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Review on Improving Agricultural Water Use Efficiency (WUE) of Crops via Nutrient Management

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ABSTRACT

Water use efficiency indicates a given level of biomass or grain yield per unit of water used by the crop. Improving agricultural water use efficiency will continue to increase because of the demand for increased grain production. Greater yield per unit of water is one of the most important challenges in water-limited agriculture. Soil properties, efficiency of crops, climate, and chemical species of the fertilizer used are factors, which affect water use efficiency of crops. Use of chemical fertilizer has quick and efficient method but the cost on energy is very high and there are several environmental concerns. Organic fertilizers incorporation may enhance the organic matter content of the soil leading towards the excessive moisture conservation and plant nutrient availability. To improve WUE of crops, a number of interventions should often make including: integrated application or implementation of best management practice like, increasing vegetation cover, maintenance and builds of soil organic matter, application of organic and inorganic nutrient sources, good agronomic practices and others.

Key words: Absorption, Crop, Efficiency, Nutrient Management

1. INTRODUCTION

Since the available fresh water resources in the world are constant and the population is continually increasing, the available water per capita will continue to decrease resulting in water scarcity or stress in some areas (M. F. Fonteh*et al*., 2013). Agriculture which consumes most of fresh water withdrawn will be expected to give up more and more water. Water use efficiency (WUE) can be described on various scales from the leaf to the field. In its simplest terms, WUE refers to the ratio of yield to the water used during crop growth whereas the ratio of yield to transpiration is termed as transpiration efficiency (TE) (EJAZ *et al*., 2011).

Water use efficiency provides a simple way of assessing whether yield is limited by water supply or other factors. A good understanding of crop management effects on WUE may provide researchers with opportunities to identify and select appropriate crop management practices for improved water use efficiency (EJAZ *et al*., 2011). Nutrient imbalance, time of nutrient application and climate change are expected to compound the problem of water availability and hence it's very important to improve the productivity of water use in agriculture for sustained development (M. F. Fonteh *et al*., 2013).

Genetic and physiological components of plants have profound effects on their abilities to absorb and utilize water under various environmental and ecological conditions. Genetic, morphological, and physiological plant traits and their interactions with external factors such as soil moisture and temperature, light, best management practices, soil biological, and fertilizer materials need to be more thoroughly evaluated to improve the WUE in crops (Abdus*et al*., 2017).

Water shortage is one of the limiting factors in crop productivity of the world. Improvement of agricultural water use efficiency is of major concern with drought problems being one of the most important factors limiting agriculture. Effective management of water for crop production in water-scarce areas requires efficient approaches. Increasing crop water use efficiency and drought tolerance by genetic improvement and physiological regulation may be a means to achieve efficient and effective use of water. Conservation of available moisture for crop is a technique which the farmers follow to attain the maximum possible yield by enhancing water use efficiency of crops (Abdus*et al*., 2017).

Invariably, many agricultural soils of the world are deficient in one or more of the essential nutrients needed to support healthy plants. Acidity, alkalinity, salinity, anthropogenic processes, nature of farming, and erosion can lead to soil degradation. Additions of fertilizers and/or amendments are essential for a proper nutrient supply and maximum yields.

There is need for breeding programs to focus on developing cultivars with high WUE. Identification of traits such as water absorption, transport, utilization, and mobilization in plant cultivars should greatly enhance water use efficiency. The development of new cultivars with higher WUE, coupled with best management practices (BMPs) will contribute to sustainable agricultural systems (V.C.Baligar*et al*.,2010).

Water is one of the major constraints in agriculture worldwide and water scarcity is a top problem worldwide. Plants water stress occurs when evaporative demand exceeds the water supply from the soil. Water stress causes stomata closure and reduced uptake of carbon dioxide, leading to diminished crop growth (Tiebiao Zhao*et al*., 2016). Aim of this paper is to review different literatures on Improving Agricultural water use efficiency of crops via nutrient management.

