Data Article

Genotypic variations in 107 poplar clones grown on a short-term waterlogging site: Long-term (1992–2015) data on survival rate, growth performance and branching traits

Ye Tian\textsuperscript{a,b}, Yang Liu\textsuperscript{a,c}, Shengzuo Fang\textsuperscript{a,b,*}, Jia Yue\textsuperscript{a}, Xizeng Xu\textsuperscript{a}

\textsuperscript{a}College of Forestry, Nanjing Forestry University, Nanjing 210037, China
\textsuperscript{b}Co-Innovation Center for Sustainable Forestry in Southern China, Nanjing Forestry University, Nanjing 210037, China
\textsuperscript{c}Jiangxi Agricultural University, Nanchang 330045, China

Abstract

The dataset reported data of survival rate, growth performance, branching architecture derived from 107 different poplar clones, including 104 introduced poplar clones (Populus deltoides) and 3 local extended poplar clones, measured within a long-term field experiment in lowland plantations in China. After 24 growing seasons from 1992 to 2015, the survival rate for all the 107 clones, and tree height, diameter at breast-height (1.3 m), and tree volume of each tree were measured and calculated for all the 107 clones, in total of 301 alive trees (one to 9 trees for each clone), in three replicated plots. Subsequently, a total of 17 potential clones were selected by approximately 15% selection intensity, and 17 sample trees (one mean tree for each clone) were harvested for the investigation of the branching number, branching angle and base diameter of first-order branches. For the interpretation of the results of this experiment the readers are referred to Ref. [1]. The data presented in this article will aid selection of superior poplar clones for study and future applications in the similar lowland sites. The data on the survival rate and growth performance of 107 poplar clones can help

Keywords: Eastern cottonwood
Tree height
Tree volume
Branch number
Branching angle
Base diameter of first-order branches
farmers and breeders to designing optimal schemes to increase timber yield and log assortment in poplar plantations. Raw data on tree structure parameters and branching traits can be used to evaluate the different performance of the clones, testing their different spacing and rotation requirement, and also designing innovative plantation schemes.

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Specifications Table

| Subject                                      | Forestry                                      |
|----------------------------------------------|-----------------------------------------------|
| Specific subject area                        | Tree breeding and siliculture                 |
| Type of data                                 | Table                                         |
| How data were acquired                       | Data were acquired from a long-term field experiment at a lowland site where physical measurements as well as calculation for growth rate, survival rate and branching index were conducted. |
| Data format                                  | Raw                                           |
| Parameters for data collection               | Survival rate data: Quantity of live trees for each clone. |
|                                              | Growth performance data: Measurement of total tree height and diameter at breast-height (1.3 m) for each clone. Estimation of tree volume. |
|                                              | Branching trait data: Measurement of branching number, branching angle and base diameter of first-order branches. |
| Description of data collection               | Survival rate data: Quantity of live trees for each clone were counted after the 24-growing seasons in the field. |
|                                              | Growth performance data: Measurements of total tree height (H) and diameter at breast-height (1.3 m; D) for each clone were conducted after the 24-growing seasons in the field. Tree volume (V) was derived from the two-entries allometry: $V=0.0000267 \times (H+3) \times D^2$. |
|                                              | Branching trait data: Branching number, branching angle and base diameter of first-order branches were measured after falling down each sample tree during the 24th growing season, and branch angle was defined as the angle between the main stem and its first-class branch and measured by a digital protractor. |
| Data source location                         | Institution: Nanjing Forestry University      |
|                                              | City/Region: Nanjing, Jiangsu Province         |
|                                              | Latitude and longitude (and GPS coordinates, if possible) for collected samples/data: Hanyuan Forestry Farm, Baoying County, Jiangsu Province; 33°08’N, 119°19’E |
| Data accessibility                           | 1. With the article                           |
| Related research article                     | S. Fang, Y. Liu, J. Yue, Y. Tian, Z. Xu. 2020. Assessments of growth performance, crown structure, stem form and wood property of introduced poplar clones: results from a long-term field experiment at a lowland site. For. Ecol. Manage. DOI: 10.1016/j.foreco.2020.118586 |

Value of the Data

- Poplar is one of the most widely cultivated timber and ecological tree species in the the world due to its characteristics of wide adaptability to different environmental conditions and silvicultural systems, fast growth rate and high timber yield. These data will aid selection of superior poplar clones for study and future applications in the short-term waterlogging sites.
- These data will benefit breeders, scientist, technical promotion personnel and farmers. Especially, the data on the survival rate and growth performance of 107 poplar clones can help farmers and breeders to designing optimal schemes to increase timber yield and log assortment in poplar plantations. Raw data on tree structure parameters and branching traits can be used to evaluate the different performance of the clones, testing their different spacing
and rotation requirement, and also designing innovative plantation schemes such as mixed (species and clone) or polycyclic poplar plantations.

- These data can also be referenced by scientist to ensure the optimum performance on the short-term waterlogging sites for planting poplars (in terms of growth and survival) during experiments thus guaranteeing the success of their research purposes.
- Although limited short-term comparative studies exist with poplars that examine clonal variation in growth performance, these data from a long-term field experiment can help researchers to clarify some contradiction results obtained from the short-term studies at the similar sites.

