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Effect of Potasium Fertilizer on Crop Production

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Abstract
Potassium is one of the three Macro primary nutrients which is necessary for plant growth. A researches review was made on the effect of potassium fertilizer on wheat,rice and sugar beet production conducted in Egypt,Turkey, Romania, pakistan ,Saudi arabia and India . In All of these areas the research findings indicated that yield and yield components of the subjected crop type is increased with the application of potassium fertilizer, nevertheless the optimum rate of K fertilizer at which highest yield recorded was different for each crop types and research areas. In Egypt,Turkey and Romania applying potassium fertilizer at the rate of 72,60 and 70 kg K2O/ha significantly enhanced yield and yield components of sugar beet respectively,Whereas in pakistan ,Saudi Arabia and India the maximum yield of wheat was recorded at the level of 60, 200 kg K2O/ha and 50 kg ha^{-1} K_2SO_4 respectively. More over In Pakistan and NewEngland the highest yield of rice was recorded at 60 and 40 kg K2O ha-1 respectively. On the other hand potassium fertilization has showed positive contribution on biotic and aboitic stress as well as improving water use efficiency of crops.So doing more researcher on the importance of K on crop production, nutritional quality and human and animal health as well as detail investigation on the level of soil K with respect to K application on specific crop production under different environmental conditions is important.
Keywords: Potassium, Wheat,Rice, Sugar beet, Fertilizer

1. INTRODUCTION

Potassium is one of the three Macro primary nutrient which is necessary for plant growth. According to Rehm *et al*.(2002) and Lakudzala (2013) Potassium (K) plays significant roles in the physiological processes of protein formation, transportation of water, nutrients and carbohydrates, photosynthesis, N utilization, stimulation of early growth and in insect and disease resistance. Besides it promotes the transportation of assimilates, control of stomata opening, enzyme activation in plants especially those responsible for energy transfer and formation of sugars, starch and protein as well as promotion of microbial activities and the nutrition and health of man and livestock (Yawson *et al*., 2011).

Potassium found in the soil in the form of mineral K, water-soluble, exchangeable and fixed. Plants take up available K from soil solution which is by soil exchangeable K. Some non exchangeable K can become exchangeable when solution and exchangeable K are depleted by plant removal, leaching, or exchange reactions with other cations. However mineral K, which is the major proportion of total K in soils, can become available only very slowly through long-term soil weathering. Distribution of K among these forms also occurs as K is added to soil as fertilizer, manure, or crop residues.

Tekalign *et al*. (2001) described in Ethiopia many of the smallholder farmers have good awareness about the potential positive contribution of mineral fertilizer to crop production but there is evidence to suggest that nationally fertilizer application is not as effective as could be hoped, i.e. only 35% of farmers apply fertilizer on about 40% of area under crop production. Moreover, in the country application of fertilizer has been popularized by extension approach focused mainly on the nitrogen and phosphorous in the form of di-ammonium phosphate (18-46-0) and urea (46-0-0) for almost all cultivated crops. Continuous application of N and P fertilizers without considering of other nutrients led to the depletion of other important nutrient elements in soils such as K, Mg, Ca, S and micro-nutrients (Bereket *et al*., 2011).

Application of Potassium as fertilizer has not been practiced in Ethiopian soils due to un updated report that Ethiopian soils are believed to contain enough or sufficient quantity of K nutrient. However ; some reports indicated that elements like K, S, Ca, Mg and micro-nutrients particularly Cu, Zn, Mn and Mo are becoming depleted and deficiency symptoms are being observed on major crops in different areas of the country (Asgelil *et al*., 2007; Deressa *et al*.,2013). In addition some vertisol of Tigray region that assessed in six locations, 76% of the investigated soils were deficient in potassium (Fassil *et al*, 2009). Recently the soil atlas of Tigray which was developed by ATA showed that there is low potassium level in the soils of many weredas of the region. These all of the information on crop responses to potassium application is indicative enough to initiate conducting seminar review on potassium fertilizer effect on crop production.

