [12].

The main purpose of this work was to test the adaptability and biomass productivity of several upland and lowland switchgrass varieties in the Mediterranean region (Greece and Italy) for a period of 5 years (1998–2002).

2. Methods and materials

2.1. Experimental sites

In view of the European funded project FAIR5 CT97 3701, two similar switchgrass trials (Table 1) were established in the Mediterranean region [one in Greece (Aliartos) and the other in Italy (Trisaia)]. At both sites (Aliartos, Trisaia) the climate could be characterized as dry with 400 mm per year mean precipitation. Due to the high temperatures and the low rainfall that occurred at both experimental sites from the beginning of June until the end of August, every year irrigation was necessary, in order to ensure the successful establishment and the unhindered development of the crop (Table 1). In both sites the soil type was SL with relatively low organic matter (less than 1%).

2.2. Switchgrass varieties and treatments

Sixteen varieties were tested. Ten varieties were established in the Greek trial and 15 in the Italian one (Table 1). In order to be able to statistically compare the two experimental trials, only the nine common varieties were statistically analyzed, namely Caddo, Cathage, CIR, Kanlow, SL 93-2, SL93-3, SL 94-1, SU 94-1 and Summer. Five varieties were upland, while the rest four were lowland (Table 2). Details on the ecotype, ploidy level, origin, maturity type as well as the seed weight (of 100 seeds) are given in Table 2. In both cases, the experimental layout was a randomized complete block design in three replications.

In the case of the Greek trial, switchgrass was sown at the end of May 1998, while in Italy sowing was carried out in July 1998. The seedbeds had been prepared by means of traditional ploughing and secondary cultivators to produce a firm seedbed with a fine textural surface. The plots were seeded at 1 cm depth with 500 pure live seed (PLS) per square meter. The distance between the rows was 15 cm. After seeding, the soil was rolled in order to ensure a good seed–soil contact. Before seeding, seed germination (%) as well as the PLS [Purity (%) × Germination] was calculated and the results are presented in Table 3. The germination capacity (%) was calculated by putting the seeds in incubator at 30 °C. The seed test results were used to estimate the recommended seeding rate for 500 PLS m^{-2} (Table 3).

One week from sowing, the first plants emerged and almost 2 weeks from sowing the rows had no gaps and the establishment rating was excellent. Only for the varieties 9005439 and 9005438 in the Italian trail, some gaps were recorded in the first year. In the following years, gaps were recorded only for the variety 9005439.

At the early stages of the establishment year, the plants were not able to compete successfully with the weeds.

Table 1 – Site and treatments of the switchgrass trials in Greece and Italy

Sites	Site coordinates	Tested varieties	Fertilization	Irrigation
Greece (Aliartos)	Latitude 38°22, longitude 23°10 altitude 114 m	Caddo[a], Cathage, CIR, Forestburg, Kanlow, SL 93-2, SL 93-3, SL 94-1, SU 94-1 and Summer	At the early stages of re-growth 75 kg N ha^{-1} was applied	345 mm (1998) 430 mm (1999) 400 mm (2000) 350 mm (2001)
Italy (Trisaia)	Latitude 40°09, Longitude 16°38 altitude 30 m	Caddo, Cathage, CIR, Kanlow, NU 94-2, Pangburn, SL 93-2, SL 93-3, SL 94-1, SU 94-1, Summer, Sunburst, Trailblazer, 9005439 and 9005438	Before sowing 75 kg P_2O_5, 100 kg K_2O ha^{-1} At the early stages of re-growth 75 kg N ha^{-1} was applied	Each year a total of 2400 m^3 ha^{-1} was applied

[a] The underlined varieties are the common ones between the two field trials in Greece and Italy.