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Editorial: Improving Water Productivity in Dry Areas

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Introduction

About 41% of the Earth's land area is classified as dryland wherein the farming system is characterized by approximately 300-500 mm of annual rainfall. The low rainfall, which is not only insufficient but irregular, constitutes a major challenge to profitable farming in dry areas. Nevertheless, local populations depend on these lands for producing food and drylands are inhabited by more than two billion people worldwide.

With a growing and more affluent global population, food demand is projected to nearly double by 2050. Without increases in water productivity, crop water requirements may increase by 70-110% with potentially serious implications for the environment. There is an urgent need to reduce the amount of water abstracted for agriculture by producing more food, income, livelihoods, and ecological benefits at less social and environmental costs per unit of water used. Water productivity, defined in physical terms, is the ratio of the mass of agricultural output to the amount of water used. In an economic sense, water productivity reflects the value derived per unit of water used. Improving physical water productivity in irrigated and rainfed agriculture reduces the need for additional water and is thus a critical response to increasing water scarcity.

Fortunately, there is substantial scope for improving physical water productivity in both rainfed and irrigated agriculture, particularly in dry areas of Africa and Asia where yields are low because of sub-optimal nutrient and water supply.

There is great interest in learning from success stories from research in drylands around the world which this Special Issue aims to capture. A total of twelve articles are included in this Issue which report on studies carried out in rainfed as well as irrigated drylands of India and Pakistan in South Asia, irrigated drylands from Uzbekistan in Central Asia, hyper-arid drylands of Saudi Arabia, Egypt and Morocco and semi-arid drylands of Lebanon in West Asia and North Africa.

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Dhehibi *et al.* (2016) report on the impacts of primary production factors on the total production of the main crops produced in Egypt. Findings show increasing returns to scale for berseem and cotton, but decreasing returns to scale for wheat, rice and maize production. Except for berseem and wheat, the irrigation water productivity for rice, cotton and maize were relatively low compared to the global average levels reported by the FAO (1.09, 0.65 and 1.80 kg m^{-3} for rice, cotton and maize, respectively). Overall, marginal productivity of irrigation water for the studied crops, especially for cotton, was low. Farmers have scope for increasing the production of these crops by applying water more efficiently. This, according to authors, highlights the need for improving irrigation performance through improved water management practices.

Karam and Nangia (2016) report of a twelve-year experiment conducted in Lebanon to determine the effects of deficit irrigation on yield and water productivity in six annual crops; maize, soybean, cotton, sunflower, bell pepper and eggplants. Results show that deficit irrigation caused in all crops lowering of yields but resulted in higher water productivity compared to the well-irrigated control. For soybean, deficit irrigation at mature seeds was more profitable compared to full bloom and seed enlargement. Moreover, flowering was most critical growth stage for sunflower and therefore deficit irrigation should be avoided at this stage, while it is acceptable at seed formation. For cotton, timing deficit irrigation at first open boll provided the highest lint yield with maximum water productivity, in comparison to deficit irrigation at early- and mid-boll loading. For maize, deficit irrigated-treatments at 80% and 60% of crop evapotranspiration produced less seed yield but resulted in higher water productivity than the well-irrigated control. In bell pepper and eggplants, deficit irrigation at 80% of crop evapotranspiration is recommended to obtain higher yield and water productivity.

Parmar and Gontia (2016) applied SEBAL remote sensing tool to estimate crop water demand and compared it with the FAO-56 method for performance assessment in the Ozat-II canal command area of Junagadh district of India. The irrigation efficiency of the study area was found to be very low at 28.22% and 30.68% based on crop evapotranspiration (ET_c) FAO-56 method and SEBAL-based actual evapotranspiration (AET), respectively. The water-use efficiency of summer groundnut and sesame crop were lower as 1.03 kg ha^{-1} mm^{-1} and 0.707 kg ha^{-1} mm^{-1}, respectively. The maximum WUE of summer groundnut was found to be 4.38 kg ha^{-1} mm^{-1} as per FAO-56 and 2.93 kg ha^{-1} mm^{-1} for summer sesame using AET method. The results, according to authors, suggest that there is a significant scope for increase land and water productivity in Ozat-II canal command by adopting crop water requirement estimation based on remote sensing tool.

Saxena *et al.* (2016) as well as Rathore *et al.* (2016) compared different cropping systems for their water productivity. Saxena *et al.* (2016) compared production potential of four different cropping system for two successive years in field conditions during. Ladyfinger-tomato-melon rotation gave the highest total yield (117.2 t ha^{-1}) under drip irrigation system. This system also gave the highest water-use efficiency (1.73 kg m^{-3}) while the lowest consumptive use of water (97.5 cm) was registered in ladyfinger-ladiolus-melon rotation. In terms of economics, tomato-gladiolus-ladyfinger crop rotation was the most profitable followed by ladyfinger-tomato-melon. Authors conclude that, ladyfinger-tomato-melon is the most suitable cropping rotation under arid ecosystem of western India.