1. Data Description

The study was conducted at Hangyun Forestry Farm, Baoying County, China. A total of 107 poplar clones were measured and included in the dataset. Raw data on the survival rate, growth performance and branching trait were measured after 24 growing seasons. Table 1 describes the results on survival rate of 107 poplar clones at the lowland site. Table 2 presents the values of diameter at breast height (DBH), tree height and single tree volume of the 107 clones after 24 growing seasons. Table 3 describes the results on branch number per meter of stem and branching angle of first-order branches for sampled 17 poplar clones at different crown positions. Table 4 presents the results on base diameter of first-order branches of the 17 poplar clones at different crown positions.

2. Experimental Design, Materials and Methods

2.1. Study site, plant material and experiment design

The study site (33°08′N, 119°19′E) is located at Hangyun Forestry Farm, Baoying County, Jiangsu Province, P. R. China [2]. The study site belongs to a warm temperate climate. The average annual precipitation is 964.1 mm. The mean annual temperature is 14.3 °C, and the mean temperature in January and in July are 0.4 °C and 27.6 °C, respectively. In this region, the annual effective accumulated temperature of ≥10 °C is 4569.6 °C. The landform is a shallow plain accumulated by ancient lagoons. The soils at this site were formed on fine sediments of Baoying Lake and have a clay-loam texture. The site has a moderate fertility with organic matter content of about 8.4 g/kg, a total nitrogen content of 0.64 g/kg, available P and K contents of 4.3 and 10.9 mg/kg, and a pH value of 7.8, respectively. The mean annual water table is about 0.8 m, with a short waterlogging period during the summer season.

A total of 107 poplar clones were sampled, including 104 introduced Populus deltoides clones from Mississippi (S; 86 clones), Texas (T; 10 clones) and Louisiana (L; 8 clones), US, and 3 local extended poplar clones. The 104 introduced clones were introduced in the form of cuttings in March, 1990 (the clone codes were shown in Table 1). After two-year propagation by cuttings, the introduction trial was set up in 1992 with 1-year-old seedlings over an area of about 8.0 ha (including protection zones), while planting spacing was 6.0 m × 6.0 m. During the establishment of the trial, three local extended poplar clones, including clone I-69 (P. deltoides Bartr. cv. ‘Lux’, introduced from Italy in 1972), Nanlin-95 and Nanlin-895 (bred by Nanjing Forestry University, hybrids of clone I-69 × clone I-45 (P. × euramericana (Dode) Guinier cv. ‘I-45/51’), were included as control CK clones, which are under considerations for veneer timber production and carbon sequestration at lowland sites in China.

The research was carried out by establishing the poplar clone test trial in a randomized block design with a three split-plot scheme. Each replication (block) included 3–8 seedlings for each poplar clone, and all the 107 poplar clones were arranged randomized. In each block, the outermost two rows of poplar trees were considered bordering area. During the first four years
**Table 1**
Survival rate of tested poplar clones after 24 growing seasons at the experimental site.

