Journal homepage www.jzs.uos.edu.krd
Journal of Zankoy Sulaimani
Part-A- (Pure and Applied Sciences)

Improve Quality and Quantity of Plant Products by Applying Potassium Nutrient (A Critical Review)

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Article info

Original: 08.08.2015
Revised:04.10.2015
Accepted: 12.11.2015
Published online: 20.06.2016

Key Words:
Potassium nutrient
Plant production
Quality and quantity

Abstract

Nitrogen, phosphorus and potassium are regarded as the main nutrients necessary for plant growing. Each of these fertilizers has significant effects on plants growth. Their functions are somehow in relationship to each other. The purpose of this article is to show the importance of the potassium nutrient on the crops life. This kind of nutrient is disregarded in Kurdistan. Generally, the farmers have not information about the impacts of potassium. Hopefully, this study will encourage scientists to do more research on effects of potassium on plants. On the other hand, this article is going to be a key for using potassium fertilizer as an important mineral for the crops in the Kurdistan at the best way. Two factors are more important for every farmer to know before using the fertilizers (Fertilizers cost and environment pollution). As known, for getting fertilizers farmers must be paid, and fertilizers can damage the environment if these are not used correctly. Hence, for solving the above problems, a soil sample must be sent to a laboratory for physical and chemical testing before application of fertilizers. Farmers must know about appropriate nutrients and amount to add to the soil. Application of little amount of nutrients cannot grow crops and too many nutrients can run off the fields and pollute streams and ground water. Fertilizers have important purpose and function. Hence, farmers must be careful to practice the right dose, at the right time, to avoid negative effects of the fertilizers on the environment.

Introduction

Nitrogen, phosphorus and potassium are the main nutrients for plants. Farmers in Kurdistan have not used these fertilizers under scientific recombination. It is due to the researchers who could not breakdown the blocking between themselves and the farmers. This factor has a negative effect on the farmers. They are using fertilizers without any recommendations. Whenever, there is no plan and information about the fertilizers type, effects and also about the importance of the fertilizers as well, it can cause to destroy soil structure and dissipation a lot of money. Generally, Kurdistan farmers were used nitrogen fertilizer without any endorsements. All of the above factors pushed us to think about writing this article. Herein, focus on the importance of the potassium fertilizer is not only for healthy growth but also for improving quality of the crops.

Potassium is an important mineral nutrient required for every main stage of protein synthesis. It also has many beneficial for all growth processes. Therefore, plant growing would be impossible without satisfactory potassium ***[1]***. Salih (2010) ***[2]*** used potassium fertilizer in the Kurdistan Region for the six genotypes of

cotton. He found that potassium was significantly affected on the growth parameters. However, Salih *et al.* (2014) ***[3]*** found that potassium fertilizer was positively required for the plant fibers including kenaf in order to get the maximum nitrogen content in the fiber that later will determine the quality of the fiber. For the growth stage of plants, potassium is very important particularly it gives the highest uptake rates during the vegetative step ***[4]***. Sangakkara *et al.* (2000) ***[5]*** reported that the accumulation of crop biomass was limited due to potassium deficiency. Also, they stated that the photosynthetic rates of crop leaves, CO_2 assimilation and eases carbon movement are increased by potassium.

Plant Nutrients and their Sources

Out of the 90 elements of plants, sixteen elements are known as essential for the plants ***[6]***. These 16 elements are shown in the (Table 1).

Table 1: Plant nutrients and their sources

Macronutrients		***Micronutrients***
Mostly from air and water	***From soil***	***From soil***
Carbon (C)	*Nitrogen (N)*	*Iron (Fe)*
Hydrogen (H)	*Phosphorus (P)*	*Manganese (Mn)*
Oxygen (O)	*Potassium (K)*	*Copper (Cu)*
	Sulphur (S)	*Zinc (Zn)*
	Calcium (Ca)	*Boron (B)*
	Magnesium (Mg)	*Molybdenum (Mo)*
		Chlorine (Cl)

Sources of Potassium in Soils

Silicate rocks are a source of the potassium and other nutrients ***[7]***. Peacock (2007) ***[8]*** reported that the potassium is an abundant element in the earth also the earth's crust (rocks and soil) contains about 2½ % potassium. As well, the potassium content of soils varies depending on the parent rock and degree of weathering ***[8]***.