1. IMPROVING AGRICULTURAL WATER USE EFFICIENCY (WUE) OF CROPS VIA NUTRIENT MANAGEMENT

a. Major Factors which affect Water Use Efficiency of Crops

The water use efficiency is affected by several factors such as soil properties, efficiency of crops, climate, and chemical species of the fertilizer used. Best management practices are the best external alternative that can be applied to improve WUE. Plant genetics and physiological mechanisms and their interaction with BMPs are also a tool that can be used to increase efficiency of cropping systems (V.C.Baligar*et al*., 2010).

i. Soil acidity

Approximately 30 % of the world's total land area consists of acid soils, and it has been estimated that over 50 % of the world's potential arable lands are acidic. Aluminium (Al) in these soils will be solubilized in to ionic forms, especially when the soil pH falls to lower than 5. These ionic forms of Al have been shown to be very toxic to plants, initially causing inhibition of root elongation by destroying the cell structure of the root apex and thus affecting water and nutrient uptake by the roots; as a consequence, plant growth and development is seriously hindered. On the other hand, phosphorous (P) is easily fixed by clay minerals that are rich in acids soils, including various iron oxides and kaolinite, and hence rendering it unavailable for root uptake. Thus, Al toxicity and P deficiency are considered to be two main constraints for crop production in acid soils (Shao JianZheng, 2010).

In order to produce a better crop yield on acid soils, farmers are recommended to apply alkaline materials such as lime (primarily calcium carbonate) to increase the soil pH and thus eliminate Al toxicity, and to apply P fertilizer to increase the bio available P in soil. However, soil has a huge buffering capacity that is able to diminish the effects of all kinds of amendments, and the soil acidification process is accelerated by factors such as acid rain and excess application of ammonium-based inorganic nitrogen fertilizers. Hence the effects of practices such as applying lime and P fertilizer are usually not sustainable (Shao JianZheng, 2010).

Moreover, as application of treatments is generally restricted to the soil surface, the properties of the sub-soil are hardly modified, thus limiting the effects for crops with deep root systems. But despite all these constraints, abundant vegetation is still found on acid soils (Shao JianZheng, 2010).

ii. Fertilization application

Sustained crop productivity relies on constant renewal when the supply of nutrients becomes a constraint to plant growth and development. Application of chemical fertilizers is necessary for enhancing crop yields and sustaining soil fertility. However, inappropriate or excessive fertilizer application does not guarantee constantly increasing yields, might result in low nutrient use efficiency, and can cause environmental problems in agro-ecosystems (Muhammad Yousaf *et al*., 2017).

Compared with PK fertilization, grain and seed yields of both rice and oilseed rape were significantly increased at each site by NPK, NP and NK, which indicates the importance of N for improving crop productivity. Among all treatments, NPK fertilization produced the highest yield of both rice-oilseed rape rotations. This high yield was due to the balanced supply of all important nutrients to the plants. Other treatments, such as NP, NK and PK, were lacking at least one major nutrient, i.e., either N, P or K, and thus may induce a specific nutrient deficiency which may result water stress and retard overall growth of rice and oilseed rape with a concomitant reduction in yield (Muhammad Yousaf *et al*., 2017).

The indigenous nutrient supply of soil can be assessed utilizing different strategies and indicators, including soil properties such as the soil organic C, total N, Olsen-P, NH_4OAC-K, and plant markers such as crop yields and nutrient uptake under a specific nutrient omission treatment. In summary, balanced fertilizer application is not only essential for producing top quality crops in high yields but also for environmental sustainability. Agricultural profitability and improved nutrient use efficiency can be achieved through better plant nutrient management, which includes optimum fertilizer applications which is prerequisite for efficient water use (MuhammadYousaf *et al*., 2017).

b. Factors that Improve Water Use Efficiency of Crops

Enhancing agricultural WUE by crop and soil management approaches refers to a farming practice that is able to take full advantage of the natural rainfall and irrigation facilities. The core problem that water-saving agricultural research has to solve is how to raise the water utilization rate and water use efficiency that is to achieve a high yield on irrigated farmland with the minimum input of water and in rainfed agriculture to maximize rainfall use efficiency (Sami Ul-Allah, 2015).