| Poplar clone | Planting number | Survival number | Survival rate (%) | Poplar clone | Planting number | Survival number | Survival rate (%) |
|--------------|-----------------|-----------------|-------------------|--------------|-----------------|-----------------|-------------------|
| S3225        | 3               | 3               | 100               | S3322        | 8               | 5               | 62.5              |
| S321         | 3               | 3               | 100               | S3239        | 10              | 6               | 60.0              |
| S389         | 3               | 3               | 100               | S3264        | 14              | 8               | 57.1              |
| S3265        | 10              | 9               | 90.0              | S3238        | 9               | 5               | 55.6              |
| L232         | 6               | 5               | 83.3              | S372         | 9               | 5               | 55.6              |
| S3109        | 6               | 5               | 83.3              | S3234        | 9               | 5               | 55.6              |
| S3240        | 11              | 9               | 81.8              | S374         | 9               | 5               | 55.6              |
| S3723        | 10              | 8               | 80.0              | T1           | 9               | 5               | 55.6              |
| S3229        | 10              | 8               | 80.0              | S3124        | 9               | 5               | 55.6              |
| S3907        | 9               | 7               | 77.8              | S3260        | 9               | 5               | 55.6              |
| S3163        | 9               | 7               | 77.8              | S363         | 9               | 5               | 55.6              |
| S391         | 9               | 7               | 77.8              | T8           | 11              | 6               | 54.5              |
| S3702        | 9               | 7               | 77.8              | S3244        | 6               | 3               | 50.0              |
| S3201        | 9               | 7               | 77.8              | S3910        | 6               | 3               | 50.0              |
| S31          | 9               | 7               | 77.8              | S3107        | 6               | 3               | 50.0              |
| S3114        | 9               | 7               | 77.8              | S3301        | 10              | 5               | 50.0              |
| S3032        | 8               | 6               | 75.0              | S312         | 6               | 3               | 50.0              |
| Nanlin-95    | 15              | 11              | 73.3              | S313         | 10              | 5               | 50.0              |
| l-69         | 24              | 17              | 70.8              | S3197        | 4               | 2               | 50.0              |
| S3236        | 9               | 6               | 66.7              | S3213        | 6               | 3               | 50.0              |
| S617         | 3               | 2               | 66.7              | S3412        | 13              | 6               | 46.2              |
| S3919        | 9               | 6               | 66.7              | S329         | 9               | 4               | 44.4              |
| S3624        | 6               | 4               | 66.7              | S3148        | 9               | 4               | 44.4              |
| S301         | 6               | 4               | 66.7              | S3121        | 9               | 4               | 44.4              |
| S371         | 9               | 6               | 66.7              | T15          | 9               | 4               | 44.4              |
| S3016        | 15              | 10              | 66.7              | S3814        | 9               | 4               | 44.4              |
| S3226        | 9               | 6               | 66.7              | T18          | 9               | 4               | 44.4              |
| L19          | 6               | 4               | 66.7              | S366         | 9               | 4               | 44.4              |
| S3127        | 9               | 6               | 66.7              | S3804        | 9               | 4               | 44.4              |
| T2           | 6               | 4               | 66.7              | S3105        | 9               | 4               | 44.4              |
| S3760        | 3               | 2               | 66.7              | S375         | 7               | 3               | 42.9              |
| S3801        | 6               | 4               | 66.7              | S3202        | 12              | 5               | 41.7              |
| S3200        | 9               | 6               | 66.7              | Nanlin-95    | 15              | 6               | 40.0              |
| S3312        | 9               | 6               | 66.7              | T120         | 8               | 3               | 37.5              |
| S3183        | 8               | 5               | 62.5              | S3319        | 9               | 3               | 33.3              |
| S3194        | 9               | 3               | 33.3              | T13          | 9               | 2               | 22.2              |
| S3830        | 9               | 3               | 33.3              | S370         | 9               | 2               | 22.2              |
| S3153        | 6               | 2               | 33.3              | S3552        | 9               | 2               | 22.2              |
| S3259        | 9               | 3               | 33.3              | S3261        | 9               | 2               | 22.2              |
| S392         | 9               | 3               | 33.3              | L28          | 9               | 2               | 22.2              |
| S3631        | 6               | 2               | 33.3              | S367         | 10              | 2               | 20.0              |
| S3921        | 9               | 3               | 33.3              | L237         | 6               | 1               | 16.7              |
| S3120        | 9               | 3               | 33.3              | L241         | 10              | 0               | 0                 |
| T20          | 12              | 4               | 33.3              | L250         | 4               | 0               | 0                 |
| S3101        | 9               | 3               | 33.3              | L337         | 3               | 0               | 0                 |
| L221         | 9               | 3               | 33.3              | S3014        | 9               | 0               | 0                 |
| T4           | 10              | 3               | 30.0              | S3017        | 3               | 0               | 0                 |
| S3531        | 7               | 2               | 28.6              | S3137        | 3               | 0               | 0                 |
| S332         | 11              | 3               | 27.3              | S3221        | 6               | 0               | 0                 |
| S315         | 9               | 2               | 22.2              | S3241        | 1               | 0               | 0                 |
| S3620        | 9               | 2               | 22.2              | S3332        | 6               | 0               | 0                 |
| S3503        | 9               | 2               | 22.2              | S3733        | 8               | 0               | 0                 |
| S3700        | 9               | 2               | 22.2              | T115         | 9               | 0               | 0                 |
| S3415        | 9               | 2               | 22.2              |               |                |                |                   |

After planting, all blocks were interplanted with winter wheat (*Triticum aestivum* L.) and about 50 kg/ha/year urea was applied for fertilizing the wheat. No supplementary nutrients and other management practices were adopted intentionally after the fourth year.
Table 2
Diameter at breast height (DBH), tree height and single tree volume of the sampled trees of the tested poplar clones after 24 growing season.