However, Schulte and Kelling (1998) ***[9]*** indicated that the three forms of soil potassium are unavailable, slowly available or fixed and readily available or exchangeable potassium. Additionally, they reported that the most common potassium fertilizer for using in field crops is potassium chloride or muriate of potash. Color of potash is red and white both are often available.

Factors Affecting Potassium Availability in Soils

Many factors are affecting of availability of potassium in the soil such as soil factors, plant factors, and fertilizer and management practices. The physical properties of the soil such as the amounts and types of clay and the cation exchange capacity (CEC) of the soil are strongly related to potassium availability. Also, other soil factors are affecting potassium availability including the quantity of available potassium in the soil, non-exchangeable potassium, potassium fixation capacity, and soil moisture. The ability to uptake potassium from a given soil also depends on the crops ability, variety, plant populations and crop yield. Moreover, fertilizer and cultivation practices are changing potassium availability in the soil ***[1]***.

Role of Potassium in Plants

Potassium has been defined as the "quality factor", confirming great quality to agronomic product. It increases yield and improves nitrogen use efficiency which causes to decrease the remaining nitrate in the soil. Consequently, less environmental pollution occurs ***[10]***. Potassium increases crops production and improves quality. It is required for many plants growing processes. However, crop yields are increased by adding potassium. Moreover, potassium causes to increase root development, improves drought resistance, activates numerous enzyme systems, maintains turgor; decreases water loss and wilting, supports the photosynthesis

process and food formation, decreases respiration, prevent energy losses, and it improves translocation of sugars and starch. Furthermore, it produces grain rich in starch, raises the protein content of plants, builds cellulose and decreases lodging and aids retard crop diseases ***[1]***.

Effects of Potassium on Grain Crops

The grain crops especially wheat and barley have a great potential in Kurdistan Region. The weather of Kurdistan is helpful for the production of both of them. Generally, farmers in Kurdistan are planted seeds of wheat and barley, and they use fertilizers but it might be used incorrect way. This section shows the importance of potassium fertilization for grain crops.

In 2004, nitrogen, phosphorus and potassium fertilizer were added to wheat plants at the rate of 120, 60 and 0 kg/ha, and also 120, 60 and 60 kg/ha, respectively. It was at farmer's field in the village of Hasanpur, Gurgaon, Haryana State, (India). Results were showed that the size and quality of wheat grain were improved by potassium nutrient (Figure- 1).

Kausar and Gull (2014) ***[11]*** reported that the potassium sulphate was significantly affected the wheat crop. They used different levels of potassium sulphate K_2SO_4 (50, 100, 150,200 mM) under 150mM NaCl stress. Maximum biomass in saline environment was obtained when 200 mM K_2SO_4 was added. Additionally, in saline soils, fertilizers used have also improved uptake essential nutrients like potassium, calcium, magnesium and phosphorus.

Figure- 1: Potassium effects on size and yield of wheat grain. Institute Research Potassium India (PRII), Gurgaon, Haryana. 2004. Courtesy of PRII, India ***[12]***.

Potassium nutrient has not effect only on the size and quality of wheat grain but also on the ear size of wheat. It can be seen in the (Figure- 2). In Bangladesh in 2005, potassium was used at the rate of 120 kg K_2O/ha for the wheat. Results were showed that the ear size of wheat was increased, and the grain production was doubled when potassium was applied. However, potassium at the rate of 66 kg/ha was produced the best yield of wheat (variety Protiva) in NW region of Bangladesh ***[13]***. Other researchers believed that the formation of grain or biomass per unit potassium, used by crops, can be used as a key in the choice of effectiveness in potassium barley genotypes ***[14]***.

