Nitrogen-fixing Woody Perennials for Agroforestry Systems in Germany

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I. INTRODUCTION

Integrating nitrogen-fixing woody perennials (NWP) into agroforestry systems has the potential to improve nutrient cycling while promoting the growth of neighbouring crops. An innovative strategy is crucial, especially for organic farming in Germany, to minimise the risk of nutrient deficiency due to sole reliance on nitrogen-fixing cover crops(1).

Why NWP?

NWP can address these challenges by increasing the nutrient and carbon accumulation at the soil surface level through nutrient pumping effect(2). They also have higher nitrogen (N), phosphorus (P), and potassium (K) in their litter compared to other woody perennials(3). Nevertheless, most importantly, studies in tropical plantations have shown that mixed-species plantations with NWP have positive feedback on adjacent and succeeding crops(4).

II. METHODS

NWP species were selected from Crawford (1995) and screened based on the following characteristics: Species origin, frost tolerance (Hardiness Zone 7b to 9), German Negative List, Probability of nodule formation, and plant height and shade tolerance.

The plant name was cross-referenced to GBIF (Global Biodiversity Information Facility) for their speices name and common name.

III. RESULTS

Species Name	N-Fixing Capacity (kg/ha· year)	Height (m)	Management	Value Added
Large/Medium Trees				
Alnus cordata (Loisel.) Duby (Italian Alder)	60-360[a]	25	SRC & P[g]	Bee plant
Alnus glutinosa (L.) Gaertn. (European Alder)	185[b]	25	SRC & P[h]	Dye, bee plant, tannins, fodder, and medicinal plant
Alnus hirsuta (Spach) Rupr. (Manchurian Alder)	56.4[c], 60[d]	18	SRC & P[i]	Dye
Alnus rubra Bong. (Red Alder)	130[e], 62[f]	20	SRC & P[i]	Sap, dye, and medicinal plant
Small Trees/Large Shrubs				
Elaeagnus angustifolia L. (Russian Olive)	240[a]	7	SRC[j] & P[k]	Edible fruit & seed, bee plant, and medicinal plant
Elaeagnus umbellata Thunb. (Autumn Elaeagnus)	236[b]	4.5	P[k]	Edible fruit & seed, bee plant, soil stabiliser, and medicinal plant
Medium/Small Shrubs				
Alnus alnobetula subsp. alnobetula (Green Alder)	60-360[a]	3	P[i]	Dye and medicinal plant
Elaeagnus multiflora Thunb. (Cherry Silverberry)	240[a]	3	n.a.	Edible fruit & seed, bee plant, and medicinal plant
Elaeagnus latifolia L. (Oleaster)	240[a]	3	n.a.	Edible fruit & seed, bee plant, and ground cover

Fig. 1 Nitrogen-fixing Trees and Shrubs Collection. Green: European Origin, Purple: Full-shade tolerant, SRC: Short-rotation coppice, P: Pruning.

a) Crawford (1995)
b) Paschke, M. W. et al (1989)
c) Tobita et al. (2013)
d) Lee, Y. Y., & Son, Y. (2005)
e) Binkley, D. (1981)
f) Tripp, L. N. et al. (1979)
g) Ducci &Tani (2009)
h) Daugaviete, et al., (2022)
i) Wilson et al., (2021)
j) Wilcox (2003)
k) USDA (n.d.)

IV. DISCUSSION

Recommended System

Based on the literatures, NWP is recommended to be implemented in alley cropping, intercropping, and silvopastoral System. NWP will benefit by conserve soil fertility(5) stabilised yield(6,7,8), improve grass and fodder quality(9,10), reduce water and wind erosion(5), and reduce environmental stress on cash crop(11).

Potential Challenge

Observation in mixed silviculture showed improved soil quality, but, no increase in neighbouring plant's biomass. Some hypothesis are:

(1) Water availability(12),
(2) Nutrient competition(13),
(3) Limiting nutrient in the soil – soil fertility status quo(13),
(4) Suitability with neighbouring plant: neighbour with similar foliage C:N ratio is a direct competition (14).

Management Recommendation

(1) Regular pruning(15),
(2) Prevent water competition with neighbouring plants (13),
(3) Spacing and canopy layer arrangement(16,17),
(4) Suitable for land reclamation and reconditioning(18).

V. CONCLUSION

NWP species from the *Alnus* and *Elaeagnus* families offer promising potential for temperate agroforestry systems in Germany. These species play a crucial role in nutrient distribution, both through litter deposition above ground and root connections below ground. To maximize the benefits of these NWPs, it's essential for neighboring plants to exhibit different C:N ratios in their foliage. However, realizing the full potential of integrated NWPs in agroforestry requires the implementation of specific management systems tailored to their needs.

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