What we stress here is that water-saving agriculture is not simply water-saving irrigation. It is a comprehensive exercise using every possible water saving measure in whole-farm production, including the full use of natural precipitation as well as the efficient management of an irrigation network and plant mineral nutrition. The different management approaches by which we can improve WUE are given (Sami Ul-Allah, 2015).

i. Plant mineral nutrition

Proper nutrition is the basic need of every living organism. There are now 17 elements which are considered essential for plants to complete their life cycle. These essential plant nutrients are divided into two categories; macronutrients and micronutrients. Macronutrients include carbon (C), hydrogen (H), oxygen (O), nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and sulphur (S). Micronutrients are zinc (Zn), copper (Cu), iron (Fe), manganese (Mn), boron (B), molybdenum (Mo), chlorine (Cl) and nickel (Ni) **(**R.Kro bel *et al*., 2012).

Although silicon (Si) is not essential, it is considered as a beneficial plant nutrient. Adequate nutrition is essential for the integrity of plant structure and key physiological processes such as light interception by chlorophyll (N, Mg), energy for carbohydrate build-up (P), and osmotic regulation of the stomata (K), among others. Therefore, a well-nourished plant is expected to produce more biomass per unit of transpired water than an under-nourished one. N and P deficient plants strongly reduced the hydraulic conductivity of the root cortical cells. These plant nutrients are not only required for better plant growth and development, but also helpful to improve agricultural WUE. Increasing evidence suggests that mineral-nutrient status of plants plays a critical role in enhancing water use efficiency by proper nutrition (EJAZ *et al*., 2011).

1. Macro-nutrients

Nitrogen

Nitrogen is important in improving WUE and soil water use. Increased yields and WUE from added N were observed in several dry-land areas where crops were grown on the same land for several years. Maximum yield and highest WUE under optimum fertilizer inputs of 90 kg N ha1 and 13 kg P ha1 in the semiarid field conditions of a loess hilly area in Ningxia. Increased N fertilizer application was positively correlated with yield (correlation coefficient, 0.96) and WUE (correlation coefficient, 0.89) of spring wheat. N fertilizer applied in spring wheat improved the development of the root system and especially enhanced the root growth in the cultivated 0 to 20 cm soil layer **(**R.Kro bel *et al*., 2012).

The increased root system in the fertilized plants was able to improve crop water use and nutrient absorption and hence crop yield and WUE were increased. He et al. (1999) conducted experiments to clarify the effects of water and N fertilizer and animal manures on WUE of potatoes. The results showed that both N and water supply very significantly increased WUE. In northern China, the crop WUE increased steadily over 10 years from 0.22 to 0.90 kg m3 due to technological developments **(**R.Kro bel *et al*., 2012).

The increase in WUE was mainly caused by the establishment of water conservation measures, soil improvement, the adoption of new crop varieties and the continuous use of increasing amounts of N fertilizers. Fertilizers including nitrogen have a great potential to further increase the efficiency of water use, especially for crops that grow in autumn when the water supply is plentiful. Nitrogen, an important macronutrient, affects photosynthetic capacity of leaves by increasing stromal and thylakoid proteins in leaves and being an integral part of DNA, RNA, chlorophyll and other molecules, it plays an important role in cell metabolism. Absorption and utilization of nutrients like N by plants growing under water stress is very critical for plant growth and productivity (Sami Ul-Allah, 2015).

Water stress results in a depression in nutrient uptake particularly of N which may contribute towards reduced yield. In addition, although the crop may have roots penetrating the deeper and wetter parts of the soil profile, nutrients concentrated in a dry surface may be unavailable to plants. Availability of N and consequently the response to N applied as fertilizers or in other forms is closely related to the ability of plant roots to absorb water from soil. When water inside the plant declines below a threshold level, stomata close which causes a decrease in transpiration resulting in a reduction in water transport through the plant. This in turn, affects the roots' ability to absorb water and nutrients as effectively as under normal transpiration. Inhibition of nutrient uptake by plants in dry soils also relates to the nutrient transport in soil by mass flow and diffusion, which may diminish nutrient availability at the root surface as well as cause a decrease in mineralization of organically bound nutrients **(**R.Kro bel *et al*., 2012).