| Poplar clone | DBH (cm) | Height (m) | Tree volume (m$^3$) |
|--------------|----------|------------|---------------------|
| S3312        | 53.6     | 32.6       | 2.73                |
|              | 51.8     | 36.8       | 2.85                |
|              | 50.1     | 34.8       | 2.53                |
|              | 49.9     | 34.0       | 2.46                |
| S3239        | 48.5     | 32.5       | 2.23                |
|              | 49.5     | 32.8       | 2.34                |
|              | 47.0     | 32.0       | 2.06                |
|              | 50.7     | 33.0       | 2.47                |
| T8           | 50.8     | 30.0       | 2.27                |
|              | 48.9     | 32.2       | 2.25                |
| L28          | 48.3     | 32.2       | 2.19                |
|              | 45.8     | 32.6       | 1.99                |
| Nanlin-895   | 48.0     | 32.0       | 2.15                |
|              | 48.1     | 32.0       | 2.16                |
|              | 45.1     | 31.0       | 1.85                |
|              | 46.3     | 34.5       | 2.15                |
| S3261        | 43.9     | 33.5       | 1.88                |
|              | 47.5     | 34.0       | 2.23                |
| S3101        | 44.4     | 33.3       | 1.91                |
|              | 46.3     | 32.2       | 2.01                |
| S3412        | 43.0     | 33.5       | 1.80                |
|              | 46.6     | 33.5       | 2.12                |
|              | 42.0     | 34.0       | 1.74                |
|              | 45.6     | 34.0       | 2.05                |
| S372         | 43.8     | 35.0       | 1.94                |
|              | 42.7     | 34.5       | 1.83                |
| T20          | 45.7     | 31.5       | 1.92                |
|              | 44.2     | 29.3       | 1.68                |
|              | 46.8     | 31.5       | 2.02                |
|              | 45.3     | 30.5       | 1.84                |
| Nanlin-95    | 44.1     | 33.5       | 1.90                |
|              | 42.2     | 34.0       | 1.76                |
|              | 44.9     | 32.5       | 1.91                |
| S3114        | 44.1     | 31.6       | 1.80                |
|              | 42.3     | 34.0       | 1.77                |
|              | 43.8     | 35.5       | 1.97                |
| S3109        | 44.2     | 35.0       | 1.98                |
|              | 41.5     | 32.0       | 1.61                |
|              | 43.6     | 32.0       | 1.78                |
| S3200        | 44.1     | 30.5       | 1.74                |
|              | 44.6     | 31.2       | 1.82                |
| S3240        | 41.8     | 33.4       | 1.70                |
|              | 42.3     | 34.4       | 1.79                |
|              | 43.7     | 32.4       | 1.81                |
|              | 41.5     | 30.5       | 1.54                |
| S3552        | 46.1     | 28.5       | 1.79                |
|              | 43.2     | 29.0       | 1.60                |
| S370         | 42.1     | 29.0       | 1.51                |
|              | 43.2     | 31.5       | 1.72                |
| S3105        | 42.8     | 29.0       | 1.57                |
|              | 43.1     | 30.0       | 1.64                |
| S389         | 39.2     | 34.0       | 1.52                |
|              | 41.4     | 33.5       | 1.67                |
| T13          | 42.1     | 29.3       | 1.53                |
|              | 43.1     | 29.5       | 1.61                |
| S3804        | 42.5     | 28.0       | 1.50                |
|              | 42.6     | 29.5       | 1.57                |
|              | 41.0     | 31.4       | 1.54                |
|              | 42.0     | 30.0       | 1.55                |

