# Using Nelder Wheel for studying some factorial effects on an early growth of poplar (*Populus* spp) clones – preliminary results after one vegetation season

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# Why Nelder's design?

Recommended by Namkoong (1965) in tree improvement research for testing the effects of genotype and growth space.

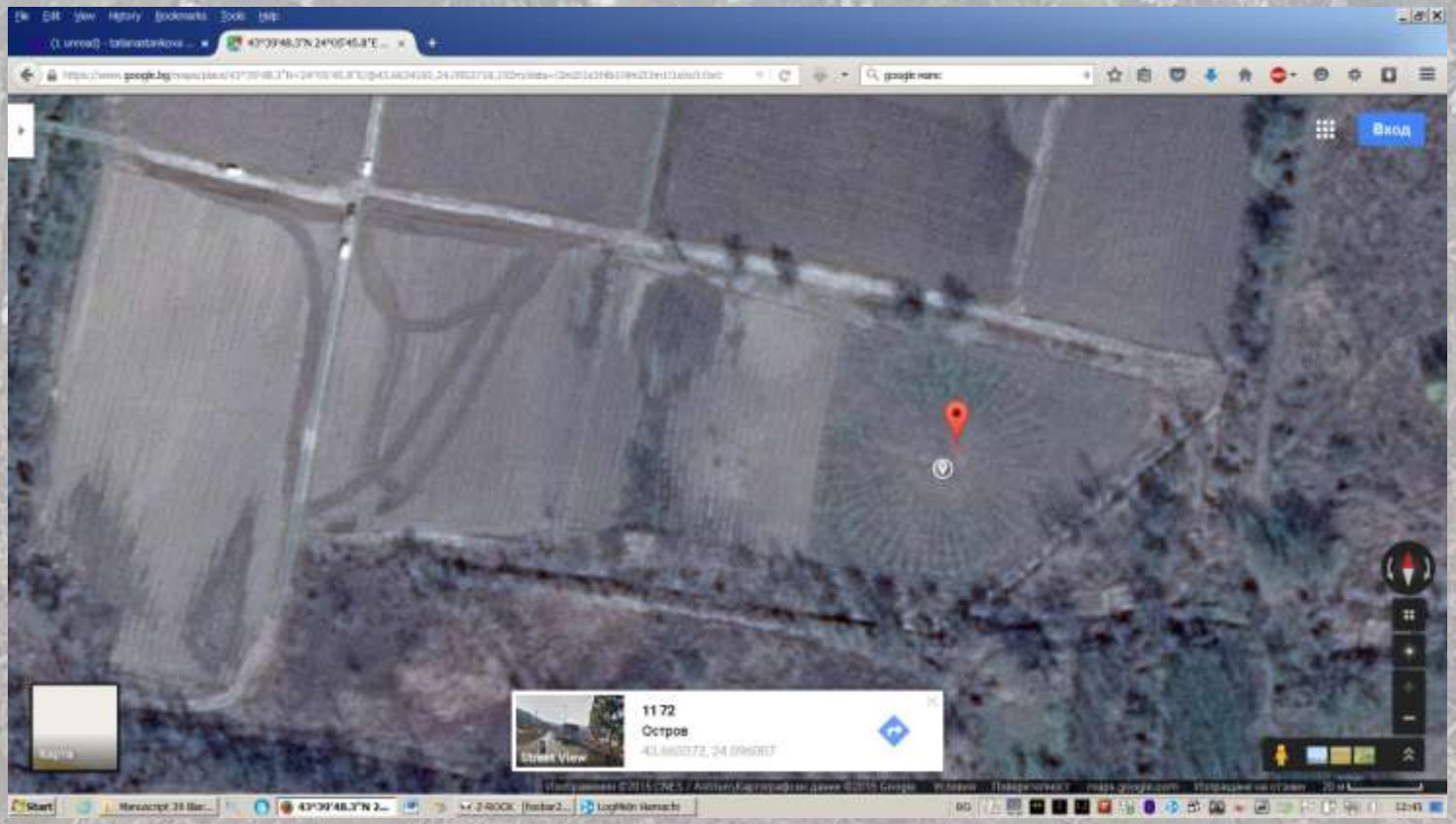
**Advantages:**

✓Makes possible to avoid difficulties of the rectangular plots and to study density response over a wide range;
✓More economic in terms of experimental area.