Severe drought may further decrease nutrient transport to the root surface by inducing root shrinkage and which thus causes loss of soil root contact. Inorganic fertilization has been reported to mitigate the adverse effects of water stress by increasing the WUE of crop growth and development. Under mild water stress low doses of N increased grain yield in winter wheat, however under severe water conditions high N application proved to be detrimental. Wheat plants were grown under low (N0P0) and high (N80P80) fertility conditions and water stress was imposed at various stages of a plant's life cycle, increasing intensities of stress adversely affected leaf metabolism and plant performance (EJAZ *et al*., 2011).

However, the performance of plants was better under high fertility conditions, at all stages, under different intensities of water stress. Nitrogen application minimizes the adverse effect of drought on dry matter and grain yield in pearl millet. This indicates that in dry land agriculture, where water is a limiting factor, fertilizer application to a reasonable extent can be considered for drought mitigation management (EJAZ *et al*., 2011).

Phosphorus

Phosphorus being a constituent of nucleic acids, phospholipids, phosphor-proteins, dinucleotides and adenosine triphosphate is required for processes including the storage and transfer of energy, photosynthesis, the regulation of some enzymes and the transport of carbohydrates. Soils in arid areas are often calcareous and have high pHs (e.g. those in Mediterranean regions). In the semi-arid tropics, soils are often rich in aluminium and iron oxides, and the pHs are low. Both of these soil types show a strong tendency for P fixation **(**R.Kro bel *et al*., 2012).

It is generally accepted that the uptake of P by crop plants is reduced in dry-soil conditions. For example, the translocation of P to the shoots is severely restricted even under relatively mild drought stress. However, large amount of molecular exudates (i.e. mainly mucilage) from plants in dry soil counteract the reduced mobility of P under such conditions **(**R.Kro bel *et al*., 2012).

P deficiency appears to be one of the earliest effects of mild to moderate drought stress in soil-grown plants. The application of P fertilizer can improve plant growth considerably under drought conditions. The positive effects of P on plant growth under drought have been attributed to an increase in stomatal conductance, photosynthesis, higher cell-membrane stability, water relations and water-use efficiency. Priming seeds with solutions containing the limiting nutrients under drought conditions (such as P and Zn) can improve barley establishment. Strategies for increasing nutrient uptake by over expressing genes encoding for high-affinity P transporters are likely to be an important strategy in the future, especially in light of the increasing problems caused by P-deficient soils of the semiarid tropics (EJAZ *et al*., 2011).

2. Micro nutrients

The contributions of micro nutrients in enhancing water use efficiency are not well-defined. Micronutrients help the macro nutrients in enhancing WUE by activation of certain physiological, biochemical and metabolic processes within the plant body. Boron is directly or indirectly involved in several physiological and biochemical processes during plant growth such as cell elongation, cell division, cell wall biosynthesis, membrane function, nitrogen (N) metabolism, leaf photosynthesis and uracil synthesis (Sharma, 2006).

Zinc is an essential nutrient for plant growth and development. Crop productivity is limited due to its deficiency Zinc is involved in cellular functions such as protein metabolism, photosynthetic carbon metabolism and indole acetic acid (IAA) metabolism. Nutritional stress of zinc may affect plant water status, net CO2 assimilation rate, stomatal conductance and transpiration rate (BenRouina et al., 2006).

ii. Mulching

Mulching with crop residues can improve water use efficiency by 10 to 20% through reduced soil evaporation and increased plant transpiration. Mulching with crop residues during the summer fallow can increase soil water retention. Straw mulching can be easily implemented by local farmers because material is easily accessible, low cost and does not contaminate the soil. Combined with N, P and potassium (K) fertilizers, mulching of residues can improve yields by at least 1500 kg ha1. Plastic film has also been widely used to mulch the soil surface and promote crop growth during early growth when temperatures are low. Several methods of using plastic film have been adopted, including sowing wheat and rice through holes in the plastic, sowing maize and wheat in rows in the furrow with plastic between the rows, and mulching two subsequent crops with the same plastic film. Effects of rainwater harvesting on WUE and yield of winter wheat. They used ridge-furrow tillage, the ridge being mulched by plastic for rainwater harvesting in the furrows (Wang *et al*., 2004).

iii. Tillage

Increasing water storage within the soil profile is necessary to increase plant available soil water. Tillage roughens the soil surface and breaks apart any soil crust. Though this leads to increased water storage by increased infiltration into soil as well as increased soil water losses by evaporation when compared with a residue covered surface or an undisturbed surface it facilitates water use efficiency of crops (EJAZ *et al*., 2011).