Figure- 2: Potassium effects on ear size of wheat. (-K) without potassium, (+K) potassium was added at the rate of 120 kg K_2O/ha. IPI project in Bangladesh. 2005. Source: IPI Coordination India, Sri Lanka and Bangladesh ***[12]***.

On the other hand, (Figure- 3) shows the effect of potassium and phosphorus on the size and grain filling of corn when the experiment was done in Bahowal, Punjab, India, 2007. The cob grain filling and size were increased when potassium and phosphorus were added at the rate of 90 and 30 kg/ha, respectively. The results demonstrated that the nitrogen fertilizer might be affects only on the vegetative stage. Despite, each of potassium and phosphorus caused to improve the quality of maize. This changed is especially related to the effect of potassium. After starch, the next major chemical component of the grain maize is protein. Potassium was also caused to increase the nitrogen content (protein) ***[3 and 15]***.

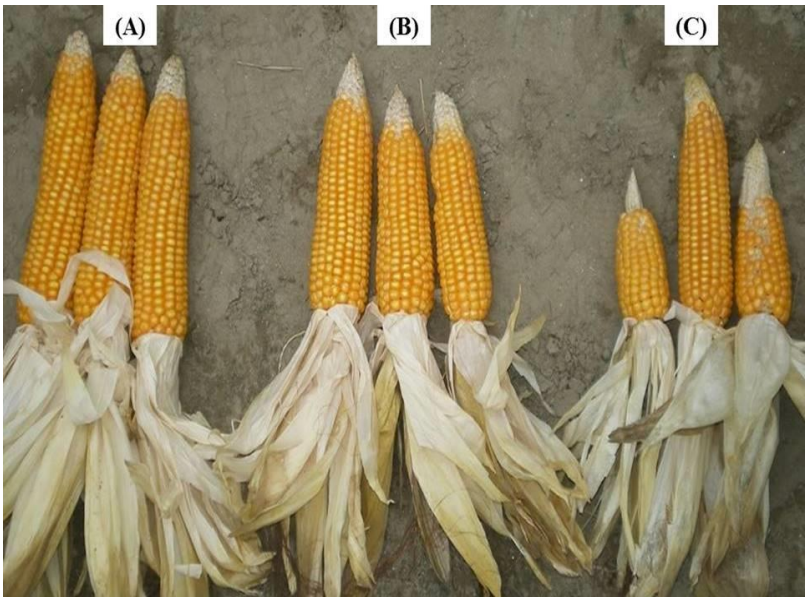

Figure- 3: Potassium and phosphorus effect on the size and grain filling of maize cobs. (A) When nitrogen, phosphorus and potassium were added at the rate of (120, 30 and 90 kg/ha), respectively. (B) When only nitrogen and phosphorus were added at the rate of (120 and 30 kg/ha), respectively. (C) Only nitrogen was added at the rate of (120 kg/ha). Source: M.S. Brar and IPI Coordination India ***[12]***.

Effects of Potassium on Fiber Crops

Improving fiber quality is more important since it produces can be used in the wide range. Potassium nutrient is a factor to this purpose. Numerous studies observed the impact of potassium mineral on fiber crops. The biggest value of fiber yield bast and core and also nitrogen content were recorded when potassium was applied at the rate of 150 kg/ha, it was for kenaf FH-952 variety ***[3]***. Furthermore, the study was showed that the ability to uptake nutrient was changed among varieties. Uptake of nutrients for kenaf FH-952 variety was more than the 4383 variety ***[3]***. Herein, we can say that fertilizers are not only a factor affecting on the plant growth and production but varieties are also another factor.

Effect of potassium, boron and zinc nutrients on the kenaf varieties are shown in the (Figure- 4). Images (A and B) when untreated for FH-952 and 4383 varieties, respectively. Despite, images (C and D) showed the impacts of potassium only on the fiber yield and quality for both varieties respectively. These results explained that the nutrients, time and amount of application are more important for reaching the aim of the using nutrients.