**Disadvantages:**

✓Not being amenable for easy mechanical planting and cultivation;
✓Sensitive to individual tree losses.

**Locality:** NothWestern Bulgaria close to Danube river, Forest estate "Oryahovo", nursery "Galovo"
**Total area:** ca. 0.5ha



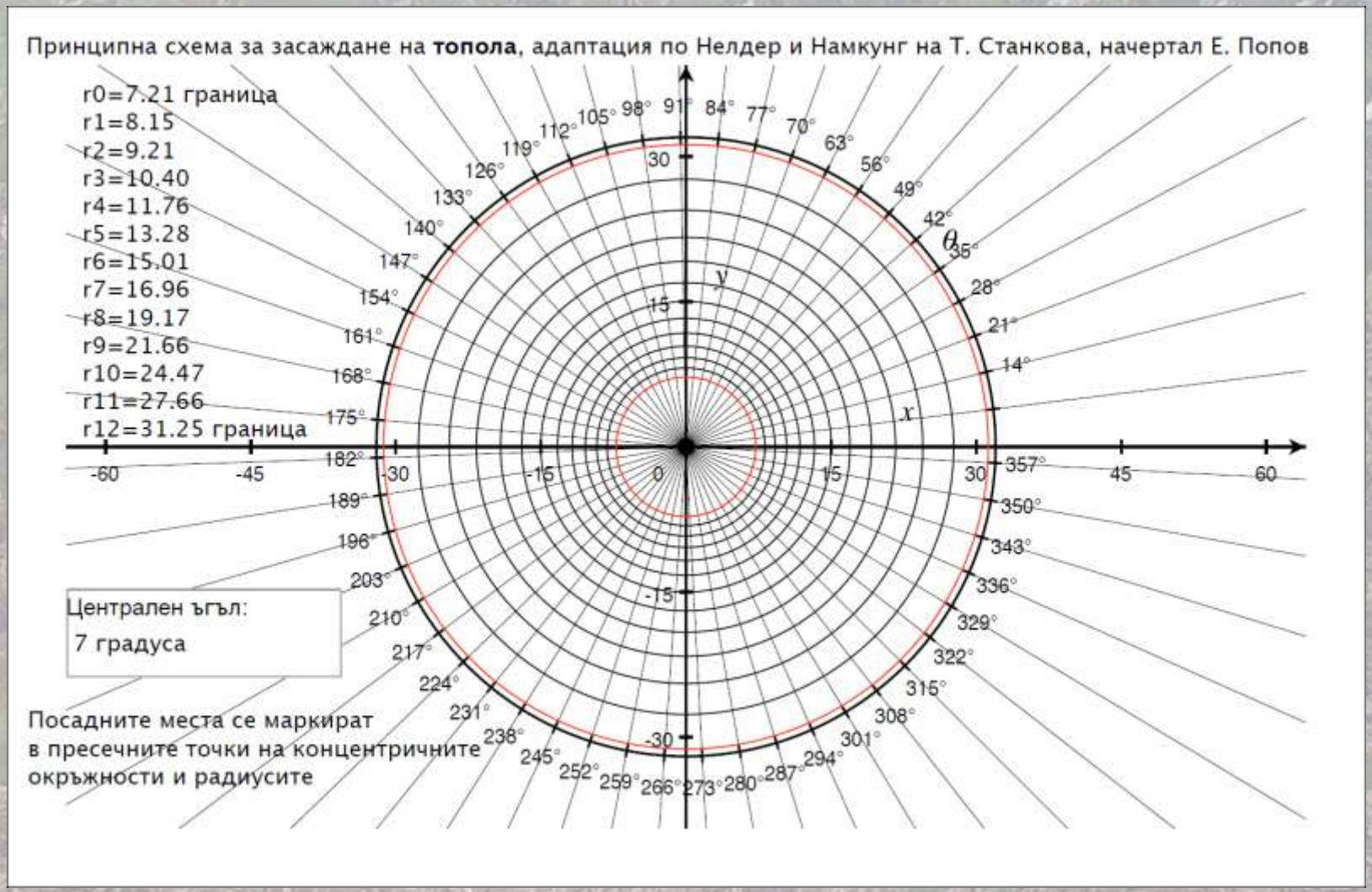

**Coordinates:** 43° 39´48.31˝ N, 24° 05´44.11˝ E

# Design features

✓System of concentric circles with varying radiuses;
✓The tested genotypes (poplar clones) are placed in radial lines situated at a constant angle, like the spoke of a wheel;
✓Provides variable growth space;
✓The growth space for the saplings cultivated in every circle is equal;

Composed that way, the design guarantees growth space variation along the spokes and genotype variation between the adjacent spokes

# Adapted Nelder's design



# Eleven plantation densities

| Radius (m) | Growth space ($m^2$) |
|---|---|
| R0 = 7.21 – border circle | |
| R1 = 8.15 | 1.0 |
| R2 = 9.21 | 1.3 |
| R3 = 10.40 | 1.6 |
| R4 = 11.76 | 2.1 |
| R5 = 13.28 | 2.7 |
| R6 = 15.01 | 3.4 |
| R7 = 16.96 | 4.3 |
| R8 = 19.17 | 5.5 |
| R9 = 21.66 | 7.1 |
| R10 = 24.47 | 9.0 |
| R11 = 27.66 | 11.5 |
| R12 = 31.25 – border circle | |

**Followed factors:** 1) genotype, 2) growth space, 3) rotation period

# Preliminary soil preparation

Trial is established at the spring of 2013

Basic operations:

- ✓Tilling
- ✓Harrowing

Prime Tech PT-400

# Planting of poplar cuttings

**Five poplar clones were planted:**

1. Agathe
2. BL
3. I-45/51
4. NNDV
5. Panonia