(continued on next page)
| Poplar clone | DBH (cm) | Height (m) | Tree volume (m³) |
|--------------|----------|------------|------------------|
| S3238        | 43.34    | 29.9       | 1.650            |
|              | 40.00    | 30.1       | 1.414            |
| S3213        | 41.60    | 34.5       | 1.733            |
|              | 40.00    | 29.0       | 1.367            |
|              | 42.40    | 28.0       | 1.488            |
| I-69         | 38.20    | 31.0       | 1.325            |
|              | 39.10    | 28.5       | 1.286            |
|              | 39.80    | 32.0       | 1.480            |
|              | 40.50    | 25.5       | 1.248            |
|              | 41.80    | 25.5       | 1.330            |
|              | 42.20    | 32.5       | 1.688            |
|              | 42.90    | 28.0       | 1.523            |
|              | 38.20    | 31.0       | 1.325            |
|              | 44.20    | 33.0       | 1.878            |
| S3265        | 37.50    | 31.5       | 1.295            |
|              | 39.00    | 33.0       | 1.462            |
|              | 39.30    | 34.0       | 1.526            |
|              | 42.00    | 31.5       | 1.625            |
|              | 42.90    | 29.3       | 1.589            |
| S366         | 36.60    | 34.0       | 1.323            |
|              | 38.00    | 34.0       | 1.427            |
|              | 40.70    | 33.5       | 1.614            |
| S3801        | 40.30    | 31.7       | 1.503            |
|              | 39.00    | 30.8       | 1.373            |
|              | 38.60    | 33.0       | 1.432            |
| S3322        | 36.00    | 31.0       | 1.177            |
|              | 40.00    | 30.5       | 1.431            |
|              | 41.60    | 33.2       | 1.675            |
| S375         | 38.20    | 34.5       | 1.461            |
|              | 37.60    | 33.0       | 1.359            |
|              | 36.30    | 33.5       | 1.284            |
| S363         | 39.80    | 29.3       | 1.366            |
|              | 38.20    | 31.5       | 1.344            |
| S3120        | 35.50    | 33.2       | 1.218            |
|              | 37.50    | 35.0       | 1.427            |
| S3760        | 37.34    | 31.4       | 1.281            |
|              | 38.30    | 31.6       | 1.355            |
| S3415        | 35.40    | 32.4       | 1.185            |
|              | 38.13    | 34.0       | 1.436            |
| S31          | 34.10    | 31.0       | 1.056            |
|              | 39.40    | 29.2       | 1.335            |
|              | 39.50    | 33.0       | 1.500            |
| S3197        | 37.67    | 29.6       | 1.235            |
|              | 38.40    | 31.2       | 1.346            |
| S321         | 35.20    | 31.2       | 1.132            |
|              | 39.20    | 32.5       | 1.457            |
|              | 37.40    | 30.1       | 1.237            |
| S3260        | 37.20    | 27.5       | 1.127            |
|              | 38.20    | 29.1       | 1.251            |
|              | 38.20    | 28.2       | 1.216            |
|              | 40.70    | 31.0       | 1.504            |
| S3202        | 36.40    | 30.5       | 1.185            |
|              | 36.60    | 30.1       | 1.185            |
|              | 37.20    | 35.0       | 1.404            |
|              | 37.50    | 31.0       | 1.277            |
| S3229        | 36.70    | 28.0       | 1.115            |
|              | 37.20    | 30.2       | 1.227            |
|              | 40.50    | 29.6       | 1.428            |
| T2           | 37.78    | 27.5       | 1.162            |
|              | 38.70    | 25.5       | 1.140            |
|              | 41.40    | 27.5       | 1.396            |
| Poplar clone | DBH (cm) | Height (m) | Tree volume (m³) |
|-------------|---------|-----------|-----------------|
| S3201       | 37.10   | 31.8      | 1.279           |
|             | 37.50   | 28.8      | 1.194           |
|             | 38.30   | 25.5      | 1.116           |
|             | 39.70   | 28.8      | 1.338           |
|             | 40.20   | 25.0      | 1.208           |
| S3183       | 35.50   | 34.2      | 1.252           |
|             | 36.60   | 30.5      | 1.198           |
| S3124       | 37.60   | 26.5      | 1.114           |
|             | 39.80   | 24.0      | 1.142           |
|             | 41.20   | 28.2      | 1.414           |
| T1          | 37.80   | 33.8      | 1.404           |
|             | 36.00   | 28.1      | 1.077           |
|             | 39.10   | 28.0      | 1.265           |
|             | 38.20   | 27.8      | 1.200           |
|             | 37.00   | 28.0      | 1.133           |
| S3531       | 35.20   | 32.5      | 1.174           |
|             | 37.50   | 30.2      | 1.247           |
| L232        | 34.60   | 31.8      | 1.112           |
|             | 36.30   | 27.0      | 1.055           |
|             | 36.50   | 29.6      | 1.160           |
|             | 39.40   | 33.0      | 1.492           |
| S374        | 37.50   | 27.2      | 1.134           |
|             | 37.00   | 29.0      | 1.170           |
|             | 38.30   | 30.0      | 1.292           |
| S3723       | 35.90   | 26.5      | 1.015           |
|             | 35.80   | 27.5      | 1.044           |
|             | 37.20   | 30.5      | 1.238           |
|             | 37.50   | 30.0      | 1.239           |
|             | 36.30   | 32.4      | 1.245           |
|             | 39.10   | 29.8      | 1.339           |
| S3127       | 35.00   | 29.3      | 1.056           |
|             | 36.00   | 30.0      | 1.142           |
|             | 36.10   | 35.0      | 1.322           |
|             | 37.40   | 28.6      | 1.180           |
|             | 37.50   | 29.5      | 1.220           |
| L19         | 33.40   | 28.5      | 0.938           |
|             | 35.40   | 30.5      | 1.121           |
|             | 40.00   | 31.4      | 1.470           |
| T18         | 36.50   | 27.2      | 1.074           |
|             | 38.30   | 26.5      | 1.155           |
|             | 37.60   | 29.5      | 1.227           |
|             | 36.80   | 31.5      | 1.247           |
| S3702       | 33.20   | 30.0      | 0.971           |
|             | 33.40   | 30.0      | 0.983           |
|             | 36.00   | 30.5      | 1.159           |
|             | 36.10   | 31.5      | 1.200           |
|             | 35.60   | 34.0      | 1.252           |
|             | 36.80   | 35.0      | 1.374           |
| S3814       | 36.80   | 26.5      | 1.067           |
|             | 35.70   | 29.0      | 1.089           |
|             | 41.80   | 25.0      | 1.306           |
| S3226       | 34.00   | 29.1      | 0.991           |
|             | 36.50   | 30.0      | 1.174           |
|             | 36.70   | 31.4      | 1.237           |
|             | 37.70   | 26.5      | 1.119           |
| S3921       | 45.00   | 32.5      | 1.919           |
|             | 44.30   | 30.5      | 1.755           |
|             | 42.90   | 31.3      | 1.685           |
| T120        | 35.13   | 32.5      | 1.170           |
|             | 36.50   | 26.0      | 1.032           |
|             | 37.50   | 27.2      | 1.134           |

