INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 22, No. 6, p. 220-226, 2023
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Response of Ginger *(Zingiber officinale)* on the duration of irrigation

Genaro D. Omo*[1], Renato F. Limon[2]

[1]*Research Office, Don Mariano Marcos Memorial State University, Bacnotan, La Union, Philippines*

[2]*Faculty, College of Agriculture, Don Mariano Marcos Memorial State University, Bacnotan, La Union, Philippines*

Article published on June 17, 2023

Key words: Ginger, Rainfed, Rainfall, Drought, Irrigation

Abstract

Ginger (*Zingiber officinale*) is perennial and endemic to South East Asia. It thrives best in humid climate from sea level to 1,500 m elevation. The crop performs well in a warm with temperature range of 19°C- 28°C and a humidity of 70-90% or more than 1,500 to 3,000mm of rainfall throughout their vegetative growth and rhizomes development. It requires moderate rainfall during their crop cycle from sowing time till the sprouting of rhizomes, fairly heavy and well distributed rain showers during the growing period and dry weather for about a month before harvesting are necessary. However, in Type 1 climate condition, the duration of rainy season is very short that lasted only for three and a half months from June to mid-September which could not sustain the soil moisture throughout the vegetative stage and rhizome formation, hence it requires supplemental irrigation after the end of rainy season to attain optimum growth and yield. The result showed that gingers irrigated from September to December 2020 and September 2020 to January 2021 were both has the most number of tillers with 13.45 tillers, while those irrigated from September to December 2020 were the tallest with 73.33cm. Likewise, those irrigated from September 2020 to January 2021 has the highest yield per hill (207.83 g) and per hectare (13,855kg).

***Corresponding Author:** Genaro D. Omo ✉ gdomo@dmmmsu.edu.ph

Introduction

Ginger (*Zingiber officinale)* plants are perennials and it is endemic to South East Asia. The rhizome is commonly used as flavoring of foods and traditional medicine to the Asians. In Asia, fresh ginger is usually consumed as well as in countries in Western Europe and Northern America with high Asian immigrant population (Weiss, 2002).

Ginger thrives best in warm humid climate in the lowland and upland to an altitude of 1,500 m above sea level, well drained soils like sandy loam, clay loam and lateritic loam with a pH of 6.0 to 6.5 rich in humus with a temperature range of 19°C- 28°C and a humidity of 70-90%. Ginger can be grown under rainfed (uniform distribution for 5 to 7 months) with 1500-3,000mm of water during its crop cycle and as irrigated in less rainfall areas where distribution is not uniform (Sharma and Sharma, 2012).. For successful cultivation of the crop, a moderate rainfall at sowing time till the rhizomes sprout, fairly heavy and well distributed showers during the growing period and dry weather for about a month before harvesting are necessary.

In rainfed areas, the planting period is usually affected by unpredictable onset of rainfall, resulting to late planting. Moreover, there is also a possibility of prolonged dry condition during the early vegetative stage of the ginger, so irrigation is very much needed to sustain their vegetative growth and rhizome development. Irrigation of crops is an agricultural practice that goes back thousands of years in human history. Irrigation is used to supply the plant with water so that it may improve the quality and quantity (Oregon State University, 2022).

Dry conditions of the soil cannot guarantee the optimum yield of crops because crop yield will possibly decreased (Jia *et al.*, 2007). On the other hand, the yield of potato will possibly increase by 41-60 percent with water application to attain the potential water requirement of the crop (USDA, 2007). The critical stages for irrigation are during germination, rhizome initiation (90 DAP) and rhizome development stages (135 DAP). The first irrigation should be done immediately after planting and subsequent irrigations are given at intervals of 7 to 10 days in conventional irrigation based on prevailing weather and soil type (Jayashree *et al.*, 2015). Ginger should be irrigated after the rainy season ended to maintain at least 60% of soil moisture at the root-zone or within 50cm from the surface of the soil.

Further, ginger requires occasional to frequent irrigation during the early to mid-vegetative stage if rainfall is not evenly distributed. Depending on soil type and seasonal rainfall, the frequency of irrigation varies (Business Diary Ph, 2018). The first light irrigation is given immediately after planting. Subsequent irrigations are given at 7-10 days interval with a total of 16-18 times of irrigating the ginger. The availability of water is one of the major factors that influence the growth, yield and classification of harvest. Excessive or deficit irrigation during critical growth stages negatively affects yield and quality (Pereira *et al.,* 2009). This study was conducted to evaluate the growth and rhizome yield of ginger as affected by the duration of water application.

