RESEARCH ARTICLE

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Legumes in soil surface maintenance system in the mountain and biological fruit growing

ABSTRACT
The new methods of soil surface maintenance of the artificial grass establishment or growing of green manure crops applied in modern fruit-growing have been the subject of research in various Agra-ecological areas in Bulgaria but they are not yet implemented in the fruit-growing technology. Legumes are a basic element of these methods because of their nitrogen-fixing system. The present article summarizes our own and foreign results about the suitability of the different types of legumes in this trend. Bulgarian studies confirm the role of legumes in optimizing the nutritional and water regime of fruit crops in the conditions of the mountain or biological fruit growing. In view of the fact that there are a wide variety of morphological and biological types of legumes in Bulgaria, it is reasonable to have a special selection of varieties for soil surface maintenance in orchards.

Key words: soil maintenance systems, biological fruit growing, legumes

Introduction

There are two traditional systems for soil surface maintenance in the cultivation of orchards in Bulgaria - fallow and natural turf is traditionally applied (Petkov & Petrov, 1998; Petkov & Mondeshka, 1999). The first one is mostly used as a stand-alone system in the intensive orchards, in the plains in Bulgaria (Djeneva & Rankova, 2010). The second, the natural turf of orchards, is a rational practice in pre-mountain and mountain fruit areas (Gergov et al., 2001; Churkova, 2007b; Petrov et al., 2008) with over-soaked soils and sloping terrains. It is preferred by farmers primarily because it reduces soil treatment activities and facilitates pruning, spraying and harvesting. The turf and mulch system that is used in the contemporary European fruit-growing, growing of green manure crops, short-term or long-term artificial grass establishment have been the subject of research in various Agra-ecological areas in Bulgaria (Georgiev et al., 1998; Vitanova, 2001; Vaneva, 2006; Djeneva & Rankova, 2010) but are not yet implemented in Bulgarian fruit-growing technology. The present article summarizes local and foreign results regarding the suitability of different types of legume genotypes for use in these new methods of soil surface maintenance in the mountain and biological fruit-growing.

Legumes for artificial grass establishment

The short or long-term artificial grass establishment of rows and interviews with legumes preserves and improves soil fertility. It maintains the nutrient balance of soil and limits erosion (Churkova, 2007b; Fiener & Auerswald, 2007; Watson & Evans, 2007; Goranova, 2012; Prasuhn, 2012; Poláková et al., 2018). Thus, it increases the carbon sequestered in the soil (Lal, 2011; Poeplau & Don, 2015; Kim et al., 2016) and controls weeds by allelopathy (Golubinova & Georgieva, 2009; Marinov-Serafimov, 2010), competition and mulching (Pollock, 2013; Freeser et al., 2014; Abouziena & Haggag, 2016; Paunović et al., 2016). The artificial grass establishment may have a restrictive effect on diseases and pests on fruit crops, achieved by disruption of the biological cycle of the major groups of pathogens, changes in the microclimate of the plantation and the provision of resources for the predators and parasites through biological control of pests (Smith et al., 1996; Sánchez et al., 2007; Mitova-Trifonova, 2009b; Granatstein & Sánchez, 2009).

The long-term grass establishment with perennial legumes is being studied in the systems for soil surface maintenance in the mountain and organic fruit-growing in Bulgaria due to the fact that a significant share of fruit plantations are located in the hilly, foothill and mountain areas where soils are infertile, most often acidic, with poor drainage, surface wet, with a low content of an organic substance absorbable phosphorus forms and mobile forms of nitrogen (Dinkova, 1980; Petrov, 1982, 1988; Nikolov, 2001; Petkova et al., 2013; Hristova et al., 2018). Plots occupied

with crops are in many cases in water catchment areas or on land with high erosion risk (Popski et al., 2015; Popski & Stefanova, 2018). Under these conditions, the possibilities for mechanical treatment, mineral nitrogen fertilization and the use of pesticides are limited and the biological fruit production systems become economically and ecologically sound.

As such, they are defined as: a shallow root system, a low habitus, a slight growth, a self-solving ability. The main focus in the studies comparing different types of legumes is given to their nitrogen-fixing system, which identifies them as the main source of biomass with a high content of N, residual soil nitrogen and an organic substance used by fruit crops (Dinkova et al., 2006; Berg, 2009; Fenchel, 2011; Pirhofer-Walzl et al., 2012; Meena et al., 2017, 2018; Mitran et al., 2018).

