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SELF-SEEDING OF SUBTERRANEAN CLOVER IN DEGRADED BIRDSFOOT TREFOIL SEED PRODUCTION STANDS

VILIANA VASILEVA[1*] AND STANIMIR ENCHEV[2]
[1] Agricultural Academy, Institute of Forage Crops, 89 General Vladimir Vazov Str, Pleven 5800, Bulgaria
[2]Agricultural Institute, 3 Simeon Veliki blvd., Shumen 9700, Bulgaria

Abstract

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In connection with the dilution of seed production birdsfoot trefoil stands the possibility of under-sowing them with self-seeding crops was studied. The trial was carried out on the experimental field of Institute of Forage Crops, Pleven, Bulgaria with birdsfoot trefoil (*Lotus corniculatus* L.) Targovishte 1 variety. In autumn after the fourth year of use of the stands (for seed production direction) an under-sowing with three subterranean clover subspecies was done as follows: T*rifolium subterraneum ssp. brachycalicinum (Antas variety), Trifolium subterraneum ssp. yaninicum (Trikkala variety)* and *Trifolium subterraneum ssp. subterraneum (Denmark variety)*. The capacity of self-sowing of subterranean clover in birdsfoot trefoil stands was assessed. It was found that subterranean clover effectively used the autumn-winter soil moisture, formed a sufficient number of seeds for self-seeding and germinated plants occupied the sites of the dropped birdsfoot trefoil plants. *Trifolium subterraneum ssp. brachycalicinum* showed the best self-seeding ability. Thus, after under-sowing with subterranean clover, degraded seed production birdsfoot trefoil stands could be used for forage.

Key words: birdsfoot trefoil, degraded seed production stands, self-seeding, subterranean clover

Introduction

The productivity of the perennial leguminous forage crops which have an important place in the sustainable agriculture systems decreased with the age of sowing. The swards are going to dilute and the free spaces are occupied by weeds (Vasilev, 2004; Sulas et al., 2006; Petkova et al., 2015).

Birdsfoot trefoil is a valuable forage crops, suitable for cultivation, both alone and in mixtures (Vuckovic, 2004; Chourkova, 2011; Zekić et al., 2012).

In relation to more effectively usage of the resources self-seeding crops are becoming more important because of the possibility of longer-lasting presence in the swards (Bartholomew, 2014). In one season they could provide productivity of forage as well seeds for propagation (Carneiro, 1999; Naydenova et al., 2013).

Subterranean clover (*Trifolium subterraneum* L.) is speices with self-seeding ability (Yakimova and Yancheva, 1986; Piano et al., 1996; Howieson et al., 2008). It has a low widespread habitat and occupies open spaces between other plants from the lowest floor of the sward, as well coexists well with perennial grasses and legumes (McCaskill et al., 2016). It grows up early in the spring and forms a dense sward (Porqueddu et al., 2003). Reproductive organs are formed in early May and the seeds ripen before the end of the spring in hedgehog-shaped heads that remain on the soil surface (Frame et al., 1998). Substantial part of the formed seeds is hard and germinates after two-three years. This biological specificity turns the

**Corresponding author:* viliana.vasileva@gmail.com

superficial soil layer into an original seed bank (Pecetti and Piano, 1994). The precipitations during the late summer contribute to emergence of new self-sown plants (Vasilev, 2006).

Subterranean clover is relatively new crop for Bulgaria and is found in open dry grasslands in the plains and lowlands (Assyov et al., 2012). The studies with subterranean clover in recent years showed that it has practical applicability for the climatic conditions of Bulgaria (Vasileva and Vasilev, 2017; Naydenova and Vasileva, 2015, 2016; Kirilov and Vasileva, 2016; Vasileva et al., 2016). Some of studies involved the use of the species for direct under sowing of degraded perennial seed production stands and the self-seeding capacity of subclover in these stands. Such studies were done for alfalfa and white clover where the best self-seeding capacity showed *Trifolium subterraneum ssp. brachycalicinum* (Vasileva, 2015, 2017).

In this study we aim to investigate the self-seeding capacity of three subclover subspecies through under sowing of birdsfoot trefoil seed production stands.