iv. Terracing and contour farming

With frequent farming activities and a high degree of cultivation, sloping land with an angle of 10 to 258 is highly susceptible to soil erosion. Cultivation on such slopes can lead to erosion of 0.43 cm and 48 t ha^{1} of fertile topsoil. Changing such sloping land into contour terraces prevents water and soil erosion, raises land quality and grain yield by increasing WUE. Sloping land with an angle of 6 to 108 can be improved by planting crops along the contour using a 0.5-m deep and 1-m wide trench or ridge to conserve soil and water, improve soil fertility and facilitate sustainable development. In the semiarid Loess Plateau, the building of level terraces has enhanced water infiltration, raised the rainfall utilization rate and created high-yielding farmland while also conserving the soil and water. Combined with other agricultural techniques, it has played a major role in increasing the productivity and sustainability of the region (Deng *et al*., 2000).

c. Relation between Inorganic Fertilizer with Water Use Efficiency of Crops

Use of mineral fertilizer seems to be a very quick and efficient method but the cost on energy is very high and there are several environmental concerns. There are very little choices available to increase the food production through the use of available resources. Water scarcity is one of the problems which hamper the yield of crops. Special emphasis should be given to the effective use of resources for growing crops (Anonymous, 2014).

The ratio of consumption of fertilizer has been skewed towards nitrogen. In case of china the ratio of usage of nitrogen, phosphorus and potassium fertilizers is 6.7:2.4:1, as compared to the recommended usage ratio of 4:2:1. The government recommended that a strategy should be initiated to promote the balanced use of fertilizers and. increasing the use of bio-fertilizers, and move towards organic farming for sustainable production through increasing nutrient use efficiency, WUE and other physiological processes of crops (TanviDeshpande, 2016).

d. Relation between Organic Fertilizer with Water Use Efficiency of Crops

Organic amendments incorporation may enhance the organic matter content of the soil leading towards the excessive moisture conservation and plant nutrient availability. The soil temperature is inversely correlated with the organic matter content, so the moisture depletion rate might be decrease with the increased organic matter content. Different researchers have found that organic manures applied in integration with the inorganic fertilizers gave higher yield than sole chemical fertilizers (Abdus*et al*., 2017).

Water holding capacity of soils which has role for water use efficiency of crops is controlled primarily by the number of pores and pore-size distribution of soils; and the specific surface area soils. Because of increased aggregation, total pore space is increased. Furthermore, as a result of decreased bulk density, the pore-size distribution is altered and the relative number of small pores increases, especially for coarse textured soils. Since the tension which causes a particular pore to drain is dependent on the effective diameter of the pore, greater tension is required to drain small pores, compared to large pores. The increased WHC at lower tensions such as those at field capacity is primarily the result of an increase in number of small pores. At higher tensions close to wilting range, nearly all pores are filled with air and the moisture content is determined largely by the specific surface area and the thickness of water films on these surfaces (A.Vengadaramana*et al*., 2012).

Sandy soils have much less surface area than clayey soils and, thus, retain much less water at higher tensions. However, with the addition of organic matter, specific surface area increases resulting in increased WHC at higher tensions. Soil "holds" water available for crop use, retaining it against the pull of gravity. This is one of the most important physical facts for agriculture. If the soil did not hold water, if water was free to flow downward with the pull of gravity as in a river or canal, we would have to constantly irrigate, or hope that it rained every two or three days. There would be no reason to pre-irrigate and there would be no such thing as dry-land farming (A.Vengadaramana*et al*., 2012).

Soil texture and organic matter are the key components that determine soil water holding capacity. Application of wastes, either for plant nutrient supply or for disposal purposes, increases the C content of the soil. An increase in C content of the soil increases aggregation, decreases bulk density, increases water holding capacity, and hydraulic conductivity (A.Vengadaramana*et al*., 2012).