Materials and methods

Location of the Study

The study was conducted at the Experimental Farm of the Don Mariano Marcos Memorial State University – North La Union Campus, Sapilang, Bacnotan, La Union, Philippines.

Land Preparation and Lay-outing

The experimental area was cleared from debris, grasses and stubbles, and then plowed and harrowed twice before the conduct of the study. The experiment was laid out in three blocks and the treatments were arranged following the Randomized Complete Block Design (RCBD). There were five treatments of the study with 40 hills planted in four rows at a distance of 50cm between rows and 30cm between hills.

Preparation of Planting Materials

Matured and disease-free rhizomes of local variety of ginger were used as planting materials and were

procured from the local ginger producing farmers within the municipality of Bacnotan, La Union, Philippines. The rhizomes were divided or cut to 25g per sett with three to four active buds, then dipped immediately to 0.50% concentration of Sodium hypochlorite solution and air dried under a shaded area within one day.

Treatments

The treatments of the study are the period of irrigation after the end of rainy season as follows; T_0– Control (Without irrigation), T_1– Irrigated from September 2020 to October 2020 (60 days), T_2– Irrigated from September 2020 to November 2020 (90 days), T_3– Irrigated from September 2020 to December 2020 (120 days), T_4– Irrigated from September 2020 to January 2021 (150 days)

Planting and Cultural Management

Planting was done at the onset of rainy season that started on June 2020. Like most annual crops, the experimental area was cleaned occasionally depending on the growth or density of the weeds. During the development of rhizomes, the gingers were hilled-up to loosen the soil and to protect the developing rhizomes from direct exposure to sunlight, better rooting system and higher rhizome production.

Rainy season in Ilocos Region started from the month June until August or sometimes up to mid-September when there are typhoons. The irrigation of the ginger was started when the rainy season has ended on the month of September while the last irrigation depends on the required period or duration of application for the respective treatments. Irrigation was done manually to be able to measure the amount of water for each plant. Only one liter of water was used per plant every 7 days. Frequency of irrigation per month depends on the absence of rain.

Harvesting

Ginger attained full maturity in 210-240 days after planting in areas with early dry season. However, irrigated ginger has prolonged vegetative growth depending on the duration of water application.

Data Collection

The plant height and the number of tillers were taken on the 3rd and 6th months after planting (MAP). The height was measured from the ground level to the tip of the tallest leaf and the number of tillers were counted per hill. The harvested rhizomes were separated and weighed per hill immediately after harvesting. The yield per hectare ($kgha^{-1}$) was computed using the formula;

$$\text{Computed Yield Hectare}^{-1}\ (kgha^{-1}) = \frac{\text{Ave. wt. of rhizome hill}^{-1}\ kg}{\text{Area hill}^{-1}\ m^2} \text{ X } \frac{10000m}{1ha}$$

The rainfall (mm) data was taken from the Don Mariano Marcos Memorial State University (DMMMSU)–Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA) Agro-Meteorological Station, Sapilang, Bacnotan, La Union, Philippines with a distance of 300 m away from the experimental area.

Data Analysis

The data were statistically analyzed with Randomized Complete Block Design (RCBD) using the Statistical Tool for Agricultural Research (STAR) version 2.0.1 (January 2014) of the International Rice Research Institute (IRRI), Los Banos, Laguna, Philippines to determine the significant differences among the treatments. The Tukey's Honest Significant Difference (HSD) Test was also used for pairwise comparison on the significant differences between treatment means at 0.05 level of probability.

Results and discussions

Amount of Rainfall, mm

Table 1 show the rainfall data taken from the DMMMSU-PAGASA Agro-Meteorological Station covering the period of January to December 2020 and January 2021. Significant amount of rains was recorded during the month of June to October 2020 but negligible amount on November to December 2020 and January 2021. The total amount of rainwater throughout the CY 2020 (1,029.60mm) and throughout the cropping season (1,072.60mm) is far below the water requirements of the ginger to sustain its growth and rhizome development.

