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Influence of foliar application on safflower yield

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Abstract
One of the most important issues about increase of crop yield and improving the quality of agricultural products is balanced plant nutrition. Safflower (*Carthamus tinctorius* L.) is an important oilseed crop of the family Asteraceae originated in southern Asia and is known to have been cultivated in China, India, Egypt and Iran. One of the most important issues about increase of crop yield and improving the quality of agricultural products is balanced plant nutrition. Foliar application of nutrients has become an efficient way to increase yield and quality of crops. Given the above mentioned points, it seems that zinc foliar application can reduce the effects of water stress and supply essential plant needs because research has shown that zinc increases crop yield, promotes the quality of produce and consequently promotes the enrichment and improvement in the health of a plant community. Great efforts have been directed to improve pea production and quality for the purpose of increasing exported yield. Application of adequate amounts of microelements is one of the most important factors involved in improving plant growth, yield and quality of pea. The nutrition of plants by foliar application is not only an addition channel of nutrients but also a mean of regulating root absorption by such plants.

Keywords: foliar application, microelement, safflower

Introduction

Safflower

Safflower (*Carthamus tinctorius* L.) is an important oilseed crop of the family Asteraceae originated in southern Asia and is known to have been cultivated in China, India, Egypt and Iran [32, 17, 9]. Safflower (*Carthamus tinctorius* .L) along with Canola, Sunflower, Sesame, Soybean and Cotton are the main seed crops in eastern countries since long ago. In order to establish necessary conditions for better use of natural reactions like biologic fixation of nitrogen by biofertilizers, interests have been raised toward environmental friendly sustainable practices which can reduce input costs [14, 22]. While in the past, mainly safflower production was in order to take advantage of its pigment in the flowers. At present, the main goal of safflower production is oil extraction from its seeds and its oil has is good quality in various usage. Safflower oil has high quality because of unsaturated fatty acids (more than 78%), oleic acid and linoleic acid especially. One of the main reasons for the low acreage of safflower is low yield and economic outcome. This crop adapted to relatively low rainfall areas receiving winter and spring rainfall with a low humidity during flowering and maturation [4, 11, 27]. One of the most important issues about increase of crop yield and improving the quality of agricultural products is balanced plant nutrition [1]. This article is review and the aims was effect of foliar application on safflower.

Foliar application of nutrients

One of the most important issues about increase of crop yield and improving the quality of agricultural products is balanced plant nutrition. Foliar application of nutrients has become an efficient way to increase yield and quality of crops [22, 29]. Safflower (Carthamus tinctorius L.) is oilseed plant that is adapted to the hot and dry regions. This is resistance to drought, salinity and heat stresses [13, 30]. Thus, in spite of country needs to import oil cultivate unsuitable conditions (against other plants such as canola and soybean). Safflower can play an important role in providing the required oil for country. Cultivation of Safflower is growing in the world and it is grown for power mechanization in many countries. In past, the culture this plant has been common in many parts of the world, especially in Middle East, but in recent years due to the availability of safflower oil, it is very important. While in the past, mainly safflower production was in order to take advantage of its pigment in the flowers. At present, the main goal of safflower production is oil extraction from its seeds and its oil has is good quality in various usage. Safflower oil has high quality because of unsaturated fatty acids (more than 78%), oleic acid and linoleic acid especially. One of the main reasons for the low acreage of safflower is low yield and economic outcome. Therefore, the availability of certified seeds with high production potential and support for purchasing seed oil plants by oil factories can be effective in country's oil needs [24, 15, 17, 31]. Micronutrients such as manganese and zinc can be important role at nutrition of oil plants. In plants, nzinc fertilizer should use at least once, twice or three times at one year and manganese can be used at leastnonce at one year for crops and horticulture [4, 6, 28]. It seems that critical level of zinc and manganese in soil is 1mg kg-1 and less than 10mg kg-1, respectively [5, 12]. Zinc also plays an important role in the production of biomass, grain yield, quality and quantity of oil [7].

Increase oil production

To compensate for the shortage of oil in the country, it is necessary lots of activities done to increase oil production that it is possible in two ways: (1) increasing in cultivation area, and (2) increasing yield in oil plants per unit area. In spite of that water and soil resources are limited, it is not possible to develop new land for cultivation of oilseeds and it is not beneficial way economically. Therefore, further work should focus on increasing yield per unit area through breeding and farming projects that production efficiency per unit area increased [27, 29].