Materials and Methods

The experimental work was carried out on the experimental field of Institute of Forage Crops, Pleven, Bulgaria on slight leached chernozem soil subtype without irrigation. Seed production birdsfoot trefoil stands (Targovishte 1 variety) was sown in 2007 and cared according with accepted technology. Long plots method was used, plot size of 5 m^2 and 4 replications of the treatments. During the autumn of fourth year from the use of the swards, across the rows, under sowing with three subterranean clover subspecies was performed, i.e. *Trifolium subterraneum ssp. brachycalicinum (Antas variety), Trifolium subterraneum ssp. yaninicum (Trikkala variety) and Trifolium subterraneum ssp. subterraneum (Denmark variety)*.

Under sowing was done with 400 germinated seeds/m2 and between rows spacing of 12 cm. Treatments were as follows: birdsfoot trefoil (without under sowing) – control; birdsfoot trefoil + *Trifolium subterraneum ssp. brachycalicinum*; birdsfoot trefoil + *Trifolium subterraneum ssp. yaninicum*; birdsfoot trefoil + *Trifolium subterraneum ssp. subterraneum*.

In the year after under sowing the number of germinated self-seeded subclover plants was recorded from 0.25 m^2 and equated to the number of m^2. They were done at the beginning of August and in early November, respectively in cotyledons, the first not true leaves and first true leaves stages. Total number of germinated self-seeded plants was calculated. Experimental data were processed statistically using a software product SPSS 2012.

Results and Discussion

Agrometeorological conditions particularly the amount and distribution of rainfall are important factor for self-seeding of subterranean clover. They could be defined as unfavourable during the period of study (Table 1). In the year after under sowing long dry period with extremely high temperatures occurs. Rainfall during the second half of the growing season (after mid-July) was below the average norm and not conducived to germination of self-seeded plants. Subterranean clover was found successfully self-seeded by mid to late growing season despite the unfavorable conditions.

The number of germinated self-seeded plants in the first true leaves stage was found to ranges within relatively narrow limits (Table 2) and was 28 plants/m^2 for *Trifolium subterraneum ssp. brachycalicinum*, 22 plants/m^2 for *Trifolium subterraneum ssp. yaninicum* and less, 15 plants/m^2 for *Trifolium subterraneum ssp. subterraneum*. Fewer number of germinated plants of *Trifolium subterraneum ssp. subterraneum* is related to the weaker competitiveness of this subspecies recognized by Lucas et al. (2015).

With the advancing of vegetation agrometeorological conditions were exeptionally bad. In September, the average daily temperature was high (22^{o}C) and rainfall lacked (0.0 l/m^2), which depress the development of subterranean clover. After the precipitations (50.2 l/m^2) fallen in the second ten days of October new self-seeded and germinated plants was recorded at the beginning of next month. The data are shown in Figure 1. The number of germinated plants in stage cotyledons for *Trifolium subterraneum ssp. yaninicum* (54 number of plants/m^2) was the highest, followed by *Trifolium subterraneum ssp. brachycalicinum* (46 number of plants/m^2) and *Trifolium subterraneum ssp. subterraneum* (38 number of plants/m^2). The number of germinated plants in first not true leaves stage varied from 10 to 25 number of plants/m^2 and in the first true leaves stage from 15 to 28 number of plants/m^2, respectively.

The total number of germinated self-seeded plants in early November was highest for Trifolium subterraneum ssp. brachycalicinum (99 number of plants/m^2), followed by *Trifolium subterraneum ssp. yaninicum* (83 number of plants/m^2) and *Trifolium subterraneum ssp. subterraneum* (63 number of plants/m^2). We found that T*rifolium subterraneum ssp. brachycalicinum* showed best potential for self-seeding when was used for under sowing of degraded birdsfoot trefoil seed production stands. We assume that this is probably due to the higher germination of seeds of *Trifolium subterraneum ssp. brachycalicinum*. In the Mediterranean area high germi nation rate and low hard seeds of subterranean clover is not seen as a good characteristics. Species and varieties with a higher percentage of hard seeds are appreciated due to the possibility of their later activation and greater reliability of the stands (Pecetti and Piano, 1994; Carneiro, 1999; Lemus, 2013). For areas with a Mediterranean climate the selection of subterranean clover for hardiness of the seeds is leading, which allows its gradual emergence and thus self-supporting in the stands for several years, although it is an annual type (Loi et al., 2005).