Water Application

The frequency of irrigation, amount of rainfall and water applied to the ginger from September 2020 to January 2021 are shown in Table 2. The ginger were irrigated twice per month to augment the available amount of rainwater on September (165.90mm) and October 2020 (125.60mm) and thrice per month to supplement the minimal amount of rainwater on November (37.30mm) and December 2020 (42.60mm) and January 2021 (43.00mm). The rainwater from September 2020 to January 2021 has a total amount of 414.40mm.

Table 1. Monthly amount of rainfall from January 2020 to January 2021.

Month/Year	Amount of Rainfall (mm)
January 2020	0.00
February 2020	0.00
March 2020	0.00
April 2020	0.00
May 2020	34.40
June 2020	120.40
July 2020	165.30
August 2020	338.10
September 2020	165.90
October 2020	125.60
November 2020	37.30
December 2020	42.60
January 2021	43.00
Grand Total	1,038.20

Table 2. Frequency of Irrigation, amount of rainfall and water applied to the ginger from the month of September 2020 to January 2021.

Treatments	Total Frequency of Irrigation from September 2020 to a Given Period	Amt. of Rainfall from September 2020 to January 2021 (mm)	Amt. of Water Applied per Irrigation (mm)	Total Amount of Water Applied to a Given Period (mm)	Total Amount of Water Applied and Rainfall to a Given Period (mm)
T_0 – Control (Not Irrigated)	0.0	414.4	0.0	0.0	414.4
T_1 – Irrigated from September to October 2020	4x	414.4	150	600	1,014.4
T_2 – Irrigated from September to November 2020	7x	414.4	150	1,050	1,464.4
T_3 – Irrigated from September to December 2020	10x	414.4	150	1,500	1,914.4
T_4 – Irrigated from September 2020 to January 2021	13x	414.4	150	1,950	2,364.4

The amount of water applied to the ginger per application was 150mm. The total amount of water applied to the respective treatments has depended on the duration of water application after the rainy season has ended. The plants of T_0 (Not Irrigated) has received a total amount of 414.40mm rainwater within the period from September 2020 to January 2021. Likewise, the plants of T_1 was irrigated four times from September to October 2020 with 150mm per application to have a total of 600mm water and the 414.4mm total amount of rainwater from September 2020 to January 2021, T_2 was applied seven times with a total of 1050mm water from September to November 2020 and the 414.4 rainwater, T_3 was applied ten times with a total of 1,500mm water from September to December 2020 and the 414.4 rainwater, and T_4 was applied thirteen times with a total of 1,950mm water from September 2020 to January 2021 and the 414.4 rainwater.

Plant Height (cm)

The growth of the ginger shoots was most active during their early vegetative growth. The ginger got taller with time as it continuously grown and developed. On the 3rd MAP, the height of the ginger has no significant differences among the treatments

with height ranging from 48.50cm to 49.78cm while at 6th MAP, the plants of T_3 (irrigated from September to December 2020) was significantly the tallest with 73.33cm because of the effects of the supplemental irrigation due to very low amount of rainwater with only 37.3mm on November and 42.6mm on December 2020 which is not sufficient to support the optimum growth of those irrigated until October and November 2020 only, but comparable to T_4 (irrigated from September 2020 to January 2021) with 73.11cm height because the vegetative growth had totally stopped in the absence of soil moisture or during the last stage of rhizome formation (Table 3).

Table 3. Height of ginger at 3rd and 6th MAP as affected by the duration of irrigation.

Treatments	Plant Height (cm)	
	3rd MAP	6th MAP
T_0 – Control (Not Irrigated)	48.50	68.00[d]
T_1 – Irrigated from September to October 2020	49.33	70.28[c]
T_2 – Irrigated from September to November 2020	49.78	71.67[b]
T_3 – Irrigated from September to December 2020	48.83	73.33[a]
T_4 – Irrigated from September 2020 to January 2021	49.55	73.11[a]

*Means in a column followed by the same letter are not significantly different from each other at 0.05 level (Tukey's HSD Test).

