OPEN ACCESS Int. J. Agr. Ext. 09 (02) 2021. 239-244 DOI: 10.33687/ijae.009.02.3528

Check for updates

Available Online at EScience Press Journals
International Journal of Agricultural Extension
ISSN: 2311-6110 (Online), 2311-8547 (Print)
https://www.esciencepress.net/journals/IJAE

EFFECT OF DEFICIT DRIP IRRIGATION ON YIELD AND WATER PRODUCTIVITY OF POTATO CROP

[a]Syed Ijaz-ul-Hassan*, [b]Arifa Khan*, [c]Shazia Erum
[a] *Potato Research Institute, Sahiwal, Pakistan*
[b] *International Islamic University, Islamabad, Pakistan*
[c] *Bio Resources Conservation Institute, National Agriculture Research Center, Islamabad, Pakistan.*

ARTICLE INFO

Article History
Received: February 10, 2021
Revised: April 28, 2021
Accepted: August 25, 2021

Keywords
Potato
Management Allowable Depletion (MAD)
Yield
Water productivity

ABSTRACT

On the eve of changing climate, it is expected that there will be a competition to reallocate water for agricultural, industrial and urban needs in near future. Thus, in view of the increased water scarcity, an adequate management for water application is required to maximize water use and increase yield. In this regard, a field trial comprising four deficit drip irrigation treatments on potato crop under drip irrigation was conducted in filed condition using RCB design with four replications. Cropwat 8.0 program was used to determine the interval and depth of next irrigation at 15, 30, 45 & 60% management allowable depletion (MAD) of soil moisture. The outcomes indicated that irrigation to potato crop at 30% MAD level gave the highest water productivity (17.28 kg/m3) followed by 60, 15 and 45% MAD levels. Maximum %age of medium sized tuber was achieved by applying irrigation to potato crop at 60% MAD level (65.70) followed by 30% MAD level (65.5), 45% MAD (64.0) and 15% MAD level (60.50). The incidence of scab was found 2.50%, 2.75%, 3.25% and 3.75% in potato tubers at 15, 30, 45 and 60% MAD level, respectively. Thus, growers can save the water by adopting this water saving technique without reduction in tuber yield. For proper adaptation of new technique and practice, common farmer of Pakistan should be educated in term of visits to govt. research institutions and adoptive research farms to understand the right step to words better yield.

Corresponding Author: Syed Ijaz-ul-Hassan
Email: syedejazqutbi@gmail.com
© The Author(s) 2021.

INTRODUCTION

Potato is very important food crop and it stands at 4th position in production (388 million tons) after corn, rice and wheat at world level (Majeed and Muhammad, 2018). It is grown in more than 100 countries of the world and used as a staple food for 1.3 billion people worldwide (Sampaio *et al.*, 2020). It provides strength (carbohydrates) in the food chain and cheap source of calories to meet the need of increasing population (Zhang *et al.*, 2017). In Pakistan, the area and production of potato during 2017-18 was 0.18 million hectares with total production of 4.0 million tons, averaging 22.4 ton/ha (Ullah *et al.*, 2020). Potato scab is a common disease of potato tubers that affects the potatoes throughout the potato cultivated areas in the world. It is caused by an organism pathogen, Streptomyces scabies, which is soil born pathogen. Though total yield is not influenced by scab however considerable economic losses may occur due to reduction in marketability of potatoes (Loria, 2021).

The irrigation water is very valuable input for the production of potato. As the population of the country is increasing the availability of water per capita is decreasing day by day. According to water security risk index 2010, Pakistan ranked at 7th position in the list of countries having extreme risk of water shortage (Maplecroft, 2010). Even under such water-stressed conditions, major irrigation systems (i.e. basin, border, and furrow irrigation) are still in practice in Pakistan, while these systems have very low application efficiency and productivity vary from 23 to 70% (Akbar *et al.*, 2020; Kahlown *et al.*, 2007). The situation is alarming if the water productivity and yield of food crops not improved. Early studies have shown that water is the most important limiting factor for potato production and it is possible to increase production levels by well-scheduled irrigation programs throughout the growing season (Zhou *et al.*, 2020; Onder *et al.*, 2005). In view of the increased water shortage better management of water application is required for farmers seeking a viable mean to maximize water use and to increase yield. To achieve this goal, there is dire need to adopt water conservation, sowing techniques and modern high efficiency irrigation systems.