Increase organic matter concentrations in soil have showed to enhance the yield of cereals improve soil properties i.e. soil density, soil aeration and enhance the soil water holding capacity for plant growth and root development. Compost is an important source of plant nutrients as it contains greater organic matter content. Compost along with increment of soil organic matter also improves the physico - chemical attributes of soil and it ultimately results in increased yield of crop (Abdus*et al*., 2017).

2. SUMMERY AND CONCLUSION

Overall WUE in plant is a function of capacity of soil to supply adequate levels of nutrients, and ability of plant to acquire, transport in roots and shoot and to remobilize to other parts of the plant. Plants interaction with environmental factors such as solar radiation, rainfall, temperature and their response to diseases, insects and allelophathy and root microbes have a great influence on WUE in plants.

Water use efficiency represents a given level of biomass or grain yield per unit of water used by the crop. With increasing concern about the availability of water resources in both irrigated and rainfed agriculture, there is renewed interest in trying to develop an understanding of how WUE can be improved and how farming systems can be modified to be more efficient in water use.

Water holding capacity refers to the amount of water held between field capacity and wilting point. Soils vary in their water holding capacity according to their structure, texture and bulk density relationship to total pore size distribution. Soil with little water holding capacity soon dries out, reducing evaporation from its surface. In turn, the rapid decrease in soil water potential places the vegetation under greater stress, which in turn reduces transpiration as the stomata's close. Photosynthesis is accordingly reduced and all this results crops WUE reduction. Water use efficiency, growth and yield attributes of crops and soil properties could be improved with the use of inorganic and organic fertilizers.

A number of approaches are being used to enhance water use efficiency and to minimize the detrimental effect of water stress in crop plants. Proper plant nutrition is a good strategy to enhance water use efficiency and productivity in crop plants. Plant nutrients play a very important role in enhancing water use efficiency under limited water supply.

With water shortages and drought affecting many regions of the world, it becomes urgent to increase water use efficiency (WUE) by optimizing irrigation schedule. Proper irrigation scheduling, which includes integrating of soil moisture monitoring, surface Evapo transpiration loss calculation, and plant based measurements is required for high WUE. Stem water potential (SWP) has become one of the more common methods to measure water status. It is, however, labor intensive and time consuming, and adoption has been slow. In plants, drought can cause reduction in photosynthetic rate, chlorophyll content, stomatal conductance, transpiration rate and relative leaf water content, and destruction of some physiological processes, which ultimately reduce plant growth and development.

An environmental stress like drought contributes significantly to reduce crop yields well below the potentially maximum yields which ultimately results in the reduction in WUE. Due to these risks, it is necessary to minimize the detrimental effects of drought in plants (primary producers) below permissible limits. The management of plant nutrients is very helpful to enhance WUE by reducing the detrimental effects of drought. Better plant nutrition can be helpful to utilize the available water more efficiently by a number of mechanisms.

Application of nutrients like N, K, Mg, B, Zn and Si reduce the toxicity of reactive oxygen species (ROS) produced under water-limited conditions by increasing the concentration of antioxidants like superoxide dismutase (SOD); Catalase (CAT) and peroxidase (POD) in the plant cells. These antioxidants scavenge ROS and reduce photo-oxidation and maintain the integrity of chloroplast membrane and increase the photosynthetic rate in the crop plants which in turn enhances the WUE. Some plant nutrients like P, K, Mg and Zn improve root growth. Improvement in root growth increases the intake of water which helps in stomatal regulation and enhances the photosynthetic rate and increases water use efficiency

These nutrients help to maintain high tissue water potential and improve the WUE under water stress condition. The micronutrients like Fe, B, Mn and Mo improve the WUE by alleviating the adverse effects of drought indirectly by activating the physiological, biochemical and metabolic processes in plants (EJAZ *et al*., 2011).

REFERENCE

A.Vengadaramana,Jashothan and P.T.J, 2012. Effect of organic fertilizers on the water holding capacity of soilin different terrains of Jaffna peninsula in Sri Lanka. *Department of Botany, Faculty of Science, University of Jaffna, Sri Lanka.*

AbdusSubhan, QudratUllah Khan, Muhammad Mansoor and M. Jamil Khan, 2017. Effect of Organic and Inorganic Fertilizer on the Water Use Efficiencyand Yield Attributes of Wheat under Heavy Textured Soil. Department of Soil and Environmental Sciences, Gomal University, Dera Ismail Khan; Arid Zone Research Center (AZRC-PARC), D.I. Khan, Pakistan.

