WATER REQUIREMENT OF MAJOR TUBER CROPS: A REVIEW

ABSTRACT

Tuber crops are major sources of carbohydrates, thus plays a key role in food safety. The starchy root of tuber crops can be used for various purposes like food, livestock feed, raw material in industry mainly for starch production etc. As most of the tuber crops are resistant to drought and withstand aberrant rainfall conditions, farmers follows rainfed cultivation of tuber crops. Anyhow water deficit stress occurring during the critical phases would adversely affect the ultimate performance of tuber crops and judicious use of water will result maximum yield. This review paper aims to know the water requirement of major tuber crops (Potato, Cassava, Sweet Potato, Amorphophallus, Taro and Tannia) and influence of water management in their yield potential.

Comment [l1]: play

Key words: Tuber crops, Water requirement, Potato, Cassava, Sweet potato, Amorphophallus, Taro, Tannia

1. INTRODUCTION

Water is the key input in crop production. The large proportion of water resource consumption is by agriculture sector, so the increase in agricultural production mainly depends on the development of water saving agriculture and water resource management [1]. Additional agricultural production can be achieved with irrigation compared to rainfed agriculture and this is essential for food security on a global level [2]. In many locations, climate change causes a great deal of uncertainty regarding future water supplies. It will have an impact on precipitation, runoff, snow melt, hydrological systems, water quality, temperature, and groundwater recharge which will adversely affect the agriculture sector [3]. In India, Agriculture uses 85 per cent of the water resources with low efficiency [4]. Water management is related to three important challenges in the agriculture sector of India namely raising productivity per unit of land, reducing poverty, and responding to food security needs [4].

Most of the tuber crops are known for their resistance to drought conditions and higher water use efficiency. Around 2.2 billion people live in underdeveloped nations worldwide, and tuber crops are regarded as a significant nutritional source in these countries [5]. Tuber crops mainly include cassava, potato, sweet potato, yams and minor tuber crops like taro, tannia, coleus etc. Among these tuber crops, potato contributes major share in global production whereas cassava and sweet potato ranks first in area under cultivation in India [5]. Tropical root and tuber crops have greater planting and harvesting flexibility, which opens up numerous opportunities for different crop production systems. Lentil, cereal, and vegetable intercropping in root and tuber crops can boost system productivity and land-use effectiveness [6].Compared to cereals, their water productivity is also on higher side. So water plays a major role in their production potential. When water scarcity or drought struck the tuberization period compared to their vegetative phase, there will be greater reduction in tuber yield and their drought resistance be more related to survival rather than yield [7]. So understanding of critical stages of water requirement and irrigation scheduling in tuber crops are need of the hour in considering their importance in food and nutritional security.

Comment [l2]: a greater

2. COMPARISON OF WATER REQUIREMENT OF MAJOR TUBER CROPS

2.1 Potato

Among tuber crops, potato(*Solanum tuberosum* L.) is a winter season crop with shallow root system. Water requirement of potato varies with many factors like soil, climate, cultural

*

practices etc. Latha et al. [8] reported difference in water requirement of potato with planting dates, where early sown potato required 212.5 mm water and late sown potato required 226.7mm water. The critical stages in growth cycle of potato demands water differently. The critical stages are stolonization, tuberization and tuber development [9]. Several studies shows that moisture stress in this critical stages results reduction in tuber yield. Iqbal et al. [10] studied field response of potato subjected to water stress at different growth stages and concluded that water stress at early development and tuber formation stage resulted greatest reduction in yield. An investigation on tuber dry matter yield of potato under different irrigation regimes by faradonbeh et al. [11]. reported that under drought stress, there is suppression of starch content of tubers. Water stress during tuber bulking stage critically influences tuber market grade, tuber specific gravity and tuber processing quality [12]. In deficit irrigation study of potato with reduced irrigations during tuber bulking stage showed reduction in yield and grade [13]. Among different irrigation methods, sprinkler and drip irrigation resulted significantly higher potato tuber yield compared with furrow irrigation. [14]. The result from different investigations clearly shows the positive yield response of potato to water management practices during its critical periods of growth.

