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ROLE OF POTASSIUM IN FORAGE LEGUMES

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Abstract: A sufficient supply of potassium in plants is important for the processes of photosynthesis, carbon dioxide assimilation, carbon movement, carbohydrate metabolism, enzyme activity, maintenance of the water balance and other processes in the plant. Potassium is an important element for the processes of growth and development, especially for the formation, growth and ripening of fruits. The aim of the study was to analyze the importance of the supply of potassium to forage legumes for achieving high and high-quality yields of forage and seed. A lack of potassium in forage legumes such as alfalfa, clover, soya beans, cowpea and lupine leads to weaker nodulation, which has a negative effect on yield components, yield and seed quality. One of the alternative options for a rapid response to symptoms of potassium deficiency in plants is foliar fertilization.

Keywords: legumes, mineral nutrition, potassium

Introduction

After nitrogen and phosphorus, potassium is the most common limiting macroelement for plant growth. It is the most abundant inorganic cation in plant cells (Dreyer and Uozumi, 2011) and it is required by plants in large amounts (Xu et al., 2011). Potassium is not a structural element in plant tissues, but it is important for the normal development of important life processes (Cakmak, 2005).

According to Römheld and Kirkby (2010) and Zörb et al. (2014) supply of plants with potassium affects their better resistance to stressful conditions, better adaptation to drought conditions, salinity, and high light intensity, cold. This is due to the important role of potassium in the maintenance of turgor pressure, metabolism and transport of nutrients throughout the plant. Sufficient

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supply of potassium to plants reduces the occurrence of plant diseases and pests (Prabhu et al., 2007).

In order to achieve a high yield of cultivated plants, they must be provided with sufficient amounts of potassium (5-40 mg g^{-1} SM in plant tissues) (White, 2013). Lack of potassium in plants not only affects crop yield reduction, but also fruit quality parameters (Lester et al., 2010).

According to Arienzo et al. (2009) legumes generally accumulate a high level of potassium, up to 5% of dry matter. The aim of the study was to analyze the importance of optimal provision of forage legumes with potassium for obtaining high and quality yield of forage and seeds.

Potassium in the plant

Lack of potassium leads to a decrease in the intensity of photosynthesis in a large number of plants (Sawan et al., 2009). According to Peoples and Koch (1979), lack of potassium in alfalfa significantly reduces photosynthesis and photorespiration, and increases respiration in the dark phase. The authors indicate that the activity of RuBPc (ribulose-1,5-bisphosphate carboxylase) is significantly reduced in potassium-deficient plants. Anuradha and Sharma (1995) state that the application of potassium has a positive effect on the increase in chlorophyll content. Potassium has a positive effect on the assimilation of carbon dioxide and facilitates the movement of carbon (Sawan et al., 2009). The physiological role of potassium is important for the metabolism of carbohydrates and their transfer from leaves to other vegetative organs, during the formation and ripening of fruits (Tiwari et al., 2001). A lack of potassium can lead to a reduction in the number of leaves and their surface area, as well as a reduction in the transport of photosynthetic assimilates from the source tissues through the phloem to other parts of the plant (Zörb et al., 2014), leads to the accumulation of sugar in the leaf tissue and to a decrease in yield and product quality. According to Hermans et al. (2006), with a lack of potassium, the intensity of photosynthesis decreases as a consequence of the accumulation of sucrose in the leaves and its influence on gene expression. This further means the accumulation of photoreductants in chloroplasts, thanks to which reactive oxygen is produced, which causes damage to chloroplasts (Cakmak 2005). However, according to Zörb et al. (2014) the influence of potassium on photosynthesis in different plant species tends to be inconsistent.

Potassium is important for the activation of numerous enzymes necessary for protein and starch synthesis (Tiwari et al., 2001; Cakmak, 2005; Mathur et al., 2006). Potassium salts stabilize various enzyme systems. Shingles and McCarty (1994) indicated the importance of supplying the plant with potassium for optimal ATPase activity. According to Anuradha and Sharma (1995), application of potassium increases nitrate reductase activity, oil and protein content in soybeans. Potassium is necessary for plants to build the high-energy phosphates ADP and ATP (Tiwari et al., 2001), for the synthesis of peptide bonds and the phosphate group of transferase (Mathur et al., 2006).

Directly or indirectly, potassium is linked with the processes of protein metabolism (Sawan et al., 2009). The supply of potassium to the plant is very important for improving the transport of amino acids, especially during seed development, which affects the increase of the harvest index in many plants (Blevins, 1985). Walker et al. (1998) indicate that with a lack of potassium, its concentration in the cytosol decreases, which leads to acidification of the cytosol, inhibition of protein synthesis and root growth.

According to Dreyer and Uozumi (2011), potassium helps maintain turgor pressure and reflect water balance in plants. An important role of potassium is in maintaining stomatal pressure so that carbon dioxide can be fixed (Römheld and Kirkby, 2010). Potassium is the main cation in the osmotic process of maintaining turgor, the movement of the stomatal apparatus and the processes of cell elongation (Szczerba et al., 2009). It is especially important for plants in stressful conditions when it positively affects the mode of opening and closing of the stomata, strengthens the plant's resistance to drought, as well as to diseases and pests (Tiwari et al., 2001). According to Peoples and Koch (1979), the lack of K in alfalfa significantly affected the reduction of the number of stomata and their size.