Another previous study was reported that the best result of nitrogen content was reached when potassium was applied at the rate of 150 kg/ha, for the kenaf FH-952 variety. Some concerns were observed for 4383 variety when potassium, boron, and zinc were practiced at the rate of 150, 1.0 and 5 kg/ha, respectively. According to the above results, potassium was really appropriate for the kenaf varieties. However, combination between macronutrients and micronutrients has importance to capture the purpose ***[15]***. The best results of plant growth such as: stem diameter and leaf number of kenaf FH-952 variety was attained when fertilizers potassium and boron applied at the rate of 150 and 1.5 kg/ha, respectively excluding the plant height which was better when potassium was added at the same rate while boron and zinc were controlled ***[16]***.

Liu *et al.* (2000) ***[17]*** reported that the potassium nutrient has a positive and significant correlation with fiber production of the ramie varieties. Potassium also affected flax which is another fiber crop and oil crop. Bakry *et al.* (2015) ***[18]*** concluded that the maximum rate of potassium sulphate (100 kg/fed.) with zinc foliar addition at rate of (5%) provided the best outcome (growth parameters, seeds, fiber and oil yield) of the both flax varieties (Sakha-2 and Amon).

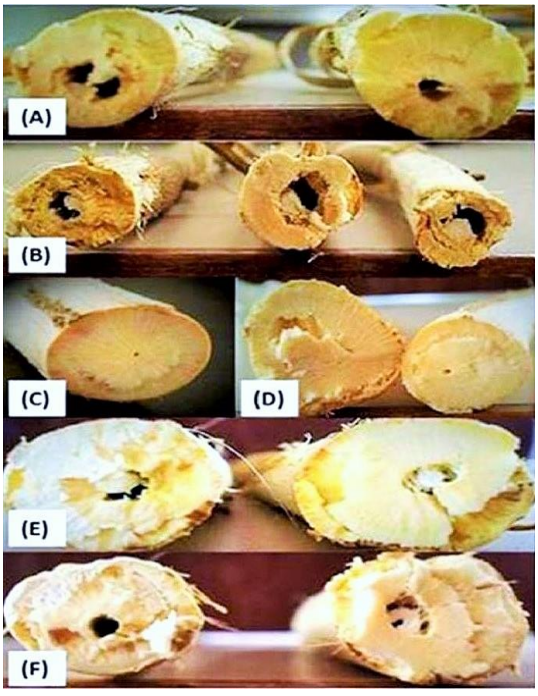

Figure- 4: Images of kenaf stem cross-cut after 48-hours oven dried at 65 °C. (A and B) FH-952 and 4383 varieties respectively when untreated; (C and D) FH-952 and 4383 varieties respectively, when potassium was added at the rate of 150 kg/ha; (E and F) both varieties when potassium, boron and zinc were added at the rate of (150, 1.5 and 5.0 kg/ha), respectively. Source: International Journal of Development Research (Salih *et al.*, 2014) ***[3]***.

Some farmers are using potassium fertilizer successfully, but generally farmers until now do not understand of the importance of potassium while it has numerous economic benefits for production. As mentioned before, they have not information about the chemical fertilizers and practice formation. One of the factors can belong to the studies have been done few decades ago; researchers showed that the potassium rate was too high in the soil of Iraq and also in Kurdistan. On the bright of these previous studies, researching on the potassium mineral was disregarded.

Salih (2010) ***[2]*** in Kurdistan Region used potassium fertilizer for six genotypes of cotton. Results were showed that some field parameters and also quality properties in some genotypes were improved by applying potassium at the rate of 200 kg/ha, (Figure- 5). Then, another experiment on the cotton (Lashata variety) was done by Mahmood *et al.* (2011) ***[19]***. The outcomes showed that potassium, phosphorus and their combinations significantly affected the cotton lint yield and oil content of seeds.

