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Production of *Pinus mugo* seedlings and reconstruction of 4070* habitat in Oslea Mountain

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Abstract *Pinus mugo* habitat was severely reduced due to human activities, but its natural regeneration (especially under the grazing pressure and extreme climate) is very difficult. Therefore, 4070* habitat was declared of community interest. At European level large efforts to attract people in habitat protection and reconstruction are demanded. Producing creepy pine seedlings is rather difficult due to its low growth rate, their necessary aclimatization period in high mountains and the very difficult planting conditions. As a concequence the aim of this work was to test more simple culture technological variants to produce seedlings.
The results have demonstrated the followings: i) planting 3 years seedlings (1 yr in cold frames and poly tents + 2 yr in a open air mountain nursery) had similar survival rate to (but lower increment) with the other tested variants (2+2 yr, 1+3 yr, 2+3 yr) in a normal climate conditions (without extreme events); ii) the seedlings kept more under the poly tents (2+1 yr *vs* 1+2 yr) had higher (but unsignificant) increment; iii) the growth rate of creepy pine seedlings in clasical nurseries is much more lower comparing to the modern ones; iv) planting the 4 yr seedlings direct from low hilly altitude in subalpine zone without an acclimatization period proved to be very risky; v) wild boars cauzed significant indirect losses in high altitude plantations.
Reconstruction of the 4070* habitat by planting the seedlings of *Pinus mugo* requires a long period to produce seedlings in traditional way (3-5 yr) and even more years to manage the young plantation to became stable in subalpine zone.

Key words

Pinus mugo, nursery culture, habitat, Carpathian Mts., Romania

The area of *Pinus mugo* habitat from Mt. Oslea (Vâlcanului Mountains, vestern part of Southern Carpathians) was continuously diminished (to favor grazing) till cca 44 ha (0.05% of protected site RO SCI 0129 NW Gorj). In these conditions, soil erosion of alpine and subalpine zones is very active and the vegetation is rather poor (Dirnböck et al. 2008). Isolated bushes of *Pinus mugo*, insularly spread all over the high mountain zone confirm the former natural range a 4070* habitat (Muică, 1995; Doniță et al. 2005). The same phenomenon was happened at the national (Coldea 1980; Pop et al., 2008; Danci & Cristea, 2009) and European scales (Blarquez et al., 2010; Šibík et al., 2010; Pisanelli et al., 2012; Zumbrunnen et al., 2012; Solár & Janiga, 2013), which has made EU to decide to protect this habitat (Directive 92/43/EEC).
The harsh subalpine climate, the limited capacity of creepy pine to recover its natural habitat under still active grazing pressure, and the lack of economic interest for this plant (Hodor, 2008) are the arguments that led to the idea of restoring a nucleus of detroyed habitat in a LIFE+ project.

Material and Method

The cons was harvested (September, 26-28th, 2012) from the scarce creepy pine population spread in the zone which was subject of reconstruction in Mt. Oslea. Cone drying process was done in natural conditions (shadow, open air). The seeds have been preserved in the Seed Conservation Center of SCDEP Brașov (ICAS/INCDS).
Due to the administrative problems (solving the purchase contesting), the construction of the cold frame and poly tents has started just in June 2013, in the backyard of the Brâncuși Forest District (willage of Peștișani – Gorj County, altitude: 250 m). Seed bed was a mixture of forest humus (spruce 40%, beech 30%) and sand (30%), which was treated with formaldehyde (1%).

Seeding was done in July, 9-10th, 2013. Seeds were put at 1 cm deep in the bed, covered with a thin layer of spruce needles and humus.
Maintenance works consisted in tratament against dumping-of (alternative with copper-sulphate, metyl-tiophanate, folpet and clorotalonil), watering, weeding, mole control, and bed mulching with dead leaves during the winter. Considering the very late seeding, supplimentary measures against freeze have been taken: the tent walls were doubled with a plyethylene layer (with thermal and antipicking effect), and the seedlings were covered in the first year with a microporous film. On the final of this stage, the seedlings were transplanted in food polyethylene bags of 15x25 cm.
Growing variants in the tents were the followings:
- T1: seedlings kept 1 vegetation season in tents (2014P⇨);
- T2: seedlings kept 2 vegetation season in tents (2015P⇨);
- T3: seedlings kept 4 vegetation season in tents (2016T⇨).