Comment [I3]: their

2.2 Cassava

Cassava (*Manihot esculenta* Crantz.) is a popular tuber crop particularly in the tropics. It provides food and revenue to over eight hundred million people particularly in Africa [15]. Cassava productivity is expected to be significantly impacted by climate change in both African and worldwide growing regions [15]. The drought is expected to continue to be a problem for cassava productivity because it will decrease tuber yield [15]. A yield increase of 150-200 per cent has been observed when crop is grown under irrigation compared with rainfed crop and furrow irrigation with 25 mm water at 100 mm CPE is recommended [16]. According to Sruthy and Rajasree [17] the aberrant weather conditions makes the rainfed cultivation of cassava risky due to poor seedling establishment on account of drying of setts and ultimately results unavailability of planting material. During first 3-4 months of growth, cassava requires enough moisture and it will not withstand waterlogged conditions [18]. Supplementary irrigations during dry months in cassava results more yield and drip irrigation system with 20 mm of water when the daily cumulative pan evaporation value reached 40 mm recorded two fold increase in the root yield [19]. For sprouting and establishment of setts, cassava needs sufficient moisture in soil and three fold yield of cassava was reported when drip irrigation at 100% of pan evaporation along with application of 50%N and K fertilizers during the first 40 days, 30% during 40-80 days and the rest 20% during 80-120 days after planting,supplied through drip irrigation system [20]. The experiment conducted at South Western Nigeria by Olanrewaju et al [21] shows that drip irrigation using 60% of the available water could be advised in places with moderate water constraint and drip irrigation at 100% available water can be advised in places where water is extremely scarce for greater cassava yields. The above investigations emphasise that cassava is well known for its ability to withstand aberrant rainfall conditions but water supplied at right time and right quantity will result more tuber with high quality.

Comment [I4]: result in

2.3 Sweet Potato

The water requirement studies in sweet potato (*Ipomoea batatas*) also revealed increase in tuber tuber yield with sufficient moisture in soil. Suitability of sweet potato in drought-prone areas in terms of their survival rate was reported by various drought tolerance studies and their leaves can tolerate up to a wilting point of −1.3 MPa [22]. According to Laurie et al. [23], drought had a harmful impact on the growth of the sweet potato plants and drought-induced growth retardation has a significant impact on its yield. When a greater dose of fertilizer was provided coupled with the maximum number of irrigation, the greatest root output was seen in the study conducted by Nedunchezhiyan et al [24]. The fragile and succulent nature of sweet potato vines cause drying up of vines, if sufficient moisture is not present in soil immediately after planting [25]. The study conducted by Opafola et al.[26] revealed that water requirement of sweet potato for early season is 22.80 mm and for late season it is 473.87 mm in south-western Nigeria and the study also concluded that supplementary irrigation is necessary during early and late seasons of growth. Ekanayake and Collins [27] studied different irrigation responses of sweet potato and concluded that irrigation treatments significantly altered dry root yield, dry matter, root nitrogenous compounds and root carbohydrates.

2.4 Amorphophallus

Amorphophallus (*Amorphophallus paeoniifolius*) is a tropical tuber crop commonly known as Elephant foot yam. A well drained soil of medium texture with annual rainfall of 150 cm during the crop period is suitable for its growth [16]. According to Santosa et al. [28], Amophophallus is a soil water stress tolerant crop but that stress affects yield and it should be avoided for better results. It is having higher production potential of 50-80 tha^{-1} and water availability influences corm yield and plant growth [29]. They studied effect of watering frequency on growth of elephant foot yam and concluded that number and size of leaves, corm size, cormel number and root growth were affected by watering frequency. The growth of yam was restricted by long interval, infrequent watering reduced yield and forced the corms to enter dormancy. Irrigation water management studies of elephant foot yam in tropical zones of India by Sunitha et al. [30] concluded that judicious management of irrigation water in tuber crops are need of the hour and water smart technologies such as mulching and ground cover mats help in elephant foot yam cultivation with less irrigation, without affecting corm yield. The yield of amorphophallus shows significant difference with fertilizer and irrigation levels and the highest corm yield (47.66 t ha-1) was observed under application of 100% recommended dose of fertilizer along with irrigation at 100% CPE [31]. In elephant foot yam and green gram intercropping system, nutritionally rich corms, higher nutrient yield , stem productivity and water use efficiency were obtained with fertigation treatments [32].