2. LITERATURE REVIEW

2.1. ROLE OF POTASSIUM IN AGRICULTURE

Potassium is required by plants in approximately the same or slightly larger amounts as nitrogen. Uptake of K occurs in the K+ form. Most of the functions of K in the plant are indirect in that K is necessary for other chemical reactions to operate properly (Daliparthy *et al*., 1994). As Darst (1992) reported that some 50 enzymes require the presence of K, with high concentrations of K found in the active growing points and immature seeds. Potassium forms no organic compounds within the plant, but remains in the ionic K+ form. The plant uses K in photosynthesis, in carbohydrate transport, in water regulation, and in protein synthesis (Marschner, 1995). The benefits of proper K nutrition include enhanced disease resistance, vigorous vegetative growth, increased drought tolerance, improved winter hardiness of forages, and decreased lodging (Egilla *et al*., 2001).

Potassium fertilization is frequently associated with improved crop quality as well as better handling and storage properties. Plants deficient in potassium are stunted and develop poor root systems. Deficiency symptoms are most obvious on the older, lower leaves since this element is readily translocated within the plant. Symptoms begin as interveinal chlorosis near the edges of lower leaves, and develop into a firing or scorch as the deficiency continues (George *et al*., 2002). This firing moves inward until the entire leaf dies and is shed. Since K deficiency can result in leaf shedding, it reduces the ability of the plant to produce carbohydrates, and ultimately, yields. Plants, especially small grains and corn, are prone to lodging when they are deficient in potassium. Severe deficiency causes premature defoliation, delayed maturity, and plant death (Mengel, 1997).

2.2. POTASSIUM IN SOIL

The total K content of soils frequently exceeds 20,000 mg kg^{-1}. Nearly all of this is in the structural component of soil minerals and is not available for plant growth (George *et al*., 2002). Because of large differences in soil parent materials and the effect of weathering of these materials, thus amount of K supplied by soils varies. Three forms of K (unavailable, slowly available or fixed, readily available or exchangeable) exist in soils. According to Mengel *et al*., (2001) depending on soil type, approximately 90-98% of total soil K is found in the unavailable form, feldspars and micas are minerals that contain most of the K. Plants cannot use the K in this crystalline-insoluble form. Over long periods of time, these minerals weather (break down) and K is released. This process, however, is too slow to supply the full K needs of field crops. As these minerals weather, some K moves to the slowly available pool. Some also moves to the readily available pool (Römheld, 2010).

The slowly Available Potassium form of K is thought to be trapped between layers of clay minerals and is frequently referred to as being fixed. Growing plants cannot use much of the slowly available K during a single growing season. This slowly available K is not measured by the routine soil testing procedures. Slowly available K can also serve as a reservoir for readily available K. While some slowly available K can be released for plant use during a growing season, some of the readily available K can also be fixed between clay layers and thus converted into slowly available K (Mengel *et al*., 2001). The amount of K fixed in the slowly available from varies with the type of clay that dominates in the soil. If montmorillonite clay soils are dominant, these clays fix K when soils become dry because K is trapped between the layers in the clay mineral. This K, however, is released when the soil becomes wet. If Illite clays are dominant in most of the soils, these clays also fix K between layers when they become dry, but do not release all of the fixed K when water is added. This fixation without release causes problems for management of potash fertilizers for crop production.

Potassium that is dissolved in soil water (water soluble) plus that held on the exchange sites on clay particles (exchangeable K) is considered readily available for plant growth. The exchange sites are found on the surface of clay particles. This is the form of K measured by the routine soil testing procedure (McLean *et al*., 1985). As George *et al*.(2002) reported Plants readily absorb the K dissolved in the soil water. As soon as the K concentration in soil water drops, more is released into this solution from the K attached to the clay minerals. The K attached to the exchange sites on the clay minerals is more readily available for plant growth than the K trapped between the layers of the clay minerals.