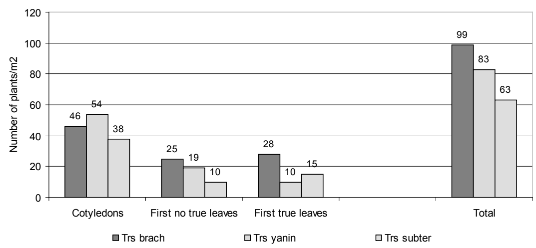

Fig. 1. Number of germinated self-seeded subterranean plants in under sowed degraded seed production birdsfoot trefoil stands (early November first year after under sowing) (SE=0.05) - cotyledons stage (4.6); first no true leaves stage (4.3); first true leaves stage (5.3), total (10.4)

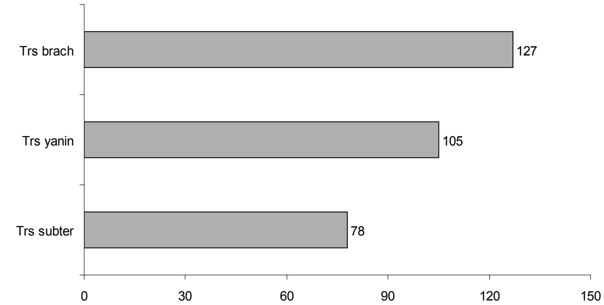

Fig. 2. Total number of germinated self-seeded subterranean plants in under sowed degraded seed production birdsfoot trefoil stands in the year after under sowing (SE=0.05, 14.1)

For the conditions of the experiment *Trifolium subterraneum ssp. subterraneum* showed weaker ability for self-seeding and germination in degraded stands. Analogous results we received when alfalfa seed production stands were under sowed with this subterranean clover subspecies (Vasileva, 2015).

The trend *Trifolium subterraneum ssp. brachycalicinum* to show the best self-seeding ability and emergence was confirmed by the total number of germinated self-seeded plants, i.e. *Trifolium subterraneum ssp. brachycalicinum* (127 number of plants/m^2) vs. *Trifolium subterraneum ssp. yaninicum* (105 number of plants/m^2) and *Trifolium subterraneum ssp. subterraneum* (78 number of plants m^2) (Figure 2). After botanical

Table 1. Agrometeorological conditions in the first year after under sowing

Months	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Av/sum
Temp, ^{o}C	-1.0	0.2	6.1	11.4	16.8	21.4	23.5	23.6	22.0	11.1	7.6	3.9	12.2
Rains, l/m^2	32.8	27.2	25.7	28.2	79.8	33.6	50.2	41.3	0.0	50.2	0.4	28.6	398.0

Table 2. Number of germinated self-seeded subterranean plants in under sowed degraded seed production birdsfoot trefoil stands (early August, first year after under sowing)

Treatments	Number of self-seeded plants/m^2
Birdsfoot trefoil + Tr. subterraneum ssp. brachycalicinum	28±3.0
Birdsfoot trefoil + Tr. subterraneum ssp. yaninicum	22±2.1
Birdsfoot trefoil + Tr. subterraneum ssp. subterraneum	15±1.5
Average	22±0.9
SE (P=0.05)	3.7

±, STDEV

composition analyses high percent of participation of this subspecies was found (Vasileva, 2017).

Experimental data showed that subterranean clover used effectively autumn-winter soil moisture and formed seeds successfully. In the conditions of our study subterranean clover formed sufficient number of seeds which in case of favorable conditions are self-seeded. This confirms the high ecological plasticity of the species found by other authors (Pecetti and Piano, 1994).

So, due to the self-seeding capacity subterranean clover could be successfully used for under sowing of degraded seed production stands. The degradation may result from various factors - short duration of the species, less adaptability to over use, adverse soil and climatic conditions, ect. The germinated plants occupied the sites of the dropped plants. Under sowing with subterranean clover prolongs the durability of the stands. In addition, self-seeding ability of subterranean clover and possibility degraded perennial stands be under sowed with subterranean clover allows more efficient use of resources – one of the challenges of modern sustainable agriculture.

Conclusions

When birdsfoot trefoil seed production stands were under sowed with subclover, Trifolium subterraneum ssp. brachycalicinum showed the best potential for self-seeding and the total number of germinated self-seeded plants was found 127 number of plants/m^2 vs. *Trifolium subterraneum ssp. yaninicum* (105 number of plants/m^2) and *Trifolium subterraneum ssp. subterraneum* (78 number of plants/m^2). The self-seeding ability allows subterranean clover be used for under sowing of degraded seed production birdsfoot trefoil stands, thus to prolonge their durability and the stands could be used for forage.

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