Comment [I5]: ha^{-1}

2.5 Taro and Tannia

Taro (*Colocasia esculenta* (L.) Schott.) and Tannia (*Xanthosoma sagittifolium* (L.) Schott.) are important aroids which are cultivated and consumed as staple or subsistence food in the tropical climate. Taro is a popular vegetable crop that was grown for both nutritional and therapeutic purposes. It provides 135 calories per 100 grams of food, more than twice as much as potatoes do [33]. There are two groups of taro “eddoe” type and “dasheen” type, both are widely grown in flooded and upland conditions [34]. In a study conducted at Newlands, South Africa, taro performed well and provided good yield when grown in continuous wetting [35]. According to Vieira et al [36], In addition to fostering the maximum water use efficiency, the subsequent application of light, more frequent watering encouraged increases in irrigation depth and favoured taro development and yield (up to 17.6 t ha-1). The study on water requirement and irrigation schedule in upland taro revealed that, it’s ideal water demand was 618 mm over the course of six months and drip irrigation at 100% crop evapo-transpiration resulted maximum cormel yield and water use efficiency [37]. Among the edible aroids, the highest starch concentration is for tannia cormels and the leaves' nutritional content is comparable to that of spinach [38]. Under conditions of low water supply, sandy soils has a larger chance of increasing the water use efficiency of taro [39]. At the Gurabo Substation, yields of 12 indigenous and imported tannia cultivars were studied by irizarry et al. [40] under irrigated and non-irrigated conditions and it is observed that all cultivars had a tendency to produce more when irrigation was present than when irrigation wasn't there. According to the research that is currently accessible, tannia has growth tendencies that are comparable to those of taro but is more drought tolerant and susceptible to water logging. However, it has been noted that in rainfed conditions, supplementary irrigation might increase tannia cormel output. Water management and the consequences of water stress on this crop are yet the subject of systematic research [41].

Comment [I6]: ha^{-1}

3. CONCLUSION

Water is the most important input in agriculture and is expected to become more limited in the near future, so the wise use of water with correct scheduling of irrigation is important in producing maximum yields. Even while tubers can resist drought conditions, efficient irrigation techniques, additional irrigations during dry spells, and irrigation during crucial growth stages can all increase its yield.