2.3. POTASSIUM IN PLANT PHYSIOLOGY

The nutrient absorption by plants depends on the growth, efficiency of roots and the availability of nutrients in the soil (Silva *et al*., 2002). Potassium is an essential nutrient for plant growth. Because large amounts are absorbed from the root zone in the production of most agronomic crops, it is classified as a macronutrient. Soils can supply some K for crop production, but when the supply from the soil is not adequate, thus K must be supplied in a fertilizer program (George *et al*., 2002). The exact function of K in plant growth has not been clearly defined. Potassium is associated with movement of water, nutrients, and carbohydrates in plant tissue (Gardia *et al*., 1980). If K is deficient or not supplied in adequate amounts, growth is stunted and yields are reduced. Potassium uptake by plants is affected by several factors. Such as soil moisture, soil aeration and oxygen level, soil temperature and tillage system (George *et al*., 2002).

2.3.1. POTASSIUM ION ABSORPTION

Plant membranes are relatively permeable to K+ due to various selective K+ channels across the membrane, low-affinity K+ channels and high-affinity channels. For the function of the low-affinity channels, the electrochemical difference between the cytosol and the outer medium (liquid in root or leaf apoplast) is of decisive importance (Morgan *et al*., 2013). The K+ is imported into the cell for as long as the electrochemical potential in the cytosol is lower than in the outer solution. With the import of the positive charge (K+) the electrochemical potential increases (decrease of the negative charge of the cytosol) and finally attains that of the outer medium, equilibrium is attained, and there is no further driving force for the uptake of K+(Steward, 1971; Morgan *et al*., 2013). The negative charge of the cytosol is maintained by the activity of the plasmalemma H+ pump permanently excreting H+ from the cytosol into the apoplast and thus maintaining the high negative charge of the cytosol and building up an electro potential difference between the cytosol and the apoplast. If the plasmalemma H+ pumping is affected, the negative charge of the cytosol drops and with it the capacity to retain K+, which then streams down the electrochemical gradient through the low-affinity channel, from the cytosol and into the apoplast. Thus in roots, K+ may be lost to the soil, which is, for example, the case under anaerobic conditions (Alexander, 1977; Hertel *et al*., 2005). This movement along the electrochemical gradient is also called facilitated diffusion, and the channels mediating facilitated diffusion are known as rectifying channels, their opening and closure are controlled by the electro potential difference between the cytosol and the apoplast (Morgan *et al*., 2013).

2.4. EFFECT OF POTASSIUM FERTILIZER AND RATE ON GROWTH AND YIELD OF CROPS.

Potassium fertilization is an important practice in improving growth and yield of crops. There are different fertilizer sources of potassium and based on their potassium content and kind of chemical formula they can be used in different soil conditions. Generally, potassium is usually taken up earlier than nitrogen and phosphorus and uptake increases faster than dry matter production. This means that potassium accumulates early in the growing period and then is translocated to other plant parts.

There are many investigations with respect to the effect of potassium fertilization on different crops productivity. However; this review is focused on crops like sugar beet, wheat and rice.Various researches has been done on the effect of potassium fertilizer on the production of sugar beet in different parts of the world. Many of the findings indicated that potassium has significant effect on the yield and yield component of sugar beet. Research conducted in Egypt, Turkey and indicated positive response of potassium fertilization on the yield of sugar beet (Basha ,1994 ; Kasap and killi,1994; Nigrila *et al*.,1994). However; the rate optimum rate of potassium fertilizer are different for these different locations.