Compared to other irrigation methods, subsurface drip irrigation system is considered the most efficient method (Ghazouani *et al.*, 2019). However, the most effective way to increase WUE is the precise control of irrigation. Several strategies aimed to reduce irrigation volumes have been developed, such as Management Allowed Depletion (MAD). Safdari *et al.* (2018) reported a high grain yield of barley by scheduling irrigation at 30% Management Allowed Depletion (MAD) level. Moreover, better economic production could be achieved by increasing more delay in irrigation. Thus, the importance of potato crop and decreasing water sources, the present study was conducted with the objective to test the different irrigation regimens that fit best in the farm settings of Pakistan, the effect of different irrigation regimens on potato yield and scab incidence on potato crop under different levels of soil moisture depletion.

MATERIALS AND METHODS

The field experiment was conducted at Water Management Research Farm (WMRF), Renala Khurd, District Okara, Punjab, Pakistan during 2018-19 cropping season. Research experiment was comprised of four MAD (irrigation) levels i.e. MAD15%, MAD30%, MAD45% and MAD60% under drip irrigation system, and potato variety Karuda was used. The design of experiment was randomized complete block design with four replications. The plot size was each treatment was 4.3 m × 14 m. The descriptions of experimental treatments are shown in the following lines.

MAD15% = Irrigation was done when soil water content was depleted to 15% of the available water
MAD30% = Irrigation was done when soil water content was depleted to 30% of the available water
MAD45% = Irrigation was done when soil water content was depleted to 45% of the available water
MAD 60% = Irrigation was done when soil water content was depleted to 60% of the available water

Cropwat 8.0 program was used to calculate the irrigation depth for all the four MADs levels. A measured quantity of irrigation water was applied to each treatment to maintain the soil moisture content according to the MADs levels through drip irrigation system. The plant-to-plant distance was maintained as 15 cm whereas paired row to row distance was maintained as 60 cm. The drip irrigation system was used where drip lateral was placed between the paired rows. All other standard agronomic and cultural practices were adopted up to maturity of the crop. Data regarding tuber yield and water productivity were collected as per plot basis while the tuber size (small, medium and large) was taken in % age from the sample of 100 randomly selected potatoes from each plot. The scab incidence was noted from a unit area randomly selected from each treatment of each replication.

$$\text{Scab incidence (\%)} = \frac{\text{Number of infected plants in unit area}}{\text{Total number of plants in unit area}} \text{ X } 100$$

Water productivity was calculated through the formula given below;

$$\text{Water productivity (kg m}^3\text{)} = \frac{\text{Tuber yield (kg)}}{\text{Volume of irrigation water applied (m}^3\text{)}}$$

Statistical analysis

The data collected was analyzed by co-stat program in excel sheet.

RESULTS

Tuber size (mm)

Results elucidated that size of potato tubers were not affected by different MAD levels (Table 1). However, maximum medium size tubers were harvested more under 60% MAD level (MAD) followed by MAD30%, MAD45% and MAD15% while smaller size tubers were produced lesser in case of 45% MAD level.

Tuber yield (kg ha-1)

Results indicated that various MADs levels significantly influenced the tuber yield of potatoes (Figure 1). The highest potato tuber yield (28411 kg ha^{-1}) was obtained with MAD level of 60% moisture depletion which was statistically equal to 30% MAD level (27998 kg ha^{-1}). Minimum tuber yield was noted for MAD 45% level (24081 kg ha^{-1}) which also was at par with and 15% MAD1 level.

