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# Effects of initial spacing on the stand structure and yield of young black locust (*Robinia pseudoacacia* L.) stands

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***Summary:*** The choice of the right initial spacing of stands is one of the most decisive operations of a successful afforestation. It is even more important in the case of fast growing tree species grown in plantations; it is expressed in their early phase of development and in wood quality. The results of a 5-year long experiment with four treatments will be presented in this paper. They proved the priority of an initial spacing of 1.61.0 m in the majority of quality parameters. This treatment has been proved optimal exploitation of growing space by the young trees.

***Key words:*** Black locust (*Robinia pseudoacacia* L.), planting density, stand structure, yield

## Introduction

The choice of planting spacing is a decisive element of the afforestation technology in Hungary (*Szodfridt,*1967, *Veperdi,* 1988, *Halupa, Gabnai,* 1990, *Veperdi, Veperdi,*1998 *Rédei,* 2001, *Rédei, Führer,* 2002). Regarding the effect of spacing in planted young stands on wood production exact documents were lacking until purposeful experiments had not been established to gain reliable proofs for the planning of an optimal system. Some of the experts argue that the traditionally accepted density of 2.40.7 to 0.8 m for black locust should be enhanced, whereas others prefer a lower density applied in hybrid poplar plantations.

We ought to draw the following main conclusions from experiments performed with diverse tree species.

*In plantations of higher densiy:*

- generally, gross wood production is higher, initially;
- the branching of the trees is more favourable, the cleaning up of the stem starts and the canopy closes earlier;
- weed-control is easier;
- natural selection has more chances; however
- the average stem diameter is less, and the development of a critical size is delayed;
- later the silvicultural operations become more expensive, and the lower diameter of the stems may reduce the revenue;
- certain mechanical operations (e.g. tillage) are more difficult to be mechanised.

*In plantations of lower densiy:*

- generally, the initial gross wood production is lower;
- the stems are branching more intensely, and canopy-closure ensues later;
- weeds become more aggressive; however
- stem diameters increase more intensely, the felling cycle is shortened;
- silvicultural operations are less expensive and the wood has better market ability;
- operations are easier mechanised.

In the following, results of one experiment are presented. It is one of the experiments of limited number, which are designed to answer the question of optimum planting density for black locust. *However, those results need to be corroborated by further similar experiments on various growing sites.*

## Materials and methods

The experiment was established at the begining of autumn in 2000 at Nyírerdő State Forest Company (Nyíregyháza), at the Forestry of Hajdúhadház, in the 16 Q forest subcompartment. The growing site is represented a type of forest-steppe climate; sandy soil with medium rootably depth and free draining.

Four spacing treatments were planned with three replications:

Treatment 1: 2.50.7 m = stem number planned: 5 700 trees/ha,

Treatment 2: 2.50.5 m = stem number planned: 8 000 trees /ha,

Treatment 3: 1.61.0 m = stem number planned: 6 250 trees /ha,

Treatment 4: 1.60.4 m = stem number planned: 15 630 trees /ha.

Treatment 1 is the most frequently used spacing, whereas the 2. was the highest density being ever applied in the

practice. Treatment 3 is closely similar to treatment 1 except the space being more favourably exploited for an individual tree. Treatment 4 was an attempt to exaggerate the adverse effects of excessively high planting densities.

The measurements started after five years in October 2005 measuring two plots per each replication. Within the plot, the stem diameter at breast height and the height of tree has been registered on each 5th plant. The living stock ($V_{eg}$) has been determined by means of the program developed by the Forest Research Institute (ERTI) for expressing the wood volume; the mean tree volume (v) is computed according to the relation:

$v = V_{eg} / N_{eg}$, where $N_{eg}$ = stem number per hectare.

The growing space (number of stems per hectare) is dependent on other stand structure factors therefore its modelling is approached by different ways. In our present analysis, the most used growing space index (NI) has been applied:

$$NI = \frac{\sqrt{10000 / N}}{H}$$

where N = stem number per hectare; H = the mean height of trees of the stand (m).

The NI values obtained in the experiment have been the following:

treatment 1: 0.29,
treatment 2: 0.21,
treatment 3: 0.30,
treatment 4: 0.15.

For example for the application of the NI parameter, we take the height H=8 m, NI=0.25 as the first opportunity to reduce the number of stems. The stem number of the main part of the stand (after carrying out the tending operation) will be: $N = 10\,000/(8 \times 0.25)2 \approx 2500$ trees/ha.

We did not compute measures of central tendency (mean, median etc.) and dispersion (variance, standard deviation etc.) of the different stand structure factors because the calculated values still would not be suitable for evaluating the later-expected correlations existing between themselves.

Taken a scale of 1 to 4 (1 being the best, 4 the weakest), which should represent the quality and value of the stands (stand quality-index). The means of data obtained are presented in *Table1.*

## Results

The evaluation of results allows the following statements:

The stem number in the 5 year old stands showed remarkable deviations from the

originally planned stem number which is expressed in per cent, and it was most approached (77%) in the treatment of 1.61.0 m, whereas in the other treatments they were more or less equalised (64–69%).