In order to adapt to a cold climate, seedlings were moved in the Geamănu mountain nursery (960 m altitude), situated in Brâncuși Forest District (UP II Bistrița, parcel 52). Maintenance works included the nursery fencing, soil preparation (vegetation removal, land leveling, gravel removal, plouging), additional humus harvesting, seedling transport from Pestișani, seedling layering, and periodical weed control, watering, and culture treatment against the pests. Geamănu is a traditional nursery with no modern facilities.
Growing variants in the mountain nursery were the following:
- N1: seedlings transplanted in April 2014, from wich N1a: kept 2 seasons before planting in Mt. Oslea (2015T⇨); N1b: kept 4 seasons (2016⇨);
- N2: seedlings transplanted in spring of 2015, from wich N2a: kept 2 years (2016⇨), N2b: kept 3 years (2017T⇨), N2c: kept as reserve for eventually necesary plantation (filling the gaps) in 2018 and postlife.

Plantation was made on 10.35 ha, in Mt. Oslea, at 1899-1946 m altitudine (according to regulations of MAAPM 2000a). Specific works were as follows: land fencing, construction of a temporary shelter, land preparation, transport of materials (compost of resinous sawdust, wood sticks), seedling transport from tents and nursery, picketing, planting, periodical maintenance / revision of plantation (removal of stones and weeds, soil mobilization and restoration of ravaged nests, mowing the seedling base), annual inventory of the seedlings (according to the national regulation - MAAPM 2000b), filling the gaps (dead seedlings), fixing the fence and shelter damages, etc. The following variants were tested:
- P1: seedlings planted in the autumn of 2015;
- P2: seedlings planted to fill the gaps (autumn of 2016 and 2017).
- P3: filling the gaps with seedlings transplanted directly from Peștișani tents to subalpine plantation, without aclimatization (autumn of 2016).

Seedling measurement (height, base diemeter, number of dead plants) were made before the transplantation or during the annual inventories (MAAPM 2000b), in all the cultures (tent, nursery, plantation).

Results

Seedling production

To obtain *Pinus mugo* seedlings suitable for planting, the traditional culture it was used a 2+4(5) years culture system (Rubțov, 1971; Zeriu et al. 1978; Pânzaru, 1983; Blada, 2007; Blada 2010), relative more recently it was recomanded a culture of minimum 4 years: 2 yr in tents / nursery (direct seeding) followed by 2 years in nursery (transplanted in pots in a high altitude nursery) (Herța et al. 1995). A core 4070* habitat reconstruction in subalpine part of Mt. Oslea by plantation of 10 ha involves the production of creepy pine seedlings (in tend and nursery - in minimum 4 years) and maintenance works of plantation (minimum 3 years), but the project duration was only 5 seasons of vegetation (with possibility of prolongation with maximum one year). Therefore, several methods of producing and planting the seedlings of different ages (and dimensions) have been tested in order to reach the objectives of the project as properly is possible.
Seeding was very late (first decade of July), comparing to recommended data (15 of March in tents and 15 of May in open mountain nurseries – MAAPM 1994), in desperate attempt to not loose a vegetation season. Seeds proved to have a high vigour (confirming the bulletin of analyse: germination >90%), all the culture springing very well, along 4 days (comparing to 20-30 days in early spring seeding – Herța et al. 1995), uniform, plants having high density. To ensure the proper space the density was reduced (from 100 to 50 seedlings / m) by removing plants.
Some problems with mole occurred, producing mechanical damages of the seedlings, followed by dumping-off. Several methods were used (ultrasounds equipments, pesticides, fumigants) till the phenomenon has stopped. Anyhow, despite the preventive treatments, dumping-off produsd 9% losses (Table 1) that are reasonable in the traditional way of seeding on natural beds (Simionescu et al., 2012; Tăut, 2016). Seedling vigour, the good developing conditions, combined with the caution measures took against frost made possible the culture passed succesfuly (without other important losses) the first winter. Adopted production technology allowed obtaining the desired number of seedlings, which average dimensions of 3.4 cm height (H) / 0.8 mm collar diameter (D) in the first season (4 months) and 5.8 cm H / 1.2 mm D after 1