Water productivity (kg m-3)

Water productivity indicates the economic yield produced by a unit volume of irrigation. Data showed that water productivity was affected by different MADs levels (Figure 2). The water productivity for Karuda variety ranged from 14.60 to 17.28 kg/m^{-3}. The maximum water productivity expressed with irrigation at 60% MAD level (17.28 kg/m^{-3}) which was statistically equal to MAD 30% and MAD 15% levels. The least water productivity was recorded for MAD 45% level (14.60 kg/m^{-3}).

Scab incidence (%)

Results revealed that scab incidence varied from 2.50 to 3.75% in potatoes (Figure 3). Maximum incidence was depicted in potatoes when irrigated at MAD 60% (3.75%) and decreased as MADs levels decreased. Minimum incidence of scab incidence was noted for MAD 15% (2.5%) followed by MAD 30%.

Table 1. Effect of applying irrigation with drip system at different MADs levels on the sizes of potato tubers.

Treatment	Percentage of different sizes of tubers		
	Medium (35-55mm)	Large (>55mm)	Small (<35mm)
MAD15%	60.50%	18.75%	20.75%
MAD30%	65.50%	15.25%	21.75%
MAD45%	64.00%	17.75%	18.25%
MAD 60%	65.75%	15.75%	18.50%

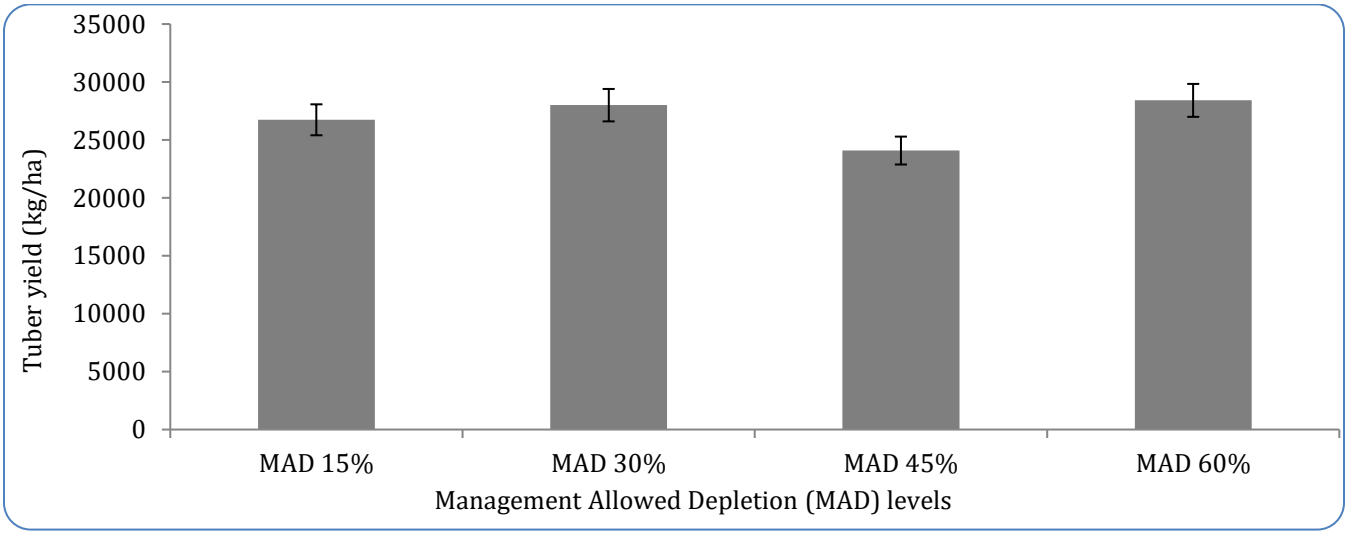

Figure 1. Effect of different MADs levels on tuber yield.