(continued on next page)
Table 2 (continued)

| Poplar clone | DBH (cm) | Height (m) | Tree volume (m³) |
|--------------|----------|------------|-----------------|
| S3016        | 31.3     | 33.4       | 0.952           |
|              | 34.5     | 29.0       | 1.017           |
|              | 35       | 29.8       | 1.073           |
|              | 35.4     | 33.0       | 1.205           |
|              | 35.7     | 30.6       | 1.143           |
|              | 36.2     | 31.5       | 1.207           |
| S371         | 33.00    | 29.0       | 0.930           |
|              | 35.90    | 26.5       | 1.015           |
|              | 34.30    | 30.5       | 1.052           |
|              | 37.50    | 33.2       | 1.359           |
| S3264        | 33.30    | 27.5       | 0.903           |
|              | 33.40    | 25.8       | 0.858           |
|              | 36.00    | 31.4       | 1.190           |
|              | 37.30    | 30.6       | 1.248           |
|              | 37.40    | 29.3       | 1.206           |
| S313         | 34.80    | 27.5       | 0.986           |
|              | 35.60    | 30.5       | 1.134           |
|              | 36.50    | 28.4       | 1.117           |
| T15          | 32.60    | 30.2       | 0.942           |
|              | 33.31    | 31.5       | 1.022           |
|              | 35.20    | 31.0       | 1.125           |
|              | 36.00    | 31.5       | 1.194           |
| S3032        | 33.4     | 32.0       | 1.042           |
|              | 34.4     | 25.2       | 0.891           |
|              | 34.5     | 33.0       | 1.144           |
|              | 36.8     | 30.0       | 1.193           |
| S3700        | 35.30    | 28.9       | 1.061           |
|              | 34.00    | 30.8       | 1.043           |
| S391         | 34.70    | 28.2       | 1.003           |
|              | 32.20    | 28.0       | 0.858           |
|              | 33.60    | 28.1       | 0.937           |
|              | 35.30    | 30.1       | 1.101           |
|              | 33.90    | 30.5       | 1.028           |
|              | 36.00    | 32.5       | 1.228           |
| S3234        | 35.20    | 26.8       | 0.986           |
|              | 36.20    | 27.2       | 1.057           |
| S3503        | 32.70    | 30.5       | 0.956           |
|              | 34.50    | 30.5       | 1.065           |
| S3163        | 33.00    | 32.0       | 1.018           |
|              | 33.10    | 30.8       | 0.989           |
| T4           | 34.00    | 26.8       | 0.920           |
|              | 35.20    | 26.5       | 0.976           |
|              | 37.12    | 26.5       | 1.085           |
| S3121        | 34.00    | 29.0       | 0.988           |
|              | 34.50    | 26.2       | 0.928           |
| S3631        | 34.00    | 26.6       | 0.914           |
|              | 35.34    | 27.0       | 1.000           |
| S301         | 32.30    | 29.5       | 0.905           |
|              | 37.60    | 29.5       | 1.227           |
|              | 31.40    | 28.5       | 0.829           |
|              | 32.10    | 27.6       | 0.842           |
| S3624        | 32.70    | 27.0       | 0.857           |
|              | 32.90    | 29.5       | 0.939           |
|              | 32.50    | 30.5       | 0.945           |
|              | 34.40    | 30.0       | 1.043           |
| S3907        | 33.00    | 28.4       | 0.914           |
|              | 31.40    | 28.9       | 0.840           |
|              | 33.60    | 28.5       | 0.950           |
|              | 35.10    | 29.8       | 1.079           |
| S312         | 32.60    | 30.0       | 0.936           |
|              | 35.20    | 25.0       | 0.926           |

(continued on next page)
Table 2 (continued)