Zinc foliar application can reduce the effects of water stress

Given the above mentioned points, it seems that zinc foliar application can reduce the effects of water stress and supply essential plant needs because research has shown that zinc increases crop yield, promotes the quality of produce and consequently promotes the enrichment and improvement in the health of a plant community [17, 23]. Under stress conditions (both mild stress and severe stress) zinc sulfate application increased seed yield more than zinc chelate application and the control. The treatment of zinc application had superior results in terms of straw and biological yield.

Effect of micronutrient on crop plants

Great efforts have been directed to improve pea production and quality for the purpose of increasing exported yield. Application of adequate amounts of microelements is one of the most important factors involved in improving plant growth, yield and quality of pea. The nutrition of plants by foliar application is not only an addition channel of nutrients but also a mean of regulating root absorption by such plants [9, 11, 27]. The deficiency of micronutrients may either be primary, due to their low total contents or secondary, caused by soil factors that reduce their availability to plants [17]. Copper as an essential micronutrient for normal growth and metabolism of plants is well documented [16, 18]. The lack of these microelements can be restored through the soil or the foliage [20, 21]. Micronutrient deficiency is widespread in many Asian countries due to the calcareous nature of soils, high pH, low organic matter, salt stress, continuous drought, high bicarbonate content in irrigation water, and imbalanced application of NPK fertilizers [3, 12]. Foliar nutrition is an option when nutrient deficiencies cannot be corrected by applications of nutrients to the soil [5]. Foliar spraying of microelements is very helpful when the roots cannot provide necessary nutrients [22, 26, 31]. Moreover, soil pollution would be a major problem by micronutrients soil application. As people are concerned about the environment and plant leaves uptake nutrients better than soil application, foliar spraying was created [11]. Micronutrients also play key roles in the release of carbon dioxide, and in optimizing the function of vitamin A and the immune system [8]. Zn is known to have an important role either as a metal component of enzymes or as a functional, structural or regulatory cofactor of a large number of enzymes [9]. Plants leaves ensure nutrient uptake for the development of plants [15]. Photosynthesis and the regulation of transpiration are the primary tasks of foliage. Because of their structure, leaves can uptake nutrients under certain conditions and to a certain extent only [20]. The advantage of nutrient uptake through the leaves is that it gets very quickly and directly to the leaf cells, where they are utilized. The importance of spraying microelements, i.e., Fe, Zn and Mn can be accounted by its essential role in respiration, their metabolism activation of the enzyme, photosynthesis, chloroplast formation, chlorophyll synthesis and natural hormone biosynthesis. Foliar application of micronutrients particularly Zn and Mn in small amounts had significant positive effect on 1000-seed weight, plant height, biological yield, grain yield, harvest index and oil content of sunflower [8], and growth of rice [11, 22]. Potarzycki and Grzebisz (2009) reported that zinc exerts a great influence on basic plant life processes, such as (i) nitrogen metabolism uptake of nitrogen and protein quality; (ii) photosynthesis chlorophyll synthesis, carbon anhydrase activity. Soils is less efficient, as these nutrients remain inaccessible to plant roots due to the higher soil pH [7, 11, 24]. However, an alternative approach under such circumstances is foliar application of these nutrients [18, 19], for 2 reasons. First, it eliminates the effects of soil pH on the availability of these nutrients [4]. Second, it is more effective and less costly [27]. For that reason, it has gained significant attention in agriculture worldwide [6]. Usually, it is recommended for horticultural crops, e.g. tomato [24], but it has also been found as a more effective technique for correcting micronutrient deficiency in cereal crops like wheat [16, 27] and sorghum [11]. Moreover, this technique generated additional benefits, in terms of cash, when applied in the right dose at the right time admixed with an appropriate surfactant [2]. On the other hand, the use of micronutrients for fiber crops, particularly cotton, is very rare in Pakistan [16]. Iron and zinc are essential elements for human nutrition [5]. Worldwide, cereals are a main staple for humans, but unfortunately, the concentrations of bioavailable Zn and Fe in grains are rather low and antinutrients such as phytic acid reduce the absorption of Fe and Zn into the body. The nutritional value of grains may be enhanced by increasing accumulation without reducing the availability of the metals or by increasing their bioavailability [4]. The role of essential microelements copper and zinc was proved in forming of more than 200 enzymes [19]. Lack of copper hinders nitrogen uptake and protein synthesis. It plays an important role in transpiration metabolism and electron transport. Copper plays a role in the redox processes in cells, and zinc in H-transportation reactions [15]. Micronutrient deficiency can greatly disturb plant yield and quality, and the health of domestic animals and humans [1, 9, 22]. The role of microelements in maintaining balanced plant physiology is becoming clearer every day as a result of studies on their reactions and the disturbances caused by their deficiency. Micronutrients are essential elements for life [8]. Micronutrients also play key roles in the release of carbon dioxide, and in optimizing the function of vitamin A and the immune system [13]. Kumar et al. [7] concluded that Cu fluxes and it's interactions with other micronutrients (Fe, Mn and Zn) affect the growth and yield of wheat plants. Application of Cu in excess amount may induce the deficiency of other micronutrients and adversely affect the yield. Experiments of foliar treatments were carried out with ion-exchanged zeolite on winter wheat for three years. The experiments were launched on small plots of calcareous Danube alluvial soil. On average of three years copper treatments were effective, if yield increase was set as a goal. As a result of zinczeolite the increase of raw protein was more favourable than that of copper-zeolite treatment. Extensive research on the effects of micronutrient fertilizers on crop yield and quality has been conducted during the past decade [12]. Results of a broad-based study conducted in 815 irrigated wheat growing regions of Iran between 1995 and 1996 showed that addition of each micronutrient (Fe, Zn, Cu, and B) or a combination of Fe^{+}, Zn^{+}, Cu^{+} ,B, to NPK fertilizer increased grain yield. The highest yield was obtained by adding all the micronutrients to NPK fertilizer [24]. A 22-site study showed that NPK+ micronutrients increased significantly protein content of wheat kernel from 11.66% to 12.01% [7]. Micronutrient deficiency limits plant growth and affects crop yield, especially in calcareous soil. The results of many researches revealed that the application of balanced fertilization significantly increased grain yield. Field tests of more than 2500 different experiments have shown that micronutrients have a significantly positive effect on crop yield and quality. Studies of several researches have shown that micronutrients

