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ENHANCEMENT OF BIOMASS PRODUCTION OF BIRDSFOOT TREFOIL, SAINFOIN AND SUBTERRANEAN CLOVER BY MIXED CROPPING WITH PERENNIAL RYEGRASS

VILIANA VASILEVA[1], TOTKA MITOVA[2] AND MOHAMMAD ATHAR[3]

[1]*Institute of Forage Crops, 89 "General Vladimir Vazov" Str., 5800 Pleven, Bulgaria*
[2]*Soil Science, Agrotechnology and Plant Protection Institute "N. Poushkarov", 7, Shousse Bankya, Str., Sofia 1080, Bulgaria*
[3]*California Department of Food and Agriculture, 3288 Meadowview Road, Sacramento, CA 95832, USA*

Abstract

The productivity of three leguminous crops birdsfoot trefoil (*Lotus corniculatus* L.), sainfoin (*Onobrychis viciifolia* Scop.) and subterranean clover (*Trifolium subterraneum* L.) was evaluated in green house grown alone or mixed with *Lolium perenne* L. perennial ryegrass in 2013 and repeated in 2014. Each leguminous crops were grown alone (100%) or mixed with ryegrass at (50:50). Birdsfoot trefoil or sainfoin was also grown with subterranean clover along with perennial ryegrass grass (33:33:33). Higher productivity was found with the treatments of mixtures, i.e., for dry aboveground biomass, by 20.4%, and for dry root biomass, by 25.4%, respectively. More stable productivity of plant biomass was obtained in mixtures.

Key words: Subterranean clover, Mixtures, Dry biomass, Root biomass, Sustainable yield index.

Introduction

Considerable evidences have now been available regarding the benefits associated with mixed cropping of legumes with grasses for the development of environmentally friendly agriculture (Kusvuran *et al*., 2014a; 2015; Luscher *et al*., 2014). Mixed cropping are more effective over pure with regard to the use of resources for plant growth and nitrogen transfer from legume to grasses (Mahapatra, 2011; Kusvuran *et al.*, 2014b; Jani *et al*., 2015, 2016). Under unfavorable condition mixed crops can overcome better than mono cropping (Porqueddu *et al*., 2003; Peyraud *et al*., 2009; Bostan et al., 2013). They are more productive than pure stands and obtained forage had more balanced nutritive value (Vasilev *et al*., 2005; Chourkova, 2007; Albayrak *et al*., 2011; Saruhan *et al*., 2012; Kusvuran *et al.,* 2014c; Stevanovic *et al*., 2015). In addition, Nikolova & Kertikov (2008) found that population density of the insect pest complex in stands of pea-triticale mixture was considerably lower, as compared to pure cultivation of winter forage pea.

The annual drought resistant legume *Trifolium subterraneum* L., well known as subterranean clover has the ability for self-sowing (Yakimova & Yancheva, 1986). It is widely distributed in Middle and Northern Europe, and America (Nichols *et al*., 2012). Subterranean clover has practical applicability under the climatic conditions of Bulgaria (Vasilev, 2006, 2009; Vasileva *et al*., 2011; Vasilev & Vasileva, 2012a, 2012b; Ilieva *et al*., 2015). Resistance to winter, tolerance to summer drought and self-sowing at the end of spring is an advantage in comparison to white clover (Porqueddu *et al*., 2003; Mihovski & Goranova, 2007). In our previous studies, subterranean clover was found a suitable component for mixtures with commonly used grasses for forage production (cocksfoot, tall fescue, wheatgrass) (Ilieva&Vasileva, 2011; Vasileva & Vasilev, 2012a, 2012b; Vasileva, 2015). Similarly, birdsfoot trefoil and sainfoin were also found valuable components for mixtures (Demdoum *et al.,* 2010; Chourkova, 2010, 2014). The present report describes the productivity of mixtures of birdsfoot trefoil, sainfoin and subterranean clover with perennial ryegrass.

Material and Methods

The experiment was carried out in green house under semi controlled condition at the Institute of Forage Crops, Pleven, Bulgaria in 2013 and repeated in 2014. Three leguminous crops sainfoin (*Onobrychis Adans*.), birdsfoot trefoil (*Lotus corniculatus* L.) cv. "Targovishte 1" and subterranean clover (*Trifolim subterraneum* ssp. *brachycalicinum*) cv. "Antas" were sown in pots separately (100 %) or mixed with perennial ryegrass (*Lolium perenne* L.) cv. "IFK - Harmoniya" (50:50%). In another set subterranean clover was also grown with mixture of birdsfoot trefoil and perennial ryegrass (33:33:33%) or sainfoin and perennial ryegrass (33:33:33%). Plastic pots (6 l) were used filled with soil (leached chernozem subtype) (6 l). Seeds of birdsfoot trefoil, subterranean clover and perennial ryegrass were sown at the depth of 1-1.5 cm while sainfoin was sown at the depth of 3 cm. Treatments were replicated four times and arranged in a completely randomized plot design.