On the other hand, a small number of studies are known to evaluate the effect of legume genotype on its function in soil maintenance systems in orchards (Granatstein et al., 2013; Pavek & Granatstein, 2014). According to the results, pasture forms, wild ecotypes and subspecies of annual and perennial legumes are best suited for grass establishment of orchards. This raises the question of the need for a special selection of cultivars for this use.

In Bulgaria (Petrov & Minkov, 2006; Vaneva, 2006; Minkov et al., 2008), are used Bulgarian cultivars for long-term grass establishment with common bird's-foot trefoil (*Lotus corniculatus* L.), white clover (*Trifolium repens* L.) and red clover (*Trifolium pretense* L.). Red clover due to its deep root system is considered to be suitable for grass establishment because the orchards in Bulgaria are predominantly created in over-moistened, non-aerated soils. Red clover is also preferred because of its good allopathic activity and the ability to attract useful insects (Kirilov, 2016; Kirilov et al., 2016).

Bird's-foot trefoil and white clover have a shallower root system and do not compete with orchard crops. These are meadow legumes with maximum detectable nitrogen-fixing activity. They enrich the soil with nitrogen up to 15-23 kg/da (for a bird's-foot trefoil) and 15-25 kg/da (for white clover) (Pachev, 2016). These grasses have excellent persistence and tolerance to shading and over-wetting, good growth and development on poor, acid and salted soils (Maslinkov & Mihovski, 1989; Churkova & Goranova, 2005; Churkova, 2007a). They can be sown in spring, late summer, and can be reasoned on the existing plant cover. In order to control weeds and soil erosion, it is considered reasonable to sow the bird's-foot-trefoil and white clover in a mixture with grasses. Legumes have a slow initial growth, which influences the period of their rooting. Bulgarian studies in a flat area indicate results for the good initial development of bird's-foot-trefoil in a mixture with spring barley (Vasilev & Dimitrova, 2011), unlike white clover, which in the Central Balkan Mountain develops better when grown alone (Mihovski et al., 1995; Mihovski & Sabeva, 2011). According to foreign studies (Evans & Williams, 1987; Elgersma & Hassink, 1997), the different types of annual and perennial ryegrass are defined as a very good grass component in such mixtures, but the conditions in Bulgaria most often do not meet the ecological requirements of these species (Katova, 2005; Katova et al., 2016).

For the mountain conditions of Bulgaria, the mixture of a common bird's-foot trefoil with red fescue and Kentucky bluegrass is defined as the most suitable for grass establishment of raspberry, black-currant and plum trees. These legumes have also been used for artificial grass establishment in organic production of black currant and raspberry plantations. According to the results, the positive influence of the humus and ammonia content of the soil ensures optimal plant maintenance with the main macroelements - nitrogen, phosphorus, potassium, calcium and magnesium (Petrov & Minkov, 2006; Vitanova & Petrov, 2010).

Strongly inclined mountain terrains are a prerequisite for intensive erosion of the soil, leading to a decrease in its moisture content and nutritional reserves (Dinkova et al., 2000). The sowing of bird's-foot-trefoil, together with red fescue, as a complete turf cover in the interest of a young palm plantation with 'Katinka', has a proven positive effect on the humidity of the fruit trees in the area of the root habitable soil layer of 0-60 cm (Popski & Stefanova, 2018). According to Vaneva (2006), the turf covering of grass strips with bird's-foot-trefoil, red clover and Kentucky bluegrass and their maintenance of the system of live mulch is most promising, having a beneficial effect on the soil microflora and at the same time does not appear to be a competitor of the fruit crops with regard to moisture and nutrients in the soil. On the other hand, the grass buffer strips in row spacing do not depress the development of plum trees and have a very good anti-erosion effect (Dinkova et al., 2004). According to Dinkova et al., (2007), the buildup in interviews with bird's-foot-trefoil, red clover and Kentucky bluegrass has a positive impact on the growth, development and plumage of a plum grown under non-irrigated conditions in a foothill area. In our later studies (Georgiev et al., 2015; Georgiev et al., 2017) the positive effect of the inter-row grassing with different legumes on the biochemical qualities of the berry fruit (*Rubus eubatus*) has been proven. The results of variants with bird's-foot-trefoil indicate higher values for the gross, dry matter, anthocyanin and pectin ratios in the fruits.