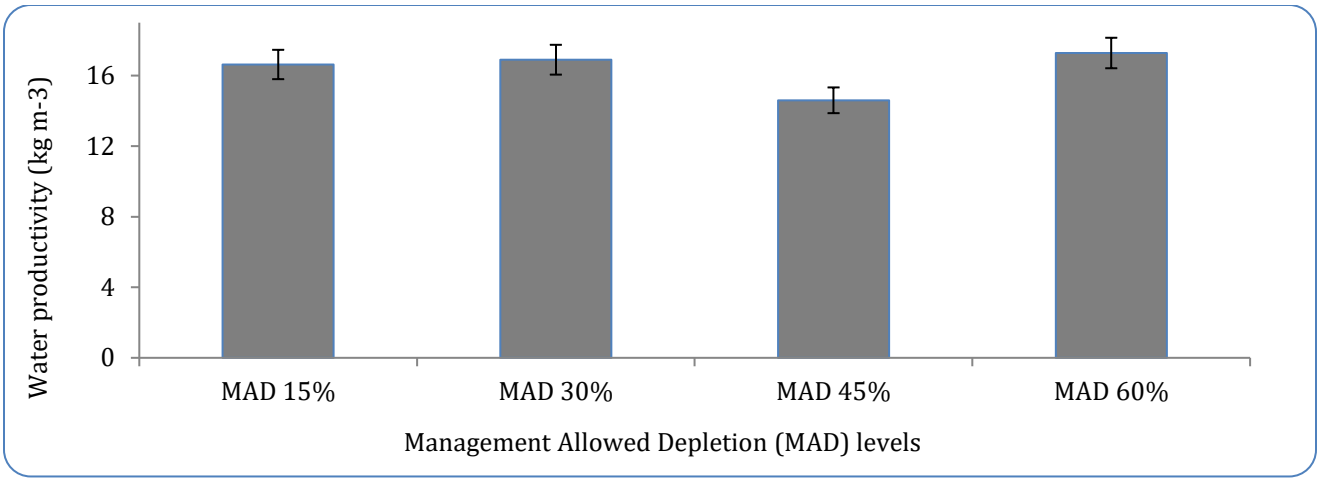

Figure 2. Effect of different MAD levels on water productivity of potato.

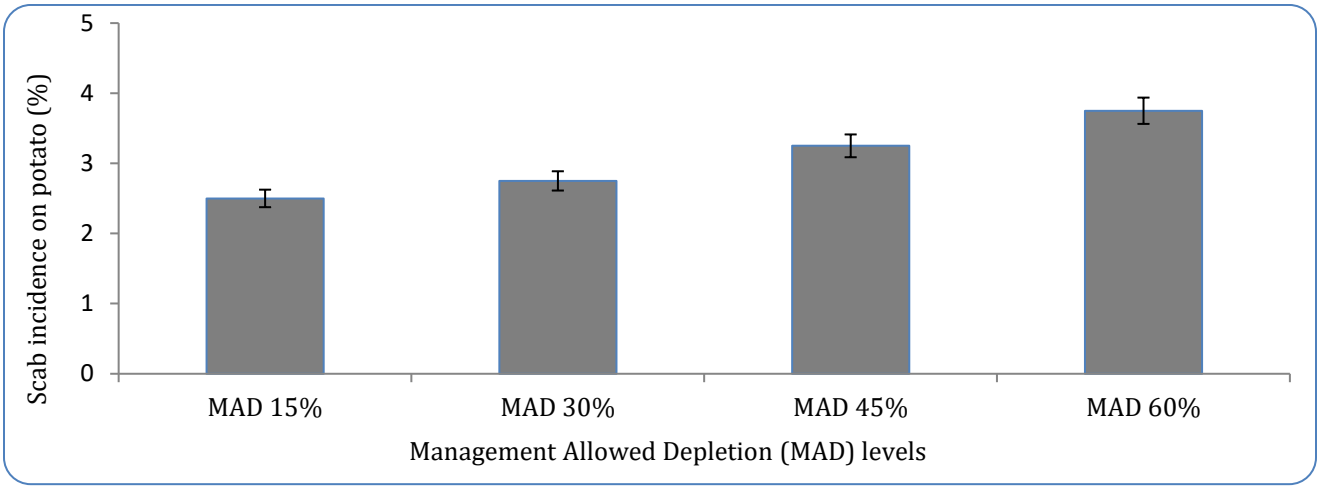

Figure 3. Scab percentage of incidence of potato tubers with different MAD levels.