Anonymous, 2014. Economic Survey of Pakistan 2014-2015. Government of Pakistan, Finance Division, Economic Advisory Wing, Islamabad.

Ben-Rouina, B., Chedli, B. A., Rehman, H. A., & Muhammad, B., 2006.Water relations, proline accumulation and photosynthetic activity in olive tree (OleaeuropaeaL. cv. ‘‘Chemlali’’) in response to salt stress.Pakistan Journal of Botany, 38, 13971406.

Deng, X. P., Wang, S. Q., &Peng, K. S., 2000.Assessment of food productive potential on the different land type in the middle-scale eco-agricultural research area of Yan’an.Journal of Chinese Soil Water Conservation, 14, 8791.

Egata Shunka Tolessa, Derbew Belew, Adugna Debela and Beshir Kedi, 2016. Ethiopian Institute of Agricultural Research, Holetta Research Center, Horticulture Research Division, Ethiopia. Jimma University College of Agriculture and Veterinary Medicine, Ethiopia

Ejaz Ahmad Waraich, Rashid Ahmad, M. Yaseen Ashraf, Saifullahandmahmood Ahmad, 2011. Improving agricultural water use efficiency by nutrient management in crop plants. Acta Agriculturae Scandinavica Section B Soil and Plant Science, 2011; 61: 291304.

M. F. Fonteh, F. O. Tabi, A. M. Wariba, and J. Zie, 2013. Effective water management practices in irrigated rice to ensure foodsecurity and mitigate climate change in a tropical climate. Department of Agricultural Engineering, Faculty of Agriculture, University of Dschang, PO Box 447, Dschang, West Region, Cameroon. Tel: +237 7774 0863, Fax: + 237 3345 1385.

MuhammadYousaf, Jifu Li, Jianwei Lu, Tao Ren, Rihuan Cong, Shah FahadandXiaokun Li, 2017. Effects of fertilization on cropproduction and nutrient-supplyingcapacity under rice-oilseed raperotation system.

R.Kro bel, C. A. Campbell, R. P. Zentner, R. Lemke, H. Steppuhn, R. L. Desjardins, and R. De Jong, 2012. Nitrogen and phosphorus effects on water use efficiency of spring wheat grown in a semi-arid region of the Canadian prairies. Effect of Nitrogen Rates and Irrigation Regimes on Water Use Efficiency of Selected Potato Varieties in Jimma Zone, West Ethiopia

Sami U-Allah, Asif Ali Khan, Thomas Fricke, Andreas Buerkert, 2015. Effect of fertiliser and irrigation on forage yield and irrigation water use efficiency in semi-arid regions of Pakistan.

Shao JianZheng, 2010. Crop production on acidic soils: overcoming aluminium toxicity and phosphorus deficiency. College of Life Sciences, Zhejiang University, Hangzhou 310058, China for correspondence. E-mail sjzheng@zju.edu.cn

Sharma, C. P., 2006. Plant micronutrients. Enfield, NH: SciencePublishers.

TanviDeshpande, 2016. Impact of chemical fertilizers and pesticides on agriculture and allied sectors in the country.Standing Committee Report Summary

Tiebiao Zhao, Brandon Stark, YangQuan Chen, Andrew L. Ray and David Doll, 2016.Challenges in Water Stress Quantification Using Small UnmannedAerial System (sUAS): Lessons from A Growing Season of Almond. International Conference on Unmanned Aircraft Systems (ICUAS)June 7-10, 2016. Arlington, VA USA.

V. C. Baligar,N. K. Fageria,and Z. L., 2010.Nutrient use efficiency in plants.USDA-ARS AFSRC Beaver, WV 25813-9423 EMBRAPA-CNPAF, Goania, GO Brazil 74001–970 Zhejiang University Dept. of Natural Resource, Hangzhou, China 310029.

Wang, C. R., Tian, X. H., & Li, S. X., 2004.Effects of plastic sheet-mulching on ridge for water-harvesting cultivation on WUE and yield of winter wheat. Scientia Agricultura Sinica, 37, 208214.