Comment [I7]: irrigation

Comment [I8]: their

REFERENCES

1. Zhou L, Wang X, Zhang S. A review on development water-saving agriculture in Asia. Agric. Sci. 2022;13(4):491-499.
2. Food And Agriculture Organization of the United Nations. Water for Sustainable Food and Agriculture. 2017 . Accessed 10 June 2023. Available: https://www.fao.org/3/i7959e/i7959e.pdf
3. Food And Agriculture Organization of the United Nations. Climate change and food security: risks and responses.2015. Accessed 10 June 2023. Available: https://www.fao.org/3/i5188e/I5188E.pdf
4. Hans VB. Water management in agriculture:issues and strategies in India. Int. J. Dev. Sustain. 2018;7(2):578-588.
5. Prakash P, Jaganathan D, Sheela I, Sivakumar PS. Analysis of global and national scenario of tuber crops production: trends and prospects. Indian J. Econ. Dev. 2020;16(4):500-510.
6. Nedunchezhiyan M, Suja G, Ravi V. Tropical-root and tuber crops-based cropping systems:A review. Curr. Hort. 2022;10(1):14-22.
7. Daryanto S, Wang L, Jacinthe PA. Drought effects on root and tuber production: A meta-analysis. Agric. Water. Management. 2016;176:122-131.
8. Vishnoi L, Roy S, Murty NS, Nain AS. Study on water requirement of Potato (*Solanum tuberosum* L.) using CROPWAT MODEL for Tarai Region of Uttarakhand. J. Agrometeorology. 2012;14(4) :180-185.
9. Begum M, et al. Water management for higher potato production: A review. Int. J. Curr. Microbiol. App. Sci. 2018; 7(5): 24-33.
10. Iqbal MM, Shah SM, Mohammad W, Nawaz H. Field response of potato subjected to water stress at different growth stages. Nuclear techniques to assess irrigation schedules for field crops . IAEA. 1996.Accessed 10 June 2023. Available: https://inis.iaea.org/collection/NCLCollectionStore/_Public/27/065/27065320.pdf?r=1
11. Faradonbeh HRB, Bistgani ZE, Barker AV. Tuber yield and physiological characteristics of potato under irrigation and fertilizer application. Communication in Soil Sci. Plant Analysis. 2022;53(11).
12. Shock CC, Wang FX, Flock R, Eldredge E, Pereira A. Successful potato irrigation scheduling. Oregon State University.2006;EM 8911.
13. Shock CC, Feibert EBG. Deficit irrigation of Potato. FAO. Deficit Irrigation Practices.2000. Accessed 10 June 2023. Available:https://www.fao.org/3/y3655e/y3655e07.htm#TopOfPage
14. Raskar BS. Increasing yield potential of potato by using irrigation and fertilizer level. Indian J. Agron. 2003; 48(3): 229-231.
15. Muiruri SK, Ntui VO, Tripathi L, Tripathi JN. Mechanisms and approaches towards enhanced drought tolerance in cassava (*Manihot esculenta*). Curr. Plant Biology. 2021;28: 100227.
16. KAU [Kerala Agricultural University]. Package of Practices Recommendations: Crops. 2016. 15th Ed. Kerala Agricultural University, Thrissur, 392p.
17. Sruthy KT, Rajasree G. Minisett Nursery Techniques in Cassava (*Manihot esculenta* Crantz): A Review. Int.J.Curr.Microbiol.App.Sci. 2020 ;9(3): 2731-2735.
18. Oshunsanya SO, Nwosu NJ. Soil-Water-Crop Relationship: A Case Study of Cassava in the Tropics .In: Waisundara V. editor. Cassava. InTech; 2018. Available: http://dx.doi.org/10.5772/intechopen.71968
19. Polthanee A, Srisutham M. Growth, yield and water use of drip irrigated cassava planted in the late rainy season of Northeastern Thailand. Indian J. Agric. Res. 2018; 52(5) : 554-559.
20. Sunitha S, George J, Sreekumar J. Productivity of cassava (*Manihot esculenta*) as affected by drip fertigation in the humid tropics. J. Root Crops. 2013; 39(2):100-104.
21. Olanrewaju OO, Olufayo AA, Oguntunde PG, Ilemobade AA, Water Use Efficiency of Manihot Esculenta Crantz Under Drip Irrigation System in South Western Nigeria. European Journal of Scientific Research. 2009; 27(4): 576-587.
22. Pushpalatha R, Gangadharan B. Climate resilience, yield and geographical suitability of sweet potato under the changing climate : A review. Natural Resources Forum. 2023. Accessed 5 July 2023. Available: https://doi.org/10.1111/1477-8947.12309.

Comment [l9]: Please follow the journal's instructions for writing citations and references.