DISCUSSION

The potato crop has been considered shallow rooted crop and sensitive to water stress. It is not usual to apply water frequently and in excess. Results revealed that tuber yield was significantly influenced with different MADs levels. Previous researchers also reported that potato production could be increased by well-scheduled irrigation programs throughout the growing season (Chowdhury *et al.*, 2001; Panigrahi *et al.*, 2001). The results relating to water productivity revealed that the maximum water productivity was achieved with 60% MAD level, which showed the superiority of most optimal interval between the two irrigations to the potato crop with respect to judicious use of water. Our results are corroborated with the finding of Onder *et al.* (2005), Darwish *et al.* (2006), Kashyap and Panda (2003) and Badr *et al.* (2012) as they reported that water productivity values for tuber yield were higher under deficit than under adequate irrigation. Similarly, Kang *et al.* (2004) and Onder *et al.* (2005) also registered similar results for potato crop. Hence, it is not advisable to apply excess water. Efficient and economical management of precious water is prime concern for farmers.

In marketing potatoes, certain quality specifications must be met, particularly with regard to size and shape. The sizes of potatoes are somewhat affected by water application period. The results of present study indicated that higher percentage of medium and large size potatoes were obtained under 60% MAD level followed by 30% MAD level where as higher percentage of small sized potato were resulted in case 30% MAD level followed by 15% MAD level. This show that water deficit had adverse effect on tuber size. Other

researchers also reported the similar results (Zhou *et al.*, 2020; Kashyap and Panda, 2003; Kang *et al.*, 2004; Shock *et al.*, 2003). The marketable tuber yield, appearance and quality of potato crop can be affected by a common potato tuber disease called scab. It can be controlled by managing soil moisture through proper irrigation (Delahaut and Stevenson, 2009). Current study reveals that occurrence of scab increased with increased irrigation interval and maximum scab incidence (3.75%) was noted for 60% MAD level. Thus, the findings of the study will be valuables for potato growers in Pakistan as the country is facing water scarcity (Zhang *et al.*, 2017; Tariq *et al.*, 2020; Aslam, 2013).

CONCLUSION AND RECOMMENDATIONS

The judicious use of irrigation water is very important. The improvement in drip-irrigation scheduling results in improving potato yield, accompanied by large savings in the amounts of irrigation water. This practice is highly effective for water- management program for potato production and to increase farm income under local conditions. To improve the yield, marketable tuber size, water productivity and cosmetic value of potato, 30% and 60% MAD level could be adopted for irrigation for this crop under drip irrigation system. Thus, water can be saved in the view of the tuber yields for per unit water used in irrigation. Therefore, by irrigation more much lands, it will have supplied the maximized of total income with the water to be saved. Proper diffusion of these approaches or practices at farm level is necessary step. For this follow up should be made through regular visits of farmers to researches institutions, adoptive research farms and progressives' farmers' fields because it is an imperative to help the farmers understanding what is the right step to achieve an optimum yield with judicious use of resources.

REFERENCES

Akbar, G., M. Asif, Z. Islam and S. Hameed. 2020. Furrow bed irrigation system: Installation and management. Pakistan Journal of Agricultural Research, 33: 406-13.

Aslam, R. 2013. Pakistan's Water Vulnerability and the Risk of Inter-State Conflict in South Asia. Forman Journal of Economic Studies, 9: 19-41.

Badr, M., W. El-Tohamy and A. Zaghloul. 2012. Yield and water use efficiency of potato grown under different irrigation and nitrogen levels in an arid region. Agricultural Water Management, 110: 9-15.

Chowdhury, S., E. Antony, R. Singh, A. Thakur and H. Verma. 2001. Leaf area development and its relationship with tuber yield in sweet potato under different irrigation regimes. Orissa Journal of Horticulture, 29: 20-23.