also ensure the efficient use of macronutrients [3, 7, 8, 10, 11]. Micronutrients have prominent effects on dry matter, grain yield and straw yield in crop (Asad and Rafique, 2000). Iron (Fe) plays role in biological redoxsystem, enzyme activation and oxygen transferring in nitrogen fixation (Romheld and Marschner, 1991); manganese (Mn) is utilized in enzyme activation, electron transport and in diseases resistance [6]; zinc is important to membrane integrity and phytochrome activities; copper (Cu) is vital for physiological redox processes, pollen viability and lignifications [22]; and boron (B) is required for reproductive plant parts, cell wall formation and stabilization, membrane integrity, carbohydrate utilization, stomatal regulation and pollen tube formation [29].

Zinc

Approximately 60% of the world arable land is considered to be difficult for the plant production due to mineral stress caused by the deficiency, unavailability, or toxicity of some essential nutritive elements [4, 13, 18]. Of the microelements, Zn is thought to be the most widespread [5]. A large number of the former investigations [12] showed that maize together with bean, soybean, flax, hop, and vine is especially sensitive to zinc deficit. Zinc uptake can depend on different factors, for example the application of potassium humate. confirmed the positive effect of humate on the decrease of Zn content in barley and oats but in maize and poppy Zn content increased. Moreover, maize genotypes (inbred lines, hybrids) differ in their zinc requirements as well as in the uptake and translocation ability [17]. Also, the maize inbred lines property of high or low zinc concentrations could be inherited in hybrids. Total soil zinc content is usually present within the range of 10–300 mg/kg in various forms [24]. Optimum zinc concentration in the ear-leaves of maize amounts to 10–20 mg/kg in the silking stage [3, 6, 8]. The most frequent causes affecting soil zinc availability are high soil pH values [11], carbonate content [22], and organic matter, further soil texture and sorption capacity as well as the mainly studied zinc interaction with other elements such as iron, copper and manganese [17, 19], and especially phosphorus . Phosphorus-induced zinc insufficiency occurs due to an increased phosphorus fertilization on soils with high pH moderately supplied with zinc [27].

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