**Poplar plantations** – 21 549ha

**Area planted with poplar clones (as of 2012)**

1. Agathe (116.7ha)
2. BL (66ha)
3. I-45/51 (32ha)
4. NNDV (11.4ha)
5. Panonia (-)

# Trial management

The management of the experimental plantation is carrying out by the Forest estate "Oryhovo" as an subcontractor.

**Basic cultivation operations:**

- ✓Watering
- ✓Soil trenching
- ✓Plant protection treatments (weed & pest control)

- ✓ **Soil feeding:** 18 kg/dka ammonium nitrate (once per year);
- ✓ **Pest treatment:** 40g/dka Mospilan

# Biometric measurements

- ✓Height measurements (cm);
- ✓Diameter measurements (at the basis of the saplings & at breast height (mm);
- ✓Cutting of 10 spokes (#11 to #20).

- ✓ Rather high variability of survival: 0-69%
- ✓ Injuries from the poplar clearwing moth (*Paranthrene tabaniformis* Rott.) – 14.6%
- ✓ Big amount of non-standard saplings

# Weight sampling

- ✓ Assembled stem samples were taken from every healthy sapling and weighted on site (100 до 250g, portable balance Tremol ACS 15, accuracy 5g).
- ✓ The samples were transported in paper bags to the lab and dried out to absolute dry weight at constant temperature of 105 °C.

# Inventory data (November 2013)

| Clone | Survival of standard saplings (%) | Non-standard (<1.5м) saplings (%) | Replaced saplings in total (non-standard & non-survived) (%) |
|---|---|---|---|
| Agathe | 40.7 | 22.3 | 59.3 |
| BL | 67.8 | 20.6 | 32.2 |
| I-45/51 | 24.4 | 42.9 | 75.6 |
| NNDV | 57.0 | 7.7 | 43.0 |
| Panonia | 57.3 | 15.3 | 42.7 |