year and 4 months (root length was, tipicaly to this species, much more longer than aerial stem).
For better understanding the influence of culture condition, a part of the seedlings was transplanted after 1 (variant T1N1) or 2 seasons (variant T2N2) in polyethylene bags and transferred to Geamănu altitude nursery, and other part was kept in Peștișani tent (T3). After the second year (optimum period for tent culture), *P. mugo* seedlings of T2 (2 years in tent) have +23-25% higher increment then seedlings transplanted after the first season T1R1 (1 yr in tent + 1 yr in nursery), due to suplementary temperature and longer growth season, but the difference was strongly influenced by the replication reaction, therefore it decreased to 2-4% after second variant passed to mountain nursery where the both variants were cultivated till the age of 4 (considered good for planting) (Fig. 1-2).
After the second season (actually 1 year and 4 months old), seedling dimensions were lower (4.7-5.8 cm H / 1.2-1.5 mm D) comparing to those of 2 years obtained in better conditions (nursery with multiple facilities) and longer vegetation season of (ICAS)INCDS Simeria (5-8 cm H / 1.5-2 mm D – Herţa et al. 1995).
After the fourth season, seedlings from the mountain nursery (T1R1, T2R2) have 15-18% lower increment comparing to those cultivated in hilly Peștișani tent, but all of the variants had at least 47-64% lower increment reporting to the similar tests (2 yr T + 2 yr N) in the more competitive nursery of (ICAS)/INCDS Simeria (Herța et al. 1995).

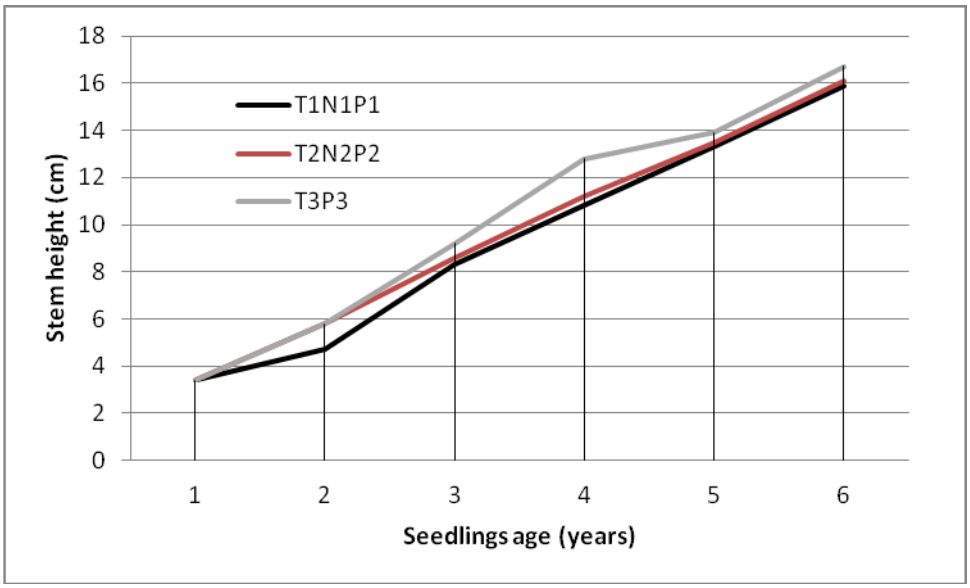

Fig. 1. Height stem increment of *P. mugo* seedlings from tent (T), nursery (N) and plantation (P)