Darwish, T., T. Atallah, S. Hajhasan and A. Haidar. 2006. Nitrogen and water use efficiency of fertigated processing potato. Agricultural Water Management, 85: 95-104.

Delahaut, K. and W. Stevenson. 2009. Potato disorders: common scab and powdery scab. Available at: https://learningstore.uwex.edu/Assets/pdfs/A3833.pdf.

Ghazouani, H., G. Rallo, A. Mguidiche, B. Latrech, B. Douh, A. Boujelben and G. Provenzano. 2019. Effects of saline and deficit irrigation on soil-plant water status and potato crop yield under the semiarid climate of Tunisia. Sustainability, 11: 2706.

Kahlown, M. A., A. Raoof, M. Zubair and W. D. Kemper. 2007. Water use efficiency and economic feasibility of growing rice and wheat with sprinkler irrigation in the Indus Basin of Pakistan. Agricultural Water Management, 87: 292-98.

Kang, Y., F.-X. Wang, H.-J. Liu and B.-Z. Yuan. 2004. Potato evapotranspiration and yields under different drip irrigation regimes 2004 ASAE Annual Meeting. American Society of Agricultural and Biological Engineers. pp. 1.

Kashyap, P. and R. Panda. 2003. Effect of irrigation scheduling on potato crop parameters under water stressed conditions. Agricultural Water Management, 59: 49-66.

Loria, R. 2021. Vegetable crops: potato scab. Access from http://vegetablemdonline.ppath.cornell.edu/factsheets/Potato_Scab.htm on 10/03/2021.

Majeed, A. and Z. Muhammad. 2018. Potato production in Pakistan: challenges and prospective management strategies–a review. Pakistan Journal of Botany, 50: 2077-84.

Maplecroft. 2010. Water security risk index, Retrieved from http//maplocroft.com/about/news/watersecurity.html.

Onder, S., M. E. Caliskan, D. Onder and S. Caliskan. 2005. Different irrigation methods and water stress

effects on potato yield and yield components. Agricultural Water Management, 73: 73-86.

Panigrahi, B., S. Panda and N. Raghuwanshi. 2001. Potato water use and yield under furrow irrigation. Irrigation Science, 20: 155-63.

Safdari, S. F., S. M. Farahani and A. Eskandari. 2018. Effect of irrigation scheduling on some characteristics of Barley under water deficit conditions. Journal of Bioscience and Biotechnology, 7: 51-55.

Sampaio, S. L., J. C. Barreira, Â. Fernandes, S. A. Petropoulos, A. Alexopoulos, C. Santos-Buelga, I. C. Ferreira and L. Barros. 2020. Potato biodiversity: A linear discriminant analysis on the nutritional and physicochemical composition of fifty genotypes. Food Chemistry, 345: 128853.

Shock, C., E. Feibert, L. Saunders and S. James. 2003. Umatilla Russet'andRusset Legend'Potato Yield and Quality Response to Irrigation. HortScience, 38: 1117-21.

Tariq, M. A. U. R., N. van de Giesen, S. Janjua, M. L. U. R. Shahid and R. Farooq. 2020. An engineering perspective of water sharing issues in Pakistan. Water, 12: 477.

Ullah, I., A. H. Shah, Z. Khan, M. Ihsan, H. Khan, U. Zeb, A. Raqib and P. Zhao. 2020. Phenotypic diversity and pest management of potato varieties grown at baffa mansehra. Polish Journal of Environmental Studies, 29: 2373–81.

Zhang, H., X. Fen, W. Yu, H.-h. HU and X.-f. DAI. 2017. Progress of potato staple food research and industry development in China. Journal of integrative agriculture, 16: 2924-32.

Zhou, S., F. Li and H. Zhang. 2020. Effect of Regulated Deficit Irrigation on Potato under-Mulched Drip Irrigation IOP Conference Series: Earth and Environmental Science. IOP Publishing. pp. 012104.

Publisher's note: EScience Press remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license and indicate if changes were made. The images or other third-party material in this article are included in the article's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this license, visit http://creativecommons.org/licenses/by/4.0/.