# Biometric data (November 2013)

| Clone | Number of saplings | $d_0$ | | | | $d_{1.3}$ | | | | H | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | min | max | Av. v | SE | min | max | Av. v | SE | min | max | Av. v | SE |
| Agathe | 53 | 1.28 | 3.42 | 1.82 | 0.44 | 0.36 | 1.90 | 0.76 | 0.30 | 1.55 | 2.97 | 1.96 | 0.30 |
| BL | 88 | 1.11 | 3.22 | 1.96 | 0.49 | 0.28 | 2.07 | 0.83 | 0.36 | 1.54 | 3.05 | 2.04 | 0.35 |
| I-45/51 | 33 | 1.60 | 2.99 | 2.08 | 0.36 | 0.40 | 1.85 | 0.98 | 0.38 | 1.51 | 2.74 | 1.85 | 0.29 |
| NNDV | 74 | 0.95 | 3.08 | 1.90 | 0.50 | 0.27 | 2.12 | 0.96 | 0.39 | 1.54 | 3.54 | 2.34 | 0.43 |
| Panonia | 82 | 1.06 | 3.22 | 1.92 | 0.51 | 0.22 | 1.82 | 0.84 | 0.38 | 1.41 | 3.22 | 2.07 | 0.38 |

# Over-ground biomass and volume (November, 2013 )

| Clone | Number of saplings | Dry mass, stem (kg) | | | | Stem volume ($m^3$) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | min | max | Av. v | SD | min | max | Av. v | SD |
| Agathe | 20 | 0.032 | 0.349 | 0.095 | 0.075 | 0.00024 | 0.00364 | 0.00087 | 0.00081 |
| BL | 19 | 0.005 | 0.238 | 0.079 | 0.066 | 0.00005 | 0.00221 | 0.00076 | 0.00066 |
| I-45/51 | 18 | 0.015 | 0.263 | 0.078 | 0.072 | 0.00010 | 0.00221 | 0.00063 | 0.00064 |
| NNDV | 22 | 0.011 | 0.410 | 0.143 | 0.099 | 0.00007 | 0.00351 | 0.00115 | 0.00090 |
| Panonia | 22 | 0.016 | 0.327 | 0.114 | 0.075 | 0.00011 | 0.00337 | 0.00103 | 0.00081 |

# Physiological study

**The aim:**

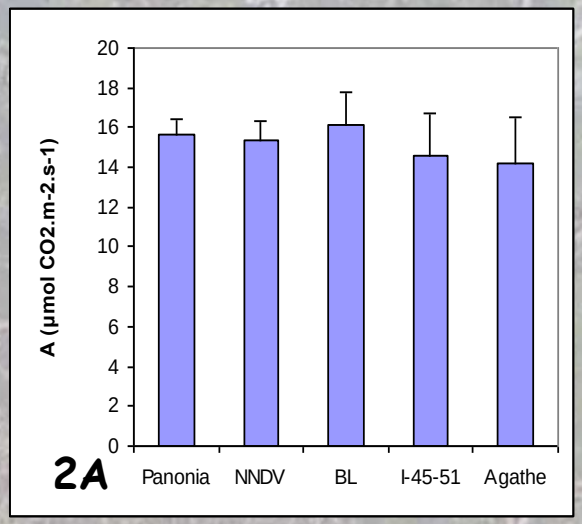
- ✓ The study was aimed at following dynamics of some basic physiological responses during the early growth of poplar clones.