In Egypt applying potassium fertilizer at the rate of 72 kg K2O/ha significantly enhanced yield and yield component, sucrose content and purity percentages sugar beet. (Basha, 1994 ; EL-Shafai, 2000). Whereas according to Kasap and Killi (1994) in Turkey the highest root fresh weight/plant, root and sugar yields/ha were associated with applying potassium fertilizer at the rate of 60 kg K2O/ha. Moreover in Romania, application potassium fertilizer at the rate of 70 kg K2O/ha increased root yield from 80 to 83 t/ha and sugar yield from 9.2 to 10.0 t/ha (Nigrila *et al*. (1994). On the other hand some findings indicated interaction of potassium fertilizer with nitrogen also improves the yield and yield component of sugar beet. EL-Zayat (2000) in Egypt, concluded that fertilization sugar beet plants with 90 kg N + 24 kg K2O/ha could be recommended for optimum root and extractable white sugar yields per unit area. Besides Salami *et al*. (2013) in Iran indicated that adding the highest level of K (114 kg K2O/ha) under different rates of N significantly increased sucrose contents, recoverable sugar yield and some quality traits. more over N fertilizer at a level of 285 kg N/ha accompanied with 114 kg K2O/ ha were the most effective in improving yield, quality and nutritional status of sugar beet grown in a sandy calcareous soil.

Another important crop which is considered on this review is wheat. Wheat is an important crop which is grown on more areas globally and it provides a major share of the nutritional requirements for the growing world population. Regarding improving wheat production various researches has been done on global bases. The effect of Potassium fertilizer on wheat production and productivity is among the investigations conducted by many researchers in various parts of the world.

Research conducted in Pakistan on wheat - rice system on the year 2004-05 indicated that wheat showed positive response to K application. The highest increase of 50% over control in paddy yield was recorded in treatment receiving K at 60 kg K2O/ ha (Khan *et al*., 2007). In Saudi Arabia research was conducted to see the effect of potassium fertilizer and its rate on wheat yield. The results shown the response of wheat yield is positive to the application of K rates. Alderfasi and Refay (2010) indicated that Application of K fertilizer at the rate of 200 kg K2O/ha at different growth stages recorded the highest value of most growth characters increasing potassium rates above this had no significant effect.

In India response of wheat to applied K showed increased yield even on the soils that have high level of potassium and application of 50 kg ha^{-1} of potassium sulphate (K_2SO_4) in the on-farm trial significantly increased grain and straw yields of wheat (Singh and wanjari,2012). Besides Aown *et al*.(2012) also indicated that In pakistan foliar application of K at all three critical growth stages (tillering, flower initiation and milking) improved the drought tolerance of plants and improved the growth and yield components with grain filling stage was found more responsive. Moreover significant response of potassium application on wheat was observed on yield and yield component with the increase of K2O up to 93 kg/ha (Abbas *et al*., 2013).

In addition rice is an important crop which serves as wide range of areas in the world as food for the growing population. Improving the production and quality of this crop is important in addressing food security in the world. As a result many trial were done to investigate the response of rice to different nutritional requirements. Field trials were conducted on effect of potassium fertilizer on yield and yield components of rice in various regions of the world. Research conducted in Pakistan on wheat - rice system on the year 2004-05 showed that rice response to K application was positive. The highest paddy yield of rice was recorded in treatment receiving K at 60 kg K2O/ ha (Khan *et al*., 2007). Besides an experiment was undertaken in glasshouses at the University of New England to investigate the effect of K fertilization on rice growth and application of K significantly increased tiller number (40-140%), plant height (<30%), shoot (120-140%) and root (80-300%) dry matter production and stem diameter (30-80%) of the crop (Bhiah *et al*.,2010). In addition to this Uddin *et al*.(2013) indicated that the yield and yield component of NERICA1 rice variety showed significant response to the increasing rate of potassium fertilizer and the highest yield was recorded at the rate of 40 kg K2O ha-1. he added that the interaction of nitrogen and potassium showed significant effect on all the yield parameters except 1000- grain weight. Simultaneous application of 80 kg N ha^{-1} and 40 kg K2O ha^{-1} produced the highest grain yield in NERICA 1 rice.