Potassium regulates the permeability of cell membranes, maintains the optimal level of hydration of the protoplasm and thus stabilizes the emulsion of highly colloidal particles (Singh, 1999). Mengel (1998) indicates the importance of K in promoting cell elongation. According to Tiwari et al., (2001) potassium has a positive effect on the absorption of other micro and macroelements (Tiwari et al., 2001). Potassium stimulates the uptake of NO_3 and its transport through the plant (Blevins, 1985).

Importance of potassium in forage legumes

Fertilization of soybean with potassium had a positive effect on the increase of seed yield, thousand seeds weight, oil content in seeds, seeds number per plant, and nodules number per plant on soybean roots (Tiwari et al, 2001).

According to Singh et al. (1999) fertilization of soybean with potassium influenced the increase of seed yield, of one thousand seed weight, oil content in seeds, seeds number per plant and better nodulation. Fertilization of soybeans with potassium had a positive effect on increasing the number of pods per plant, the weight of individual seeds and the number of seeds per pod (Coale and Grove, 1990). Xiang et al. (2012) determined that fertilization of soybean with potassium influenced a significant increase in stem height and diameter, number of branches per plant, seed yield, thousand seeds weight, number of pods per plant, number of seeds per pod and harvest index. Fertilizing soybeans with potassium increases the oil content of the seeds while decreasing the protein content (Yin and Vyn, 2003). Gaydou and Arrivets (1983) claimed that the content of linolenic acid in soybeans increased with potassium fertilization, while the content of oleic acid decreased. Yin and Vyn (2003) also reported that potassium fertilization increased the content of isoflavones in soybeans. Fernández et al. (2009) determined that the application of a larger amount of potassium fertilizer influenced a significant increase in seed yield, potassium concentration in shoots, potassium uptake and leaf area index. According to Hoeft et al. (2000) young soybean shoots do not use much potassium, but the rate of uptake increases with plant growth. During the period of pod formation and ripening, potassium is transferred to the grain. The authors also state that during the ripening stage of the crop, the soybean contains over 60% of the total potassium in the plant. Its deficiency in soybeans reduces the yield, which is caused by reduced absorption of magnesium, to which the soybean is particularly sensitive. Insufficient supply of K led to accelerated ripening of plants, which ended about 3 days earlier than under conditions of sufficient supply (Peoples and Koch., 1979). In the case of potassium deficiency, weak growth, low resistance to drought and less resistance to diseases are observed in plants (Xu et al., 2011). Foliar applied potassium increases soybean yield due to its positive effect on many yield components (Nelson et al. 2005).

Potassium deficiency in alfalfa affected the slowing down of root and shoot growth (Peoples and Koch, 1979), as well as earlier flowering of plants, which is less extensive and uneven (Bahaeldeen et al., 2009). Grewal and Williams (2002) indicated that potassium fertilization had an effect on increasing alfalfa seed yield.

According to Bahaeldeen et al. (2009) application of potassium in the amount of 50 kg ha^{-1} had a significant effect on plant height and forage yield of later alfalfa cuts. However, Abusuwar (2004) stated that the application of K did not affect the seed yield components, inflorescences number per shoot, pods number per inflorescence, seeds number per pod, as well as the total seed yield of alfalfa. This indicates that the effect of fertilizing alfalfa with potassium is largely dependent on the soil's supply of this element.

Growth of leguminous plants, nitrogen fixation and nitrogen accumulation are very sensitive to potassium deficiency in the soil (Mengel and Steffens, 1985). Mathur et al. (2006) showed that the total number of nodules on cowpea roots, the number and mass of effective nodules, the accumulation of dry matter in the plant, the number of pods per plant and the seed yield were significantly increased with an increase in the level of potassium fertilization.

Jensen (2003) indicated that the sudden withdrawal of potassium from the nutrient solution in white clover led to a significant decrease in nitrogenase activity per unit of root mass, as well as per unit of nodule mass, the rate of photosynthesis per unit of leaf area remained unchanged, and the supply of carbon dioxide for plants as a whole is increased due to the expansion of the total leaf area during plant growth. Thus the ratio between CO_2-fixation and N_2-fixation increased.

Gremigny et al. (2001) determined that potassium deficiency stimulates the accumulation of alkaloids in sweet lupine (*Lupinus angustifolius* L.) seeds and affects the reduction of seed yield. The largest amount of potassium taken up by the lupine plant from the soil is stored in the seeds (Wong et al., 2000). However, according to Gremigna et al. (2001), the application of potassium in different concentrations did not significantly affect the mineral composition of the seeds.

Conclusion

The growth and development of leguminous plants are very sensitive to the lack of potassium in the soil. In the case of potassium deficiency, the growth of alfalfa plants slows down, earlier and weaker flowering, and a decrease in the forage and seed yield. The lack of potassium in soybeans leads to weaker nodulation, negatively affects yield components, seed yield, but also greatly affects the reduction of seed quality. Cowpea, lupine, and white clover show a similar reaction to potassium deficiency. One of the alternative ways for a quick reaction in case of potassium deficiency in plants is foliar application of this element.

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