In different parts of the world, species such as annual clover and alfalfa (*Trifolium subterraneum*, *Trifolium michelianum*, *Trifolium hirtum*, *Trifolium fragiferum*, *Trifolium incarnatum*, *Medicago truncatula*, *Medicago*

polimorpha, *Medicago lupulina*) are used for long-term grass establishment, which are self-sustainable through self-sowing and have hard shell seeds (Carneiro, 1999; Entz et al., 2007; Taylor, 2008; Escaray et al., 2012; Bartholomew, 2014; Vasileva & Enchev, 2018). In this way, they function as perennials. During a 3-4-year period, these species are artificially reseeded and this is sufficient to ensure their permanent dominance in the vegetation of the interiors. In order to control diseases and pests, sowing of strips of different species and varieties of them, with different heights and phonology (Bugg & Waddington, 1994) is practiced.

Legumes for green manure

In Bulgaria, there are experienced in the use of common vetch (*Vicia sativa* L.) and forage peas (*Pisum sativum subsp. arvense* L.) as green manure (Mitova-Trifonova, 2009a; Dinev & Mitova, 2018) in organic farming. According to these studies, these species introduce on average 1410 kg/ha of carbon and 109 kg/ha of nitrogen in the soil. The relationship between C and N in the incorporated biomass is within optimal limits, which ensures its rapid mineralization. The sowing of winter biotypes of vetch and peas is considered more appropriate because they form a powerful overground mass and optimally use the moisture in the autumn-winter and early-spring period. Autumn sowing (September, October) has an advantage of the conditions of Bulgaria, because it is significantly easier to implement than this one in the spring. Also, according to foreign studies in winter and spring, these crops protect the soil surface from water and wind erosion and prevent nutrient washout (Kaspar & Singer, 2011). Their significant role is also associated with the suppression of early and perennial weeds (Akemo et al., 2000; Brennan & Smith, 2005; Mitova-Trifonova, 2009ab), because climatic conditions often restrict spring treatments.

In the selection of species and genotypes of legumes for sideration (Dimitrov et al., 2003), it is important to quickly cover the area in autumn, rapidly growing in the spring, and in a relatively short period of time to accumulate a large amount of biomass. In his study, Pachev (2014) points to peas and sinfulness as suitable green manure crops because they have an impact on the organic carbon in the soil and can reach the level of fallow land - 1.13 (humus 1.95%) and 1.14 (humus 1.96%). The author reports on the enrichment of the humus horizon and improvement of soil fertility after application of green manure with bird's-foot trefoil and phacelia. According to foreign studies, the introduced N amount of individual pea crops is up to 200 kg/ha (at 4.8 N t/ha dry biomass) and from peas and rye mixture is accumulated about 200 kg/ha N (Cherr et al., 2006).

Sand and Pannonian vetch are legume species that are adapted to the conditions of Bulgaria. Also in other studies, sand vetch (*Vicia villosa* Roth.) is defined as a very suitable green manure crop with very high levels of nitrogen-fixing (90-280 kg/ha) (Rochester & Peoples, 2005; Choi et al., 2012; Lim et al., 2014). It is characterized by high winter resistance, dryness and tolerance to shade, growing well on different soil types and high allelopathic activity (Hill et al., 2007; Owsley, 2011). The growth of the aboveground mass in autumn and winter is slow and causes poor soil coverage and root system development is fast and powerful. As a green manure (Mikic et al., 2009), another type of winter vetch could be used (*Vicia pannonica* Crantz), which is less productive, but grows better in drought conditions (Uzun et al., 2004; Firincioğlu et al., 2011; Demirhan et al., 2018) and is ready to incorporate into soil earlier than sand vetch. This species forms quality nectar (Stoyanov et al., 2018) for a long period of time (from the beginning of April to the beginning of June) and thus attracts many useful insects in orchards. The only disadvantage of these legumes, when used as green manure, is the highest seed cost.

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