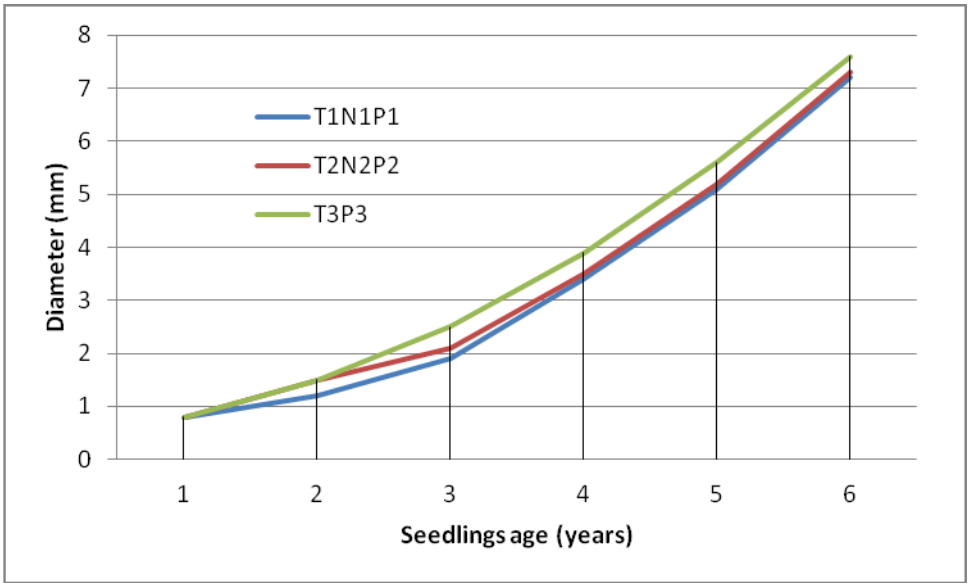

Fig. 2. Collar diameter increment of *P. mugo* seedlings from tent (T), nursery (N) and plantation (P)

Transplantation losses were higher (7%) in T1N1 variant (1 year plant age) due to the removal of the subdimension plants, seedling manipulation, and delay of planting, which spent a period of time in a ditch till the snow layer was melting allowing the works in mountain nuresery. In the second year, weather conditions was optimal (spring of 2015), plants were more developed (age: 2 years), seedlings being transplanted and transferred in the same day, resulting lower damages (2%). No other problems were recorded in the nursery stage (Table 1).

Table 1

Evolution of *Pinus mugo* cultures

	Number of seedlings						
	2013	2014	2015	2016		2017	2018
Tent stage	59034⇨	T1:54011 40000⇩ 14000⇨	14000 T2:9000⇩ 5000⇨		T3:5000⇩		
-losses	-5023 (9%)[1]	-4011 (7%)[2]					
Nursery stage		N1:36000⇨	N1+N2:45000 30000⇩ 15000⇨	14003 2500⇩ 11503⇨		11503⇩⇨	6003
-losses			-997 (2%)[3]				
Plantation stage			P1:30000⇨	22628 P2a:+2500 25128⇨	25128 P3:+5000 30128⇨	26308 P2b:+5500 31808⇨	31808
-losses				-7372 (25%)[4]		-3820 (13%)[5]	?[4]

[1]dumping-off,
[2]undevelopped seedlings + transplantation & manipulation problems,
[3]transplantation & manipulation problems,
[4]damaged by wild boar (majority) + transplantation & adaptation problems,
[5]dying of non-acclimatised seedlings.

