EFFECTS OF MANAGEMENT STRATEGY AND SITE ON SPECIFIC GRAVITY OF A *POPULUS* HYBRID CLONE[1]

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(Received October 1990)

ABSTRACT

Wood specific gravity was analyzed for second rotation four-year-old *Populus* hybrid NE-388 grown under four management strategies on two sites. Significant differences among management strategies at each site and for each management strategy between sites were evident. At both sites, the control and irrigations strategies produced coppice stems with higher average wood specific gravity values than fertilization and fertilization/irrigation stems. Between sites, the Morrison site produced average wood specific gravity values that were consistently higher than the Basher site for each management strategy. The specific gravity values were normally distributed across all sites and management strategies.

Keywords: Site, specific gravity, management, *Populus,* intensive culture.

INTRODUCTION

Considerable debate has taken place on the extent of the influence inheritance and/or environment has on specific gravity values. Some investigators maintain that within a species, genetics has considerable influence on specific gravity (Zobel and Rhodes 1955; Kennedy and Smith 1959; Goggans 1961; Kennedy 1966). Other reports indicate that site or other environmental factors influence specific gravity (Spurr and Hsiung 1954; Larson 1957; Goggans 1961; Paul 1963, 1965; Geyer and Gilmore 1965; Holt and Murphey 1978; Murphey et al. 1979). Growth rate has also been identified as influencing the specific gravity in diffuse porous hardwoods (Kennedy and Smith 1959; Cech et al. 1960; Paul 1965; Smith and Rumma 1971). Tree age is another parameter that influences specific gravity (Kennedy 1966; Koch et al. 1968; Smith and Rumma 1971; Blankenhorn et al. 1985a, b, c). Zhang and Zhong (1991) report that age, more than growth

[1] This project was supported in part by funding from The U.S. Department of Energy Subcontract No. 19X-07928 with Martin Marietta Energy Systems, Inc. Martin Marietta Energy Systems, Inc. operates under contract No. DE-AC05-84OR21400 with the U.S. Department of Energy and McIntire Stennis Project 2817.

Wood and Fiber Science, 24(3), 1992, pp. 274–279

rate, influences the specific gravity values in East-Liaoning oak. Few analyses are available on the effects of site and management strategies on the specific gravity of intensively cultured hardwoods.

The objectives of this research were to determine the effects of management strategy and site on specific gravity and the variation in specific gravity values for a *Populus* hybrid clone. Specific gravity data were collected and analyzed for the range in stem diameters for *Populus* hybrid NE-388 second rotation four-year-old wood grown under four management strategies (control, fertilization, irrigation, fertilization/irrigation) on two sites.

PROCEDURES

Populus hybrid short rotation intensive culture (SRIC) plantations were established under four management strategies (control, fertilization, irrigation, and fertilization/irrigation) on two sites that contained Basher silt loam and Morrison sandy loam soils. Both sites were about 200 m apart. All management strategies included tillage prior to planting dormant unrooted cuttings and weed control in the first growing season. The control strategy had no additional investments. All fertilization strategy treatment units included annual amendments of a balanced N-P-K-Ca-Mg nutrient set to achieve equal nonlimiting availability of macronutrients at both sites. Amount of nutrients added was based on annual soil tests and recommendations for a high corn silage yield. All irrigation strategy treatment units employed a trickle system to maintain a nonlimiting soil moisture condition at each site. Site-specific irrigation was conducted mainly in July and August, depending on soil moisture levels. All fertilization/irrigation strategy treatment units combined the fertilization and irrigation investments.

Each plantation site (1.2 ha) consisted of six replications (0.2 ha each), with three replications planted in spring of 1980 and three replications planted in 1981. Trees were harvested at the end of their second 4-year rotation. Each replication included four treatment units (0.05 ha each for control, fertilization, irrigation, and fertilization/irrigation). Growing space for *Populus* hybrid NE-388 (*P. maximowiczii* × *trichocarpa*) cuttings was 0.48 m^2, with 0.8 meters between rows and 0.6 meters between trees in the rows. In each treatment unit, trees were designated for both continuous inventory and annual destructive sampling over a 4-year period (Blankenhorn et al. 1985c).

TABLE 1. *Summary of second rotation four-year-old* Populus *hybrid NE-388 size and yield characteristics.*[1]

Management strategy	Yield[2] OD tonne/ha	Diameter[3] (cm)	Height[3] (m)
		Basher	
Control	39.59	4.4	7.1
Fertilization	44.96	5.9	8.5
Irrigation	42.35	4.4	7.2
Fertilization/ Irrigation	46.77	5.8	8.5
		Morrison	
Control	37.23	4.2	6.8
Fertilization	45.92	6.0	8.5
Irrigation	36.64	4.2	6.8
Fertilization/ Irrigation	49.37	6.0	8.7

[1] Bowersox, T. B. et al., 1990a, b.
[2] Predicted weight from all trees, year and treatment.
[3] 75 tree data base, size of largest sprout/stump.

