Seed Yield of Herbaceous Crops under Agroforestry System

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Seed yield of herbaceous crops under agroforestry system

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Introduction

Agroforestry is a perspective way of biomass production which combines simultaneous growing of woody plants with agricultural crops on the same area for different purposes (Reisner *et al*., 2007). Agroforestry like multifunctional agriculture has the objective of promoting economically, socially, and environmentally sustainable rural development (Leakey, 2012). It is more sustainable than the monocultures of forestry or agriculture separately. Agroforestry can be an appropriate technology in the areas with fragile ecosystems and subsistence farming.

The main advantage of this technology is improved efficiency of resource utilization and smaller competition of plants for nutrients (Bardule *et al*., 2013). Agroforestry has the ability to provide short-term economic benefits while the farmer is waiting for traditional long-term forestry products.

In the system of agroforestry perennial herbaceous plants can be successfully cultivated along with fast-growing trees for different purposes. There is an opportunity to place various herbaceous crops species for seed production, including cross-pollinated crops in the cultivation of which it is important to comply with spatial isolation. Perennial grasses and legumes have been widely used as fodder crops for centuries and there has been an increasing interest in the use of them as energy crops because they have many economic and ecological advantages. Both woody and herbaceous crops need fertiliser for increasing productivity and it is a good opportunity to use various by-products for this purpose in the agroforestry system. The investigation was performed on the seed production of herbaceous plants cultivars grown in columns alternated with aspen rows and fertilized with residual materials - wood ash and wastewater sludge that contain chemical elements with considerable fertilizing value.

Materials and Methods

The experimental plot is a part of the large scale multifunctional plantation of short rotation energy crops and deciduous trees with the total area of 16 ha. It was established in the spring of 2011 on agricultural land in the central part of Latvia (56°41 N and 25°08 E) on Phaeozems/ Stagnosols soil.

Two different clones of hybrid aspen (*Populus tremuloides* x *Populus tremula*) were planted in the agroforestry system. The average spacing between the trees was 2.5 x5.0 m; the planting density - 850 trees per ha. Between the aspen rows fodder galega (*Galega orientalis* Lam.), reed canary grass (RCG) (*Phalaris arundinacea* L.) and festulolium (*Festulolium pabulare*) were sown in 2.5 m wide strips for seed production, the accounted area of seed yield for each species was 300 m^2. Between the trees and grass lines an empty space of 1.25 m was provided. Sowing was carried out without a cover crop using narrow row spacing (12 cm) for RCG and festulolium, and broad row spacing (36 cm) for galega. Seeding rates: galega 12 kg ha^{-1}; RCG 10 kg ha^{-1}; festulolium 12 kg ha^{-1} of germinating seeds. Seeds of galega were treated with nodule bacteria - wet nitragin grown on agar.

Table 1: Chemical composition (content of elements, g kg^{-1}) of applied fertilisers

Fertiliser	N	P	K	Ca	Mg	Mn	Fe	Na
Wood ash	0.40	10.9	31.6	224.8	30.9	3.1	4.6	1.6
Wastewater sludge	25.9	16.3	2.2	10.9	11.3	0.3	23.4	0.2

Four replications of three different fertilization subplots - the size of each - 30 x 24 m were established in the combined woody – herbaceous plantation: control (no fertilization), wastewater sludge (WWS) (10 t_{DM} ha^{-1}), wood ash (WA) (6 t_{DM} ha^{-1}) (Table 1); for comparative evaluation of herbaceous plants seed yield along with the mentioned fertilizers there was a mineral fertiliser (MF) option included: N25:P50:K125 for galega and N60:P50:K125 for the grasses. WWS and WA were spread mechanically before the planting of hybrid aspen and sowing of perennial grasses, it was done once as a basic

fertiliser – in the establishment year. MF were used after the sowing of herbaceous plants, referred dose was used for each year.

Meteorological conditions during the trial years were different. Year 2012 was characterized as rich in precipitation, the annual rainfall was 928 mm (it is 139% of a long-term average). Precipitation distribution in Skriveri for years 2012 – 2013 is shown in Fig. 1.