| Poplar clone | DBH (cm) | Height (m) | Tree volume (m³) |
|--------------|----------|------------|-----------------|
| S3148        | 31.70    | 27.8       | 0.826           |
|              | 33.70    | 26.5       | 0.895           |
|              | 33.70    | 31.5       | 1.046           |
| S3301        | 32.40    | 26.4       | 0.824           |
|              | 33.10    | 27.8       | 0.901           |
|              | 33.70    | 28.0       | 0.940           |
| S392         | 32.09    | 29.5       | 0.894           |
|              | 32.60    | 27.6       | 0.868           |
|              | 33.30    | 28.5       | 0.933           |
| S3919        | 31.70    | 25.5       | 0.765           |
|              | 31.40    | 28.5       | 0.829           |
|              | 32.50    | 26.5       | 0.832           |
|              | 30.00    | 33.0       | 0.865           |
|              | 33.10    | 29.0       | 0.936           |
| S3620        | 32.40    | 26.7       | 0.832           |
|              | 32.70    | 27.0       | 0.857           |
| S329         | 30.20    | 28.8       | 0.774           |
|              | 30.90    | 29.0       | 0.816           |
|              | 32.60    | 25.0       | 0.795           |
|              | 32.70    | 31.5       | 0.985           |
| S617         | 33.45    | 25.4       | 0.848           |
|              | 32.10    | 26.4       | 0.809           |
| S3259        | 30.00    | 25.5       | 0.685           |
|              | 32.00    | 28.0       | 0.848           |
|              | 33.30    | 28.5       | 0.933           |
| S3153        | 30.20    | 28.5       | 0.767           |
|              | 31.31    | 30.1       | 0.867           |
| S3107        | 29.30    | 28.0       | 0.711           |
|              | 31.60    | 25.5       | 0.760           |
|              | 32.60    | 30.5       | 0.951           |
| S367         | 30.50    | 29.5       | 0.807           |
|              | 30.34    | 28.9       | 0.784           |
| S3830        | 30.90    | 26.3       | 0.748           |
|              | 30.00    | 28.5       | 0.757           |
|              | 32.14    | 26.5       | 0.814           |
| S332         | 33.70    | 26.2       | 0.885           |
|              | 29.60    | 26.4       | 0.688           |
|              | 30.60    | 24.5       | 0.688           |
| S3236        | 29.10    | 27.0       | 0.678           |
|              | 30.20    | 25.5       | 0.694           |
|              | 30.40    | 25.0       | 0.691           |
|              | 31.80    | 27.0       | 0.810           |
| L237         | 28.40    | 30.0       | 0.711           |
| S315         | 29.35    | 25.5       | 0.656           |
|              | 30.90    | 26.8       | 0.760           |
| S3194        | 30.00    | 26.0       | 0.697           |
|              | 30.10    | 26.5       | 0.714           |
| S3319        | 28.60    | 27.5       | 0.666           |
|              | 29.90    | 28.0       | 0.740           |
| S3910        | 28.20    | 26.1       | 0.618           |
|              | 29.36    | 26.0       | 0.667           |
|              | 28.50    | 27.0       | 0.651           |
| S3244        | 29.30    | 24.0       | 0.619           |
|              | 29.10    | 24.5       | 0.622           |
| L221         | 26.80    | 23.0       | 0.499           |
|              | 27.30    | 24.3       | 0.543           |
| S3225        | 23.10    | 25.6       | 0.407           |
|              | 28.50    | 26.5       | 0.640           |
|              | 24.90    | 27.5       | 0.505           |
Table 3
The branch number per meter of stem and branching angle of first-order branches for the 17 poplar clones at different crown positions.

| Poplar clone | Branch number per meter of stem | Branching angle of first-order branches (°) |
|--------------|---------------------------------|------------------------------------------|
|              | low layer | middle layer | up layer | Low layer | Middle Layer | Up layer |
|              | mean  | range    | mean  | range    | mean  | Range    | mean  | range    |
| Nanlin-95    | 0.7    | 0.7      | 1.1    | 33.75    | 15–60 | 46.25    | 25–60 | 54.17    | 25–80    |
| Nanlin-895   | 0.3    | 0.7      | 3.0    | 32.50    | 25–40 | 30.00    | 15–50 | 70.00    | 35–90    |
| I-69         | 0.5    | 1.2      | 1.8    | 33.33    | 30–35 | 33.00    | 20–45 | 47.73    | 30–60    |
| L232         | 1.0    | 1.5      | 3.1    | 55.38    | 40–65 | 54.17    | 35–70 | 52.65    | 15–75    |
| S31          | 1.0    | 1.3      | 3.0    | 28.75    | 15–55 | 40.80    | 24–65 | 50.76    | 25–70    |
| S3109        | 0.5    | 1.5      | 4.5    | 28.75    | 25–30 | 34.42    | 20–50 | 51.58    | 30–90    |
| S313         | 0.3    | 0.8      | 4.0    | 50.00    | 50.00 | 39.33    | 30–58 | 33.75    | 15–45    |
| S3200        | 0.4    | 1.1      | 2.6    | 33.33    | 25–40 | 39.44    | 25–70 | 45.00    | 20–45    |
| S3238        | 0.4    | 1.1      | 3.4    | 40.00    | 15–60 | 36.44    | 20–55 | 54.71    | 20–90    |
| S3239        | 0.8    | 1.6      | 5.8    | 35.83    | 15–50 | 40.23    | 28–55 | 33.87    | 20–50    |
| S3240        | 0.8    | 1.1      | 3.8    | 35.83    | 10–60 | 22.78    | 10–35 | 48.68    | 25–85    |
| S3312        | 1.2    | 1.7      | 2.7    | 44.29    | 25–60 | 35.00    | 30–45 | 47.19    | 30–70    |
| S3412        | 0.4    | 1.4      | 3.0    | 55.00    | 40–70 | 45.00    | 30–75 | 52.75    | 35–94    |
| S366         | 1.1    | 1.5      | 2.6    | 37.22    | 20–60 | 40.42    | 25–70 | 59.38    | 40–90    |
| S371         | 0.7    | 2.8      | 4.7    | 28.75    | 25–35 | 46.00    | 35–62 | 64.35    | 42–90    |
| S372         | 0.6    | 1.8      | 1.7    | 40.00    | 25–60 | 52.83    | 23–83 | 74.30    | 35–95    |
| T8           | 0.7    | 1.5      | 3.2    | 41.43    | 15–70 | 65.00    | 45–80 | 61.54    | 30–90    |
| Average      | 0.7    | 1.4      | 3.2    | 38.48    |        | 41.24    |        | 53.08    |         |
Table 4
The base diameter of first-order branches of the 17 poplar clones at different crown positions.