Plants were harvest twice (two cuts) to evaluate the productivity of leguminous crops. Plants were uprooted and roots were washed and blot dry. Fresh and dry above and below ground biomass (g/pot) were recorded. For dry biomass shots and roots were dried at 60ºC and total productivity was calculated (dry aboveground biomass + dry root biomass). For the assessment of productivity, sustainable yield index (SYI) was used (Singh *et al*., 1990).

$$SYI = (Ym-Sd)/Ymax,$$

where: Ym – mean yield, Sd – standard deviation and Ymax – the maximum yield

These characteristics were compared to the characteristics of pure legumes (birdsfoot trefoil, sainfoin and subterranean clover). Data of two years was averaged and statistically analyzed using software SPSS (2012).

Results and Discussion

All mixtures tested showed higher productivity of dry aboveground biomass as compared to pure crops (Table 1). The productivity of dry aboveground biomass from the pure crops was similar in values. When compare the mixtures of birdsfoot trefoil with the pure birdsfoot trefoil an increased yield was obtained by 22.5% for the two components mixture with perennial ryegrass, and by 27.0% for the three components mixture with perennial ryegrass and subterranean clover, respectively.

Dry aboveground biomass productivity for the mixtures of sainfoin was higher by 10.7 and 15.8% higher as compared to pure grown sainfoin. Similar findings were observed in other study, where crested wheatgrass was used as a grass component (Vasileva, 2011). The promotion in dry aboveground biomass productivity for the mixture of subterranean clover with perennial ryegrass was by 22.1%. There is report of suppression the productivity of dry aboveground biomass in mixtures with some grass components. So, it was with a mixture of birdsfoot trefoil with wheatgrass (Vasileva, 2011). Perennial ryegrass although destructive as a species had no adverse effect on the productivity of dry biomass in all mixtures tested in our study.

The amount of dry root biomass of legume components in mixtures was found higher as compared to pure crops, in the birdsfoot trefoil's mixtures. We assume it was due to the peculiarity of this species to fix small amount of nitrogen from the atmosphere (Carlsson & Huss-Danell, 2003). The main factors for the formation of plant biomass in sainfoin according to Hardarson & Atkins (2003) are nitrogen from the soil and from nitrogen fixation.

When the proportion of legume components was higher as in three components mixtures of sainfoin the productivity of dry root biomass higher with pure cultivated sainfoin by 18.0%. Mixtures of subterranean clover with perennial ryegrass produced higher dry root biomass. In the mixtures productivity of plant biomass was higher by 20.4% more dry aboveground biomass and by 25.4% more dry root biomass as compared to pure crops. Total productivity of plant biomass in mixtures was significantly higher (Fig. 1). In birdsfoot trefoil's mixtures – by 25.2 and 29.3% for two and three components mixtures and there were no significant differences between them. For sainfoin - the productivity of mixtures of sainfoin with perennial ryegrass increased by 7.7% higher as compared to pure sainfoin and twice more in the mixture with perennial ryegrass and subterranean clover. In the mixtures there was 22.7% more plant biomass obtained over pure crops. Total plant biomass productivity from two components mixtures was increased by 17.3% and almost twice as compared to three components mixtures (by 30.7%). In an analogous study with grass component tall fescue it was found that total productivity from the mixtures had been over 30.0% than pure cultivated crops (Vasileva, 2014). A large amount of plant biomass (aboveground and root biomass) could be explained with higher nitrogen use efficiency in mixtures (Vasileva *et al*., 2015). Successful competition between components for available inorganic nitrogen in the mixtures resulted in higher nitrogen use efficiency in the system.

Table 1. Productivity of dry above ground and dry root biomass.

Treatments		**First cut**	**Second cut**	**Average**
		g/pot		
	Ratio, %	**Above ground Biomass**		
Birdsfoot trefoil	100	2.89	3.02	2.96
B. trefoil + Ryegrass	50:50	3.66	3.59	3.63
B. trefoil + Subcl + Ryegrass	33:33:33	3.72	3.80	3.76
Sainfoin	100	2.78	2.66	2.72
Sainfoin + Ryegrass	50:50	3.09	2.93	3.01
Sainfoin + Subcl + Ryegrass	33:33:33	3.29	3.01	3.15
Subclover	100	3.43	2.01	2.72
Subclover + Ryegrass	50:50	4.22	2.42	3.32
SE (P=0.05)		0.16	0.20	0.13
		Root biomass		
Birdsfoot trefoil	100	1.27	2.18	1.73
B. trefoil + Ryegrass	50:50	1.46	3.01	2.24
B. trefoil + Subcl + Ryegrass	33:33:33	1.62	2.96	2.29
Sainfoin	100	2.81	3.09	2.95
Sainfoin + Ryegrass	50:50	2.91	3.28	3.10
Sainfoin + Subcl + Ryegrass	33:33:33	3.21	3.74	3.48
Subclover	100	1.98	0.97	1.48
Subclover + Ryegrass	50:50	2.41	1.14	1.78
SE (P=0.05)		0.25	0.36	0.25