Figure- 5: Cotton plant when potassium was used at the rate of 200 kg/ha. Source: Rabar F.S. (2010). MSc. Study, College of Agriculture University of Salahaddin, Erbil/Kurdistan-Iraq ***[2]***.

Effects of Potassium on Oil Crops

Application of nutrients is necessary for all crops. Potassium was also used for improving yield and quality of oil crops including sunflower (*Helianthus annuus*). Potassium causes to produce a big head of sunflower and increase number of seeds (Figure- 6). On the other hand, it was not only affected on the yield of the sunflower but also improved the stem. It was provided bigger diameter and stronger stems than compared to the nitrogen effects. Cellulose and protein accumulation in both parts of kenaf stem (bast and core) was increased by potassium effects, and then it produces bigger stem ***[3 and 15]***.

From the results of this study, the researcher can say that application of potassium for the sunflowers has two important effects. First, it causes to improve quality and quantity of oil seeds. Second, it gets better stem yield in order to use as forage for animal and also as an organic nutrient for the crops.

Figure- 6: Potassium effects on head size and number of seeds in sunflower. The IPI-PAU Project is conducted at KVK, a farmers' training center, Directorate of Extension Education of the PAU. This project has a specific extension character and includes demonstration plots, farmers' field days and literature in local language (Punjabi). 2004. Source: M.S. Brar and IPI Coordination India ***[12]***.

Growth of groundnut or peanut (*Arachis hypogaea*) was improved by adding potassium fertilizer. The experiment was done in 2004 in China. In the (Figure- 7) it can be seen that the potassium has effect on the growth of peanut and increase production.

Figure- 7: Potassium effects of groundnut. Source: IPI Coordination China ***[12]***.

Effects of Potassium on Horticulture Crops

The potassium necessity of fruit crops are mainly high. In contrast, the use of potassium fertilizers in Indian horticulture is slight. Great rate of potassium is required to reach not only maximum total fruit production but also for the highest proportion of fruit production appropriate for marketing, good in quality, great in mineral content and good in keeping quality. Added potassium effects fruit size, appearance, and color and consumer acceptance like fruit recovery, aroma, and taste ***[20]***. Neilsen and Gerry (2009) ***[21]*** stated that the potassium nutrition improved the fruit color and quality without increasing the bitter pit.

Fruit and Vegetables

In Indian project in 2015, potassium was applied to the apple trees at the rate of 2.5 kg/plant. Results showed that the potassium increases the size and color of apples as can be seen in the (Figure- 8). When potassium was applied at the rate of 700 g/tree to peach fruits the yield and fruit weight were increased ***[22]***.

On the other hand, potassium was also used for improving yield and quality of other fruit. Wu *et al.* (2013) ***[23]*** reported that the application of single potassium to jujube trees give a much higher production than the phosphorus effect. However, in the results of Quaggio *et al.* (2011) ***[24]*** found that potassium has beneficial effects on the citrus tree.

Additionally, the yield of the fig tree (*Ficus carica* L.) was improved when potassium was added at the different levels. The best results of production of dry matter of branches and fruits were recorded when potassium was applied at the rate of 90 g K_2O/plant ***[25]***. Different levels of potassium were applied to grapes in 1999. Results showed that the bunch number and fruit yield were increased by increasing the potassium doses up to 200 g/vine ***[26]***. Also, Ganeshamurthy *et al.* (2011) ***[27]*** reviewed that the fruitfulness of latent buds of Thompson seedless grapes evidently increased by applying potassium when potassium was deficient in vineyards.

Figure- 8: Potassium effects on yield and quality of apple fruit from a demonstration farm in Aham Sharief Village, Bandipora district, Jammu and Kashmir, India. Source: Potash for Life, 20 January 2015 ***[12]***.

The number and size of potato tubers were increased with increasing rate of potassium. The project was done in Jalandhar, Punjab, 1997. The best results were recorded when potassium levels were up to 150 kg/ha (Figure- 9).