| Poplar clones | Low layer | Middle layer | Up layer |
|---------------|-----------|--------------|----------|
|               | mean      | range        | mean     | range    | mean     | range    |
| Nanlin-95     | 77.30     | 50.9–132.4   | 56.58    | 27.7–102.1 | 32.92    | 15.5–62.4 |
| Nanlin-895    | 121.99    | 54.0–190.0   | 65.74    | 41.4–118.2 | 11.75    | 7.1–32.2  |
| I-69          | 64.89     | 43.0–85.3    | 87.78    | 32.4–131.3 | 49.56    | 30.0–91.5 |
| L232          | 48.62     | 27.9–140.1   | 57.72    | 20.6–102.9 | 24.99    | 4.4–64.9  |
| S31           | 54.07     | 31.2–133.9   | 52.45    | 16.7–94.7  | 28.62    | 4.0–75.0  |
| S3109         | 123.77    | 48.5–200.0   | 56.47    | 23.0–112.2 | 23.14    | 5.8–54.4  |
| S313          | 75.38     | 20.0–120.9   | 60.15    | 40.9–78.3  | 41.39    | 29.3–51.1 |
| S3200         | 91.11     | 45.3–137.5   | 56.47    | 44.9–136.6 | 23.14    | 18.8–65.2 |
| S3238         | 47.02     | 21.5–83.0    | 57.58    | 22.4–116.9 | 20.03    | 6.4–42.0  |
| S3239         | 57.51     | 47.2–78.3    | 71.09    | 14.2–190.0 | 54.77    | 11.9–155.0|
| S3240         | 51.05     | 32.1–81.8    | 54.50    | 7.8–109.1  | 25.54    | 4.3–91.2  |
| S3312         | 105.77    | 53.6–185.0   | 87.30    | 34.6–122.5 | 32.25    | 15.0–67.0 |
| S3412         | 89.14     | 52.5–114.4   | 81.42    | 32.9–151.9 | 37.14    | 8.0–94.7  |
| S366          | 78.18     | 11.0–146.8   | 35.89    | 8.2–143.5  | 5.49     | 5.9–61.5  |
| S371          | 103.46    | 56.6–180.0   | 51.21    | 32.4–84.8  | 18.10    | 4.2–48.4  |
| S372          | 52.36     | 25.6–93.0    | 43.15    | 20.5–75.8  | 27.85    | 6.1–61.0  |
| T8            | 55.41     | 30.2–79.1    | 55.27    | 29.8–138.9 | 26.64    | 5.8–62.0  |
| **Average**   | **76.30** | **60.63**    | **60.63**| **28.43**  |          |          |

2.2. Data collection and sampling

After 24 growing seasons from 1992 to 2015, tree survival rate, tree height and diameter at breast-height (1.3 m; DBH) were measured for each clone in 2015. The survival rate of each clone was achieved by counting the surviving individual trees in three replicated blocks and dividing by the planting number. Tree height, DBH and tree volume of each tree were measured and calculated for all the 107 clones, in total of 301 alive trees with 1 to 9 average trees for each clone. Tree height was measured by trigonometric method using a Blume-Leiss hypsometer; DBH was measured at breast-height (1.3 m) using a diameter tape; while tree volume was estimated using a taper function with DBH and tree height, which was described in Section 2.4. In terms of approximately 15% selection intensity, a preliminary selection of potential clones was done base on the survival rate, growth performance and tentative observation of stem form. In line with the result of the preliminary selection, a single tree closest to the means of DBH, tree height and crown features of each selected clone and with good form and vigor was selected for destructive sampling and subsequent sectional measurement. In total, 17 sample trees (one tree for each selected clone) were harvested to further investigate the growth, crown structure, stem form and wood property [1].

2.3. Branching index measurement

Sample trees for 17 selected clones were felled close to ground level in late October 2015. Before felling, the north-direction was marked on the stem, and the crown width was estimated by measuring crown radii at the four cardinal directions. After felling, the crown height for each tree was measured and a layered method [3] was used to separate the crown into three layers at equal crown height for each sampled clone. The three layers were assigned as upper, middle and low layer from the top to the base of the crown. The branching number, branching angle and base diameter of first-order branches were measured for each sample tree, while the branch angle was defined as the angle between the main stem and its first-order branch and measured by a digital protractor.
For each layer, the branching number per meter of stem (branch number/m) was calculated according to the numbers of total branches within the layer divided by the corresponding layer height, while branching angle and base diameter of the first-order branches in the layer were averaged within the crown layer.

2.4. Tree volume calculation

Tree volume over bark from ground to tip (V, m³) for each poplar clone was estimated using a taper function with measured tree height and DBH. The calculation was according to the following equation [4]:

\[ V = 0.0000267 \times (H + 3) \times D^2 \]

where H is tree height (m), and D is the DBH (cm).

Ethics Statement

Since this was a tree-experimental investigation, no ethical approval was required.

Declaration of Competing Interest

The authors declare that they have no competing financial interests or personal relationships which have, or could be perceived to have, influenced the work reported in this article.

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