Reconstruction of 4070* habitat

Restoring a nucleus (10,35 ha) of the *Pinus mugo* habitat in Mt. Oslea has included several variants of planting, using seedlings of 3, 4, and 5 years (Tab. 1).
In all the tested variants, planted materials corresponded to Romanian quality conditions recomanded by normatives (STAS 1347/2004) for *Pinus mugo* seedlings. After 5 years spent in different stages (tent, mountain nursery, subalpine plantation), creepy pine seedlings had low differences function of culture variant: the plants of T3P3 spent 4 years in tent having a small (unsignificant) increment advantage in the whole period (max. 5-6%) comparing to the other variants (T1N1P1, T2N2P2) (Fig. 1-2).
Plant losses had predicted causes, i.e. seedling manipulation, harsh climate, species low growth rate, but some were unexpected - wild boars damage (>20% dislocated plants in 2016/2017), even isolate old individuals may be found from time to time feeding in subalpine grasslands they generally avoid creepy pine bushes (Sârbu G., personal communication).
Acclimated plants well resisted to the difficult subalpine climate from Mt. Oslea, but the use of un-climatised seedlings moved direct from 250 m to 1900 m altitude without an adaptation period (T3P3) favoured intense dying (76% of 5000 died in one year), cancelling the additional increment of the first stage (Fig. 1-2, Tab. 1).
Losses were annualy substituted with new plants, so an optimal number of plants to be uniform distributed into the plantation.
The extreme climate (abundant snowing, very short vegetation season), using suboptimal dimensions and transport difficulties (in the upper part very few types of forest tractor or ATV are able to reach the 4070* habitat) lead to managementul plantației de jneapăn să se efectueze în conduiții improprii.
Many NGO-s involved in nature protection and academic institutions claim for public support for threatened habitats and species conservation. Restoration of *Pinus mugo* habitat is one of the subjects of intense debate, because: i) the human human actions are responsible for its degradation (Motta & Nola, 2001; Pelfini et al., 2006; Leys et al., 2014), ii) it still a subject of conflicts between nature protection and grazing activity (Kulakowski et al., 2011), iii) the climate worming is moving the habitat (area reduction in lower part due to the forest pressure and spreading in upper part in alpine grassland zone) in Carpathians (Jodłowski, 2006; Mihai et al., 2007; Martazinova et al. 2009; Svajda et al., 2011) or other

mountain regions (Dullinger et al., 2003; Palombo et al., 2013). Management plans of 4070* habitat try to find the optimum ways among these factors (Pop & Florescu, 2008, Hodor, 2008).
Very good results (>90% survival rate) in *Pinus cembra* habitat restoration (mixed with *Picea abies* and *Pinus mogo*) due to better developed seedlings (6 years old, produced in ICAS Sinaia nursery), more vigorous / resistant species better climate conditions (in high mountain forest sites, lower altitude: 1500-1800 m) were recorded in northern part of Oriental Carpathians (Blada et al., 2007). The same source of *Pinus mugo* seedlings (ICAS Sinaia nursery) were used in the following periods (7-8 yr old) in reconstruction of 4070* habitat in Retezat Mts. in subapline zone (1900-2000 m altitude), in eroded stony soils, with good results (cca. 25% losses) (LIFE05 NAT/RO/000165 – Zoran Acimov, personal communication; Kiss & Alexa, 2015). Using the undeveloped seedling of *P. mugo* was always very risky.

Conclusions

In Romanian sylviculture, the production system for seedlings of *Pinus mugo* requires a seeding stage in cold frame of two years, followed by transplantation in a high altitude nursery for plant acclimatization of minimum 2 years, in order to obtain the minimal developed plants that may survive in the subalpine zone.
Present attempts to find some simplified production methods (shortening the period or avoiding transplantation) of production the *Pinus mugo* seedlings have highlighted the following aspects:
- Planting three years old seedlings had similar results of survival rate (in south Carpathian winter conditions) with the other variants (2+2 yr, 1+3 yr, 2+3 yr), even the plant dimensions were significantly lower.
- On the same age, seedlings cultivated for a longer period in wormer climate had a small increment, that remains in all the following stages.
- In all the variants, the 3-4 years old seedlings cultivated in the traditional forest nursery system had much more reduced growth comparing to the modern nurseries.
- Planting the four years seedlings directly form the hilly to subalpine zone, without a period of acclimatization in high mountain climate was a failure.
- Significant losses in alpine plantation were produced by the wild boars (destroying the seedlings searching the soil souce of food).
- Culture of seedlings in plastic bags avoided other losses in nursery stage (only transplantation phase produced important damages).
- Very late seeding could be an aption to save a season if the frost protection methods are taken.

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