23. Laurie RN, Laurie SM, Plooy CP, Finnie JF, Staden JV. Yield of Drought-Stressed Sweet Potato in Relation to Canopy Cover, Stem Length and Stomatal Conductance. J. Agric. Sci. 2015;7(1):201-214.
24. Nedunchezhiyan M, Byju G, Ray RC. Effect of Tillage, Irrigation, and Nutrient Levels on Growth and Yield of Sweet Potato in Rice Fallow. ISRN Agronomy. 2012. Available: https://doi.org/10.5402/2012/291285
25. Nedunchezhiyan M, Byju G, Jata SK, Sweet potato Agronomy. Fruit vegetable and cereal science and biotechnology. Global Science Books. 2012;6:1-10.
26. Opafola OT, David AO, Lawal NS, Babalola AA. Estimation of water needs of sweet potato (*Ipomea batata*) using the penman-monteith model in Abeokuta, South Western Nigeria. Arid Zone Journal of Engineering, Technology and Environment. 2018; 14(1):143-152.
27. Ekanayake, IJ, Collins W. Effect of irrigation on sweet potato root carbohydrates and nitrogenous compounds. Food, Agriculture & Environment.2004; 2 (1) : 243-248.
28. Santosa E, Sugiyama NO, Sulistyono E, Sopandie D. Effects of watering frequency on the growth of elephant foot yams. J. Trop. Agr. 2004; 48(4) : 235 – 239.
29. Ravi V, et al. Crop physiology of elephant foot yam [*Amorphophallus paeoniifolius*(Dennst. Nicolson)]. Adv. Hort. Sci. 2011; 25(1): 51-63.
30. Sunitha S, GeorgeJ, Suja G, Jyothi AN, Rajalekshmi A. Water smart technologies for irrigation water management of elephant foot yam in tropical zones of India. J. Water and Climate Change. 2020;11(4):1495.
31. Venkatesan K, Saraswathi T, Pugalendhi L, Jansirani P. Impact of Irrigation and Fertigation Levels on the Growth and Yield of Elephant Foot Yam (*Amorphophallus paeoniifolius* (Dennst.) Nicolson). J. root crops. 2014; 40(1):1-4.
32. Jata SK, Nedunchezhiyan M, Maity SK, Mallikarjun M. Drip fertigation effects on quality characters of Elephant Foot Yam and water use efficiency of Elephant Foot Yam+Green Gram intercropping system. Int. J. Curr. Microbiol .App. Sci. 2020; 9(8): 1307-1316.
33. Patel A, Singh J. Taro (*Colocasia esculenta* L): Review on Its botany, morphology, ethno medical uses, Phytochemistry and pharmacological activities. The Pharma Innovation J. 2023; 12(2): 05-14.
34. Okonkwo CAC. Taro: *Colocasia* spp. In: Kalloo G, Bergh BO, editors. Genetic Improvement of Vegetable Crops. 1st ed. Pergamon; 1993.
35. Busari TI, Senzanje A, Odindo AO, Buckly CA.Evaluating the effect of irrigation water management techniques on (taro) madumbe (Colocasia esculenta (L.) Schott) grown with anaerobic filter (AF) effluent at Newlands, South Africa. J. Water Reuse and Desalination. 2019; 9 (2): 203–212.

- 36. Vieira GH, et al. Strategies for Taro (*Colocasia esculenta*) Irrigation. J. Exp. Agric. Int. 2018; 24(1):1-9.
- 37. Sunitha S, Kumar SJ, Sreekumar J, Suja G, Ramesh V, Byju G. Water requirement of upland Taro (*Colocasia esculenta*) under humid tropical zones of India. Indian J. Agric. Sci. 2022; 92 (11): 1364–1368.
- 38. O'Hair SK, Maynard DN. Edible Aroids. In: Cabellaro B, editors . Encyclopedia of Food Sciences and Nutrition. . 8th ed. Academic Press.1993.
- 39. Li M, Deus A, Ming LC. Response of Taro to Varying Water Regimes and Soil Textures. J. Irrigation and Drainage Engineering. 2019;145(3).
- 40.Irizarry H, Capiel M, Acosta MA. Yield of twelve tanier cultivars grown with and without irrigation in East central Puerto Rico. The J.Agric.university of Puerto Rico. 1977; 61(1):100-105.
- 41. Sunitha S, Ravi V, George J, Suja G. Aroids and Water Relations: An Overview. J. Root Crops. 2013; 39(1):10-21.