Aziz *et al*. (2016) and Soni *et al*. (2016) employ different crop simulation models to simulate scenarios under which water productivity can be maximized. Results of Aziz *et al*. (2016) showed that CERES-Wheat and CERES-Barley models were calibrated well using the field trial data in predicting phonological stages as well as grain yield at different locations using different treatments. Scenario simulations showed that optimum sowing date for wheat and barley was between 20 and 30 November and 25 November and 5 December, respectively, and in case of dry year 30 mm supplemental irrigation should be applied at the time of sowing or 30 DAS. Soni *et al*. (2016) calibrated CropSyst model using the experimental data of crop parameters, soil profile data and observed daily weather data of experimental site for 2012-13 and validated using the experimental data of crop growth, yield parameters and soil moisture for 2013-14 for psyllium crop grown at farmer's field in IGNP stage-II of Bikaner, India. The results showed that the model calibrated seed yield, above ground biomass and soil moisture reasonably well. The simulated seed yield of psyllium matched well with the observed yield with relative error of 7.1%. The observed above ground biomass at harvest also matched with simulated with relative error of 8.1%. During validation, prediction of simulated seed yield was very good and matched well with the observed seed yield with relative errors of 7.3%. Simulated soil moisture was also predicted well for most of the soil layers.

Yadava and Chauhan (2016) and Sikaoui *et al.* (2016) tested the use of drip irrigation method to improve the water productivity in dry areas of western India and southern Morocco, respectively. Yadava and Chaudhan (2016) conducted a study to optimize crop geometry under drip system, optimum drip irrigation schedule and optimum fertigation schedule for American cotton (hybrid *hirsutum* cotton), Bt cotton, sugarcane and brinjal. The pooled results of the trials revealed that paired planting in Bt cotton, sugarcane and brinjal was most cost effective. In American cotton, paired planting gave significantly higher seed cotton yield over single row planting. Drip irrigation schedule at 1.0 ET_c, 1.0 ET_c, 80% PE and 1.0 ET_c were found to be optimum for American cotton, Bt cotton, sugarcane and brinjal, respectively. The increase in yield of respective crops was 24.2, 31.0, 26.4 and 30.9% and saving of water was 13.3, 32.9, 17.1 and 29.6% over conventional practice. Drip irrigation also improved the quality of produce by increasing fiber length and fineness in cotton lint and commercial cane sugar to the extent of 35.8% over conventional practice. Drip irrigation also suppressed the pest population in cotton. The increase in yield of respective crops due to optimum fertigation schedule was 49.8, 15.6, 20.7 and 30.6% and water saving was 13.3, 24.3, 25.0 and 29.6% and fertilizer saving was 0, 20, 25 and 20% over conventional practice of irrigation and fertilizer application. In both drip irrigation and fertigation, water-use efficiency increased by 43.3 to 85.9% over that of conventional practice. Sikaoui *et al*. (2016) conducted a four year study on olive plantations to optimize irrigation water management practices. Results indicated that adding water at 70% of crop evapotranspiration using drip irrigation led to 63-77% saving in water compared to flood irrigation along with a 13-43% increase in yield. At the policy level, switching from flood to drip irrigation (100% of crop evapotranspiration) on 25% of the olive planted area in the country can lead to additional olive fruit worth USD 213 million and switching to deficit drip irrigation (70% of crop evapotranspiration) can lead to an additional olive fruit worth USD 390 million from the same size area.

Ihsan *et al*. (2016) conducted a study in Saudi Arabia to select drought-resistant wheat genotypes. Drought stress was applied as 100% and 50% of total crop water requirement on four wheat cultivars-Yocoro rojo (YR), Faisalabad (Fsd), Millat and F-50. Drought stress significantly decreased crop growth, yield and yield components while increased water use efficiency, harvest index and stress susceptibility index, however the effect of genotypes was significant for all traits except harvest index. The cv. Fsd throughout growth period presented higher values for leaf area index and dry matter accumulation. Maximum days to 50% maturity (93 d), water-use efficiency (8.88 kg ha^{-1} mm^{-1}), harvest index (28.79%), stress susceptibility index (1.23) and stress tolerance index (39%) were recorded for cv. Fsd. The drought tolerance potential of the genotype resulted in up to 21% increase in final grain yield under drought stress as compared to local cv. YR. Correlation analysis estimated the highest contribution of water-use efficiency and stress indices towards genotype drought tolerance that translated in term of final grain yield.

Finally, Mukhamedjanov *et al*. (2016) used the evapotranspiration-based irrigation scheduling method which has the potential to replace subjective daily water management decisions at Water Users Association (WUA) level with crop water demand-based decisions to improve on-farm water-use efficiency. Results from a two year study conducted in Fergana Valley of Uzbekistan showed that there can be a 25-34% saving of water without any significant change in yield when irrigation is applied using the ET-based scheduling method.

We hope that this Special Issue will encourage development of further studies on improving water productivity in dry areas.

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