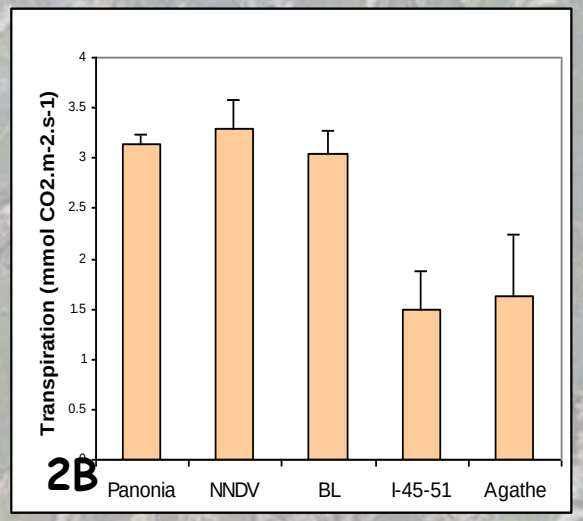
**Measurements:**

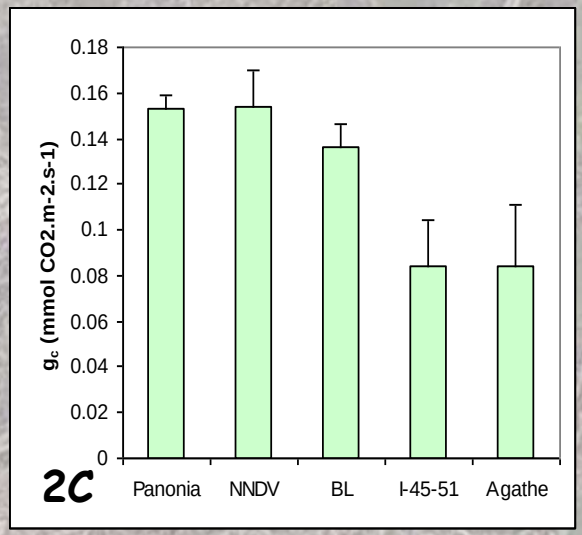
- ✓ The $CO_2$ gas-exchange was measured with a portable infrared gas analyzer Li 6400 (LiCor Inc., Lincoln, NE, USA);
- ✓ The measurements (net $CO_2$ assimilation, transpiration and stomatal conductance) were performed between 10.00 and 13.00h, with only green and healthy leaves being selected for that purpose;
- ✓ All the measurements were done after the values of the variation coefficient reached values less than <0.5%.

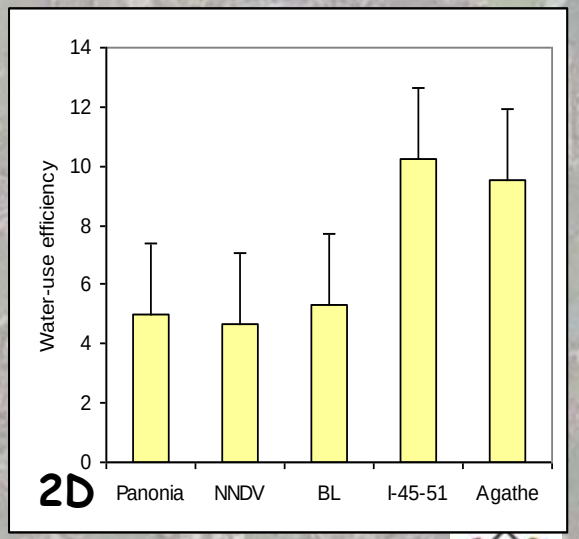
# Physiological measurements

- ✓No significant differences in the net $CO_2$ assimilation patterns were found among the different poplar clones within the experiment based on Nelder's design (Fig. 2A).
- ✓The clones I-45/51 and Agathe demonstrated both significantly ($P<0.001$) lower transpiration and stomatal conductance, being at the same time the best water-use efficiency performers (Fig. 2 B, C, D).



# Provisional conclusions:

- ✓Clone I-45/51 demonstrated fastest growth in diameter, but NNDV clone was best performer regarding the height and diameter at breast height;
- ✓Clone NNDV shows highest productivity as compared to all of the tested clones;
- ✓The established trial has strong potential for enriching the knowledge about the efficiency of different rotation regimes as et the end of the last vegetation season there will be data for three variants of rotation: three year old roots in combination with one, two and three year old sprouts.

**The project team:**

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2. Dr. Tatiana Stankova - FRI
3. Dr. Emil Popov - FRI
4. Dr. Vesela Giyleva-Pantova - FRI
5. Dr. Proletka Dimitrova – FRI
6. Prof. Nikolina Tzvetkova - UF
7. eng. Emilia Todorova – FE "Oryahovo"

**Thanks for your attention!**