At the end of the second four-year rotation, all living stump sprouts for the surviving continuous inventory trees were measured for height and diameter (15 cm above ground). The diameter data were used to identify those second rotation trees that fit into the following categories: (1) twenty trees per replication, management strategy, and site that were near the average diameter (average single stem diameter ±2% averaged over all replications, management strategies, and sites); and (2) approximately forty trees per replication, management strategy, and site that were within the full diameter range (including the smallest and largest single stem tree per replication). A 20- to 30-cm section above a 15-cm stump was harvested from the butt of each stem. The sections were placed in a plastic bag and transported to the laboratory for analysis.

Specific gravity values (ASTM 1980) were obtained by cutting a disk (approximately 7

TABLE 2. *Specific gravity average values for second rotation four-year-old* Populus *hybrid NE-388.*

Management strategy	Specific gravity (oven dry wood weight/green volume basis)[1] Average diameter (±2%) SpGr[2]	Diameter range SpGr (No. of specimens)[3]
	Basher	
Control	0.428 Aa	0.429 (390) Aa
Fertilization	0.386 Ba	0.392 (359) Ba
Irrigation	0.425 Aa	0.431 (400) Aa
Fertilization/ Irrigation	0.386 Ba	0.394 (354) Ba
Basher Average	0.406	0.412 (1503)
	Morrison	
Control	0.443 Ab	0.446 (363) Ab
Fertilization	0.408 Bb	0.415 (341) Bb
Irrigation	0.458 Cb	0.447 (386) Ab
Fertilization/ Irrigation	0.396 Db	0.414 (333) Bb
Morrison Average	0.426	0.431 (1423)

[1] Average specific gravity values are based on oven dry wood weight and green volume (ASTM D-2395-77).

[2] Specific gravity values are for a total of forty single stem trees (twenty trees per planting year) for each management strategy and site that have diameters within two percent of average single stem tree diameter. Differences among management strategies for each site are denoted by upper case letters. Differences between sites for each management strategy are denoted by lower case letters.

[3] Specific gravity values are for single and multiple stems for each management strategy and site that includes trees with the smallest and largest single stem diameters per replication. Approximately forty trees were harvested for each replication, management strategy, site and planting year. Difference among management strategies for each site are denoted by upper case letters. Differences between sites for each management strategy are denoted by lower case letters.

mm thick) from the center of the 20- to 30-cm section. The bark was removed and the green volume was obtained by immersion in water. The disk was then oven-dried to obtain oven-dry weight. Specific gravity was calculated as oven-dry wood weight divided by green volume. Analysis of variance and other statistical tests were used to determine significant differences (0.05 confidence level).

RESULTS AND DISCUSSION

Coppicing stand structure and sprout size values have been reported by Bowersox et al. (1990a) and end of rotation yields have been reported by Bowersox et al. (1990b). End of rotation diameter, height, and total tree oven-dry yields are summarized in Table 1. Fertilization and fertilization/irrigation produced trees with significantly greater diameter, height and yield than control and irrigation strategies at both sites (Table 1). There were no significant differences in growth characteristics between the two sites.

Statistical analyses identified significant differences among mean specific gravity values associated with year of planting in a management strategy on a site, replication in a management strategy on a site for a given planting year, and multiple stems for a given management strategy on a site for a given planting year. However, the range in the average specific gravity values from the lowest to highest mean value was within 0.03. The range was within ±5% of the average value. From a practical viewpoint, the specific gravity values for each management strategy and planting year were combined to form an overall second rotation four-year-old average value for analysis.

TABLE 3. *Regression analysis of wood specific gravity (SG) values for second rotation four-year-old* Populus *hybrid NE-388 versus stem diameter (DIA) and height (HT).*

Planting year	Regression relationship (0.05 significance level)	Coefficient of determination R^2
1980	SG = 0.41139 − 0.00984(DIA)	0.15
	SG = 0.41139 − 0.00905(HT)	0.13
	SG = 0.41139 − 0.01415(DIA) − 0.00450(HT)	0.15
1981	SG = 0.42739 − 0.00860(DIA)	0.09
	SG = 0.42739 − 0.00823(HT)	0.08
	SG = 0.42739 − 0.00811(DIA) − 0.00050(HT)	0.09
Combined 1980 and 1981	SG = 0.42058 − 0.01032(DIA)	0.13
	SG = 0.42058 − 0.01005(HT)	0.12
	SG = 0.42058 − 0.00817(DIA) − 0.00225(HT)	0.13

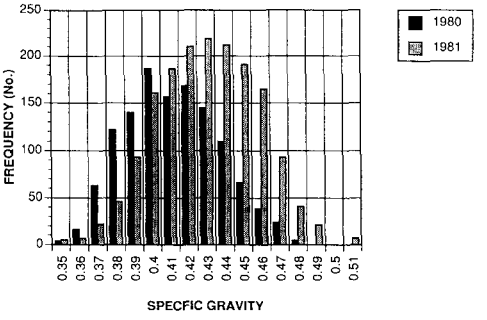

FIG. 1. Frequency versus specific gravity for each planting year of *Populus* hybrid NE-388 grown under four management strategies.