***Table 1.*** Means of stand structure and yield factors in the experiment of 5 year old black locust stands planted at different spacing. (Hajdúhadház 16 Q forest subcompartment)

| | | Designation of treatments | | | |
|---|---|---|---|---|---|
| | | 1. | 2. | 3. | 4. |
| | | Planned spacing (m) | | | |
| | | 2.50.7 | 2.50.5 | 1.61.0 | 1.60.4 |
| Factors | | | | | |
| Stem number per hectare | | | | | |
| – planned (rounded up) ($N_1$) | trees | 5 700 | 8 000 | 6 250 | 15 650 |
| – counted at the 5th year ($N_2$) | | 3 640 | 5 550 | 4 820 | 10 800 |
| Ratio of $N_2/N_1$ | % | 64 | 69 | 77 | 69 |
| Height (H) | m | 5.7 | 6.3 | 6.4 | 6.4 |
| Diameter at breast height ($D_{1,3}$) | cm | 4.2 | 4.0 | 4.1 | 3.5 |
| Living stock ($V_{eg}$) | m3/ha | 30.1 | 37.2 | 38.3 | 49.5 |
| Dead wood ($V_{sz}$) | m3/ha | 0.6 | 0.9 | 0.5 | 1.6 |
| Periodic total volume ($V_ö$) | m3/ha | 30.7 | 38.1 | 38.8 | 51.1 |
| Mean tree volume (v) | dm3/tree | 8.3 | 6.7 | 7.9 | 4.6 |
| Ratio of $V_{mell}/V_{eg}$ | % | 24 | 33 | 30 | 42 |
| Growing space-index (NI): | | | | | |
| – before cleaning | | 0.29 | 0.21 | 0.23 | 0.15 |
| – after cleaning | | 0.35 | 0.29 | 0.30 | 0.25 |
| Stand quality-index | | 2.1 | 2.2 | 1.9 | 2.4 |

At an age of 5 years, the variation of increment caused by the treatments was not considerable regarding the diameter at breast height and tree height. The effect of natural selection due to high plant densities was of moderate practical importance as expressed in the mentioned properties.

The living stock (referred to the whole stand) varied together with the planting densities, which means that the higher densities meant initially higher living stocks. The dead wood followed the tendency of wood volumes. As expected, the tendency was reversed if the densities are plotted against the mean volumes of individual trees, the latter being lower in dense plantings (*Figure 1*).

In our experiment, the mean tree volume was bigger in the treatment 2.5×0.7 m and 1.6×1.0 m in the 5th year by 180% and 172% compared with the treatment 1.6×0.4 m (100%). This fact confirms the common technological principle that the density should not trespass ±6 000 tree per hectare in black locust plantations.

The marked secondary stand consisting of trees which are to be removed ($V_{mell}$) was related to the whole stand. Its ratio varied between 24 and 42%. Lower values were found in the treatments of lower planting densities.

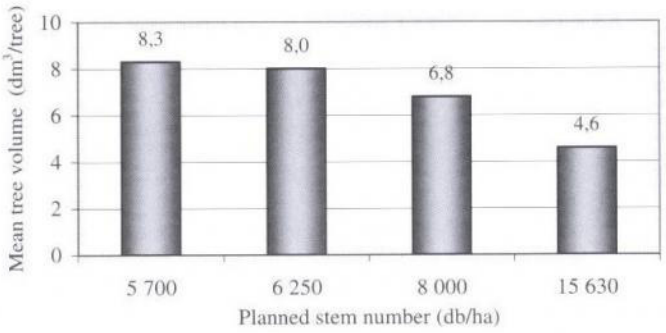


*Figure 1* Variation of the mean tree volume as a function of planned stem number

The growing space-index (NI) values – calculated according to the formula indicated – varied between 0.15 and 0.29 in the whole stand, whereas in the main part of the stand (after the first cleaning) between 0.25 and 0.35. Optimum value should be around 0.30.

The stand quality-index varied between 1.9 and 2.4, and declined with the increasing planting density, as a rule.

## Conclusions

As a summarised evaluation it could be stated that the best results were obtained – regarding the rate of tree survival, consequently the drying out rate, moreover the height, the diameter at breast height and the quality indices of the stands – *in the treatment of 1.6×1.0 m planting density.*

This density provided a better exploitation of the growing space relatively to the treatment 2.4×0.7 m, whereas the stem quality was better (cleaning up of branches) due to the narrow row distance. All technological conditions of introducing this optimum treatment at Nyírerdő State Forest Company are given.

Regular experiments for the purpose of finding the right planting density for the main stand forming tree species grown for wood production are of prime practical importance. Information of that type is indispensable to improve the growing technologies.

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