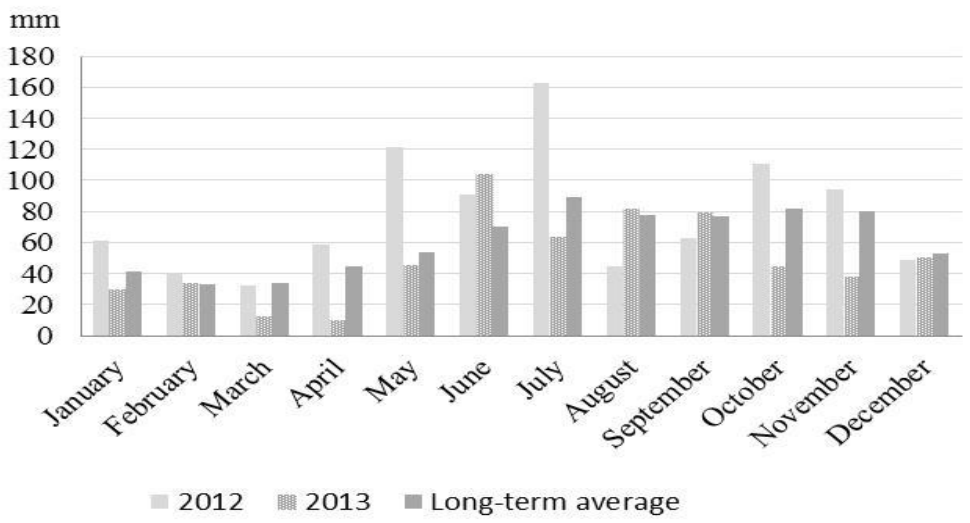

Fig. 1: Precipitation over the months in years 2012 and 2013, compared with long-time average rates in Skriveri.

Herbaceous plants seeds were collected by using a small experimental harvester winter steiger, the seeds were dried, cleaned and the seed yield was determined. The experimental data were statistically analyzed by applying the analysis of variance (ANOVA).

Results and Discussion

The results obtained confirm that populus plantings did not have a negative effect on the herbaceous seed harvest in two years of use. Seed yield formation was mostly influenced by plant biological traits and meteorological conditions. The average seed yields in the 1st year of use are estimated as good for festulolium and moderate for reed canary grass and galega. Fodder galega usually has a very slow development in the sowing year and in the 1st year of use. The most important factor for legumes, including galega, forming seed is the weather conditions therefore seed yield varies by year, depending on the weather conditions at the time of flowering and harvesting (Meripold, 2005). Numerous rainy days during the vegetation period in the 1st year of use (Fig.1) did not allow the pollination of galega flowers and made a negative effect on the seed yield, so average seed yield of galega in the 1st year of use was 244 kg ha^{-1} (Table 2). Due to favorable weather conditions in the 2nd year of use the seed yield of galega increased twice on average. In both crop years the highest seed yield for this nitrogen fixing papilionaceous plant was obtained using WA fertiliser.

Alike RCG seed yield increased on average from 153 in the 1st year of use to 220 kg ha^{-1} in the 2nd year of use; better results for this crop were obtained using WWS and MF. In general the seed production of RCG is complicated due to the fact that seed often shatter from the upper branches while seed at the base is still immature (Baltensperger and Kalton, 1959).

Table 2: The seed yield of perennial grasses in 1st and 2nd year of use under agroforestry system, kg ha^{-1}

Fertiliser	Reed canary grass		Festulolium		Galega	
	1st year of use	2nd year of use	1st year of use	2nd year of use	1st year of use	2nd year of use
Control	129	197	1176	202	142	427
Mineral fertiliser	225	436	1539	278	185	535
Sewage sludge	304	373	1451	191	276	444
Ash	241	282	1296	220	372	568
Mean	225	322	1365	223	244	493
$LSD_{0.05}$	153.2	220.0	253.5	54.3	123.1	128.3

The greatest increase of seed yield for festulolium in both years was provided by the use of MF. Agro-technical specificity affected the seed yield of festulolium in the 2nd production year – the unharvested aftermath heavily delayed festulolium

development in the following spring, thus reducing the seed yield significantly. At the same time the left aftermath did not affect RCG and galega development in the following spring.
The results of the both production years indicate that in general the use of all types of fertilizers in the plantation facilitates higher yields of seeds and it is a good opportunity to use by-products alongside with mineral fertilizers for increasing the seed yield of herbaceous plants in energy plant plantation.

Conclusion

Reed canary grass, festulolium, and galega could be successfully grown for seed production between the rows of trees in the agroforestry system in the 1st and 2nd year of use. The use of different bio-energy and municipal waste products as fertilizers in general provided higher seed yields. Still the influence of fertilizers under research on the grass species was different. The greatest increase in seed yield in two years on average was provided by wastewater sludge for RCG; by mineral fertilizers for festulolium; and by wood ash for fodder galega.

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