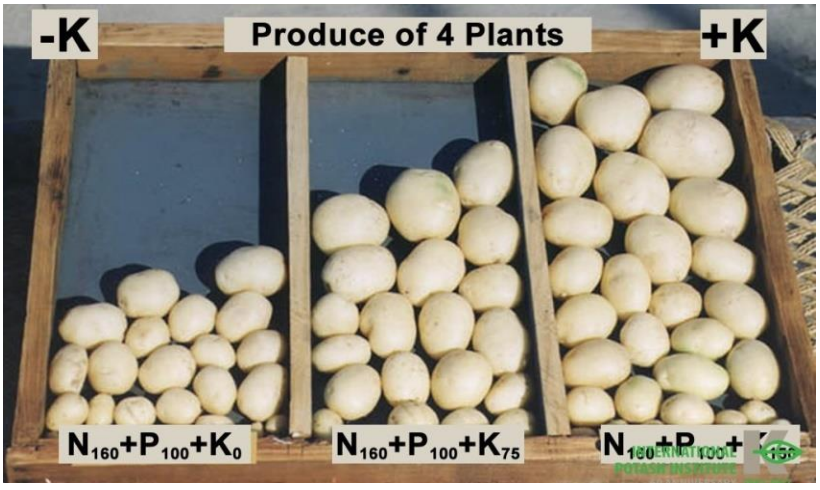

Figure- 9: Potassium effects on number and size of potato tubers. Source: IPI Coordination India ***[12]***.

In the Turkey in a project, potassium fertilizer was applied at different levels to watermelon (*Citrullus lanatus*). The rate 240 kg/ha of potassium was recorded the best results of the quality parameters, number of fruits, fruit weight and fruit width ***[28]***. However, they concluded that the yield and quality were increased when the dose of available potassium is adequate in the soil. They also stated that the potassium has significant effects on the formation and transportation of carbohydrates, transformation of amino acids to proteins, root growth, maturity and some quality characteristics .

Lester *et al*. (2010) ***[29]*** concluded that the potassium was improved fruit quality of melon (*Cucumis melo* L) by increasing the firmness, sugar content, ascorbic acid and beta-carotene levels. On the other hand, they believed that the potassium has slight or no useful effects on fruit quality when it was applied during fruit maturation. It is better to apply during the vegetative growth periods when the nutrient is most required for development of leaves with great photosynthetic capacity.

Potassium effects on carrot productions can be seen in the (Figure- 10). Results showed that the potassium nutrient has vital beneficial for improving quality and increasing yield. Different concentrations of potassium were used to two cultivars (Florida and Super Strain B) of Tomato plants (*Lycopersicon esculentum* L.). Outcomes displayed that the contents of total soluble solids, Vitamin C contents, titratable acidity and juice pH in tomato fruits were increased by applying potassium nutrient. Florida cultivar has a higher yield than the Super Strain B cultivar when potassium was applied at the high level (350 ppm) ***[30]***.

Figure- 10: Potassium effects on product and quality of carrot from a demonstration plot in Budgam, Kashmir, India. Source: Potash for Life, 20 July 2014 ***[12]***.

Conclusion:

Soil analysis before choosing and using fertilizers is necessary. Based on the evaluation of the soil, farmers can decide about the type of fertilizers, strategies of using and also amount of nutrients have beneficial for improving quality and quantity of the crops. Furthermore, it prevents the waste of money, and it causes not to apply some nutrient that could be limited in production, consequently improving the economic outcomes of cultivation with no damages to the environment .

Generally, results from all previous studies were showed that the adequate potassium nutrient in the soil causes to improve production and quality of crops. Potassium is directly and indirectly related to the produce of the chemical compounds in the plants including: carbohydrates, cellulose and also protein synthesis. All the above benefits of efficiency in the use of potassium are suggested that for more researching about this nutrient individually and also combined with other macronutrients and micronutrients.

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