2.5. ROLE OF POTASSIUM IN PLANT STRESS RESPONSE

2.5.1. BIOTIC STRESS RESISTANCE

Crop production is significantly restricted by biotic stresses (Oerke*et al*.,2004). According to Sarwar(2012) estimated that weeds produce the highest potential loss (32%), followed by animal pests (18%), fungi and bacteria (15%) and viruses (3%). In many cases, K-deficient plants tend to be more susceptible to infection than those with an adequate supply of K (Holzmueller*et al*., 2007). Williams *et al*. (2001) also reported that increased K fertilizer significantly reduced the disease incidence of stem rot and aggregate sheath spot.

K fertilizer application decreased the incidence of diseases in most cases, but sometimes had no effect or even the opposite effect. The variable effects of K on disease incidence could be affected by the amount and source of K, plant and pathogen species (Prabhu *et al*., 2007). Higher K+ concentrations decreased the internal competition of pathogens for nutrient resources (Holzmueller *et al*., 2007). This nutritional status enables plants to allocate more resources to developing stronger cell walls for preventing pathogen infection and insect attack and to obtain more nutrients to be used for plant defense and damage repair (Mengel *et al*., 2001). Adequate K increases phenol concentrations, which play a critical role in plant resistance (Prasad *et al*., 2010). Furthermore, (Sarwar, 2012) concluded that less pest damage in higher K plants can be attributed to a lack of pest preference under sufficient nutrient concentrations, as well as the synthesis of defensive compounds leading to higher pest mortality.

2.5.2. POTASSIUM AND DROUGHT RESISTANCE

The major limitation for plant growth and crop production in arid and semi-arid regions is soil water availability. Plants that are continuously exposed to drought stress can form reactive oxygen species, which leads to leaf damage and ultimately, decreases crop yield (Cakmak, 2005). During drought stress, root growth and the rates of K+ diffusion in the soil towards the roots were both restricted thus limiting K acquisition. The resulting lower K concentrations can further depress the plant resistance to drought stress, as well as K absorption. Maintaining adequate plant K is critical for plant drought resistance.

The maintenance of a favorable water status is critical for plant survival under drought stress. Many studies have shown that osmotic adjustment of leaves is positively correlated with drought tolerance in various plant species (DaCosta *et al*., 2006). As one of the most prominent inorganic osmotic in plants, K^+ plays a key role in formation of the osmotic adjustment ability, even under drought conditions (Marschner, 2012). Cell turgid recovery in osmotic-generated stress was regulated by increasing K^+, Cl^- and Na^+ uptake by root cells, which was partly mediated by voltage-gated K^+ transporters at the cellular plasma membrane (Shabala *et al*., 2002). Furthermore, sufficient K induces solute accumulation, thus lowering osmotic potential and helping to maintain plant cell turgid under osmotic stress.

One of the major functions of the stomata is to control plant water loss via transpiration. During drought stress, quick stomata closure and internal moisture preservation are essential for plant adaptation to drought conditions. K plays a crucial role in turgor regulation within the guard cells during stomata movement (Marschner, 2012). As Egilla *et al*. (2005) reported that when plants were supplied with different K^+ concentrations and then subjected to drought stress, their stomata conductance was more markedly reduced in normal K plants than in low K plants. During drought stress, the stomata cannot function properly in K+ deficient plants, resulting in greater water loss. Drought stress did not decrease water use efficiency (WUE), whereas it did increase WUE by rapid stomata closing during water deficit (Egilla *et al*., 2005) thus, adequate levels of K nutrition enhanced plant drought resistance, WUE and plant growth under drought conditions.

3. CONCLUSION

Based on the reviewed results Potassium fertilization has great importance in increasing crop production of wheat, sugar beet and rice. Besides different crops in different areas has responded to different rate of potassium application. More over K is an essential plant nutrient that impacts a number of physiological and biochemical processes that are involved in plant resistance to biotic and abiotic stresses. So doing more researcher on the importance of K on crop production, nutritional quality and human and animal health as well as detail investigation on the level of soil K with respect to K application on specific crop production under different environmental conditions is important. Inline to this identifying the common or specific response of K to distinct stress and the role of K on long-term plant responses under multiple stress conditions in nature should be studied.

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