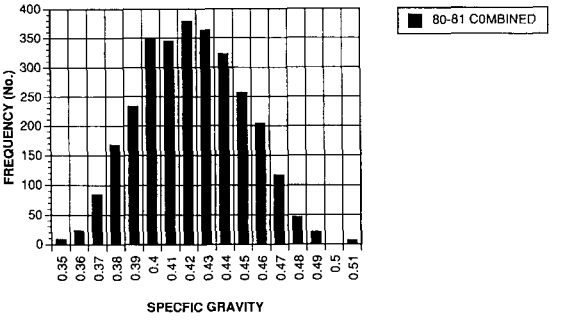

FIG. 2. Frequency versus specific gravity for four management strategies, two sites, and two planting years for *Populus* hybrid NE-388.

The average wood specific gravity values (Table 2) for second rotation average diameter (±2%) four-year-old stems and the values for diameter range stems had significant differences and definite trends. There were significant differences among management strategies at each site (Table 2). Control and irrigation stems had higher average wood specific gravity values than fertilization and fertilization/irrigation stems with similar stem diameters and the complete range in stem diameters. Apparently, moisture was not the limiting factor at both sites and fertilization stimulated growth resulting in lower specific gravity. Average specific gravity values for each management strategy had a full range of 0.042 at the Basher site and 0.062 at the Morrison site. Clearly, management strategy influenced specific gravity values for this clone. These results are similar to previously reported results (Kennedy and Smith 1959; Cech et al. 1960; Paul 1965; Smith and Rumma 1971).

For each management strategy, the Morrison site average wood specific gravity values were higher than the Basher site values for both the average diameter stems and the diameter range stems (Table 2). Spurr and Hsiung (1954) and Zobel and Rhodes (1955) reported that differences in site may have produced variation in specific gravity of conifers, but generally site quality had not been highly correlated with specific gravity. The exact reason for these differences in specific gravity values between sites has not been determined, but these differences must be related, at least in some degree, to site differences. The site characteristics are described in detail in Blankenhorn et al. (1985c).

Since the data set included specific gravity, diameter, and height for each stem, a statistical analysis was performed on specific gravity versus diameter, versus height, and versus height and diameter (Table 3). While the regression relationships were significant between specific gravity and diameter and/or height, the coefficient of determination values were low, indicating that diameter and height had limited influence on the specific gravity.

Specific gravity frequency plots for the 1980 and 1981 plantings (Fig. 1), and the combined data set (Fig. 2) produced normal shaped distributions. The mean specific gravity value for all management strategies and sites planted in 1980 and 1981 was 0.411 (standard deviation of 0.025) and 0.429 (standard deviation of 0.028), respectively. These specific gravity values were similar to previously reported values for short rotation intensively cultured hardwoods (Holt and Murphey 1978; Murphey et al. 1979; Geyer 1981; Blankenhorn et al. 1985a, b, c). The combined 1980 and 1981 data sets produced a mean specific gravity value of 0.422 with a standard deviation of 0.028. Statistical analyses of the data using a univariate procedure indicated that the distributions (Figs. 1, 2) had less than a one in one hundred chance of not being normal. Therefore, this clone has specific gravity values that are normally dis-

tributed across all management strategies and both sites with standard deviation between 6 and 7%.

SUMMARY

Specific gravity values, based on oven-dry wood weight and green volume, were determined for second rotation four-year-old *Popular* hybrid NE-388 grown under four management strategies on two sites. The data were collected to determine management strategy effects on specific gravity and the statistical distribution of the data for a clone.

Significant differences in average wood specific gravity values among management strategies at each site were present. Control and irrigation stems had higher average wood specific gravity values than fertilization and fertilization/irrigation stems within a site. There were significant differences in specific gravity between sites within each management strategy. The Morrison site average wood specific gravity values for a management strategy were consistently higher than the Basher site average values for the same management strategy. Management strategy, or environmental effects, and site influenced the average wood specific gravity values for the *Populus* hybrid clone.

The specific gravity frequency plots produced normal distributions. *Populus* hybrid NE-388 has second rotation four-year-old wood specific gravity values that are normally distributed across all management strategies and both sites with standard deviations at about 6% of the average value.

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