Average for	**Above ground biomass**	**Root biomass**
	g/pot	
Pure crops	2.80	2.05
Mixtures	3.37	2.57
Two components mixtures	3.32	2.37
Three components mixtures	3.46	2.88
SE (P=0.05)	0.14	0.17

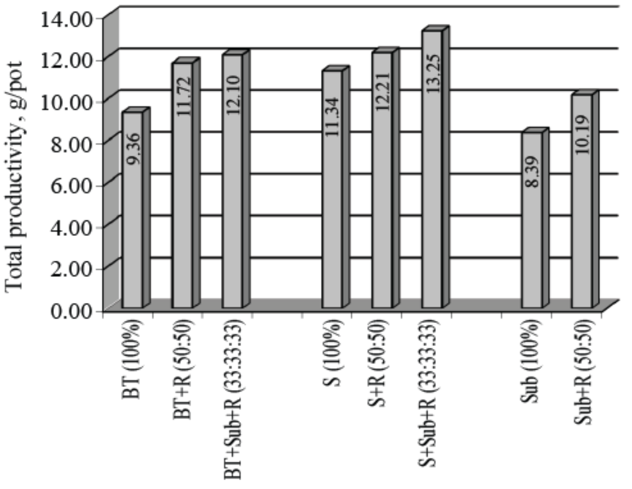

Fig. 1. Total productivity (dry aboveground biomass + dry root biomass) of mixtures.

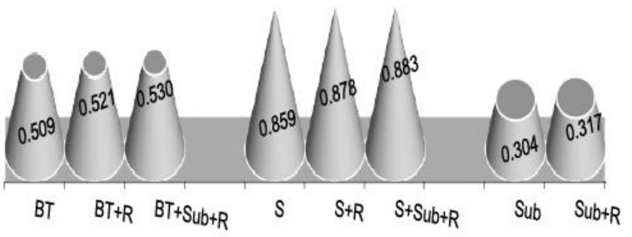

Fig. 2. Sustainable yield index (SYI) of the total productivity.
SE (P=0.05) = 0.001

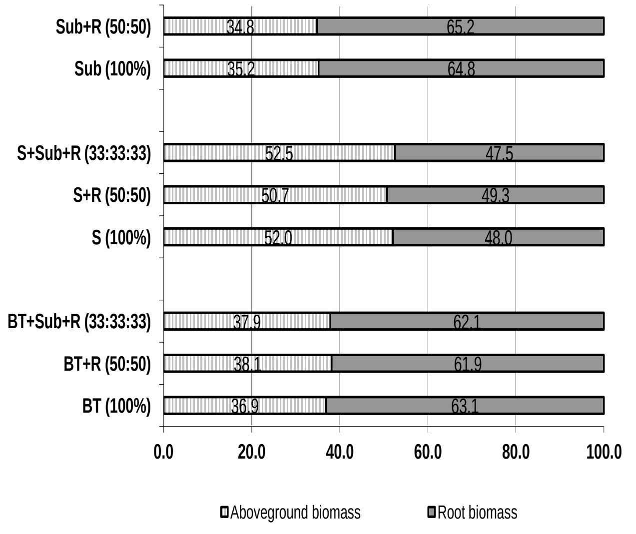

Fig. 3. Aboveground and root mass proportion in the total productivity, %.

In grasses total accumulated nitrogen was result only of the uptake of nitrate nitrogen through the roots by leaf nitrate reductase and efficiency of their use was lower. In legumes nitrogen comes from nitrogen fixation. The relations between components affected the sustainable yield index of the biomass productivity of plants. Sustainable yield index values were significantly higher for the all mixtures studied (Fig. 2).When the proportion of aboveground and root biomass in the total productivity was assessed (Fig. 3) it was observed that in pure crops the proportion of aboveground biomass was the lowest for subterranean clover (35.2%) and the highest (52.0%)for sainfoin. This is determined by the morphology of the crops. The proportion of aboveground biomass in mixtures varied between 34.8% in mixture of subterranean clover with perennial ryegrass to 52.7% in mixtures of sainfoin with subterranean clover and perennial ryegrass.

Conclusions

Productivity of dry aboveground biomass in two components mixtures of subterranean clover with perennial ryegrass was by 22.1% higher than pure subterranean clover. Dry root biomass productivity in three components mixtures of birdsfoot trefoil and sainfoin (with perennial ryegrass and subterranean clover) was by 32.4% and 18.0%, respectively, higher as compared to pure birdsfoot trefoil and sainfoin. More stable were productivity of plant biomass in mixtures and sustainable yield index showed higher values.

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