In crop production, the water requirement is supplied by rainwater during rainy season and through irrigation when the rainy season has ended (Hajare *et al.*, 2008). This proved that irrigation had significant effects to the growth of ginger because it dissolved the available nutrients to be taken up by the roots of the plants to support their growth. According to Prasad *et al.* (2008) that limited water affects crop growth and physiological processes of the plants. Aside from the physiological responses, crops also undergo morphological changes, such as in the distribution of assimilates, that may reduce the vegetative growth and inhibit the advancement of the reproductive organs. Moreover, Gatabazi *et al* (2022) cited as mentioned by Xu (2000) that the improved growth of *Zingiber officinale* is due to the availability of nutrients under frequent irrigation because when the plants are restricted with water, the photosynthetic and stomatal conductance will be reduced that affects the vegetative growth.

Number of Tillers

The number of tillers produced per hill by the ginger on the 3rd MAP has no significant differences among the treatments ranging from 5.61 to 6.00 tillers per hill, while at 6th MAP, the number of tillers emerged per hill has significant differences among the treatments. The plants irrigated for extra four months from September to December 2020 (T_3) and those irrigated for five months from September 2020 to January 2021 (T_4) after the rainy season ended have the highest number of tillers, both with 13.45 tiller per hill (Table 4) which is significantly differed to those that were not irrigated from October to November 2021 (T_2) because the amount of rainfall was very low during those months.

Table 4. Number of tillers of ginger at 3rd and 6th MAP as affected by the duration of irrigation.

Treatments	Number of Tillers/Hill	
	3rd MAP	6th MAP
T_0 – Control (Not Irrigated)	5.61	9.00[d]
T_1 – Irrigated from September to October 2020	5.56	11.78[c]
T_2 – Irrigated from September to November 2020	6.00	12.84[b]
T_3 – Irrigated from September to December 2020	5.94	13.45[a]
T_4 – Irrigated from September 2020 to January 2021	5.61	13.45[a]

*Means in a column followed by the same letter are not significantly different from each other at 0.05 level (Tukey's HSD Test).

The number of tillers increased as the ginger growing; however, the number of tillers varied with duration or the amount of water applied. This conformed to the statement of Khanna (2012) that irrigation is necessary for the absorption of mineral nutrients by the plants from the soil which is essential for the general growth of the plants. Similar study of Islam *et al.* (2015) revealed that the ginger irrigated during dry season emerged earlier, has the tallest height, highest number of leaves and tillers per plant.

Rhizome Yield

The development of the rhizomes was not only depending on the available nutrients from the soil but

it was also affected by the duration of the availability of water that continuously supported the growth and rhizome development of the ginger. The result in Table 5 revealed significant differences on the rhizome yield of the different treatments. The irrigated plants from September 2020 to January 2021 (T_4) had the highest rhizomes yield with 207.83g per hill and 13,855.60kg per hectare.

Table 5. Rhizome yield of ginger as affected by the duration of irrigation.

Treatment	Rhizome Yield	
	Per Hill (g)	Per Hectare (kg)
T_0 – Control (Not Irrigated)	104.80^e	6,986.70^d
T_1 – Irrigated from September to October 2020	143.33^d	9,555.60^c
T_2 – Irrigated from September to November 2020	162.33^c	10,822.27^b
T_3 – Irrigated from September to December 2020	177.50^b	11,833.37^b
T_4 – Irrigated from September 2020 to January 2021	207.83^a	13,855.60^a

*Means in a column followed by the same letter are not significantly different from each other at 0.05 level (Tukey's HSD Test).

So, despite the amount of precipitation during the latter vegetative growth and rhizome formation was very low with only 37.3mm and 42.6mm for November and December 2020, respectively, the application of water maintained the availability of soil moisture throughout the growing period of the crop even after the rainfall season ended, therefore the rhizomes continuously developed as the number of tillers was continuously increases. According to Owusu-Sekyere *et al.* (2010) that the lack of rainfall to supply water losses through evapotranspiration by a crop requires supplementary irrigation to attain the expectation of farmers for higher yield. Yield may influence by the timing of irrigation or on the quantity applied. Likewise, the study of Islam *et al.* (2015) revealed that the gingers irrigated during dry season have the highest rhizome yield.

Chaudhary and Kumar (2018) mentioned that the ginger being a crop with high water requirement, the supply of water throughout its growth period of 8 to 9 months is essential. Similarly, Reddy and Reddy (1993) reported too that crop species growing under variable water supply, especially during yield formation stages, can still produce optimum yields with maximum water use efficiency.

Conclusions

The amount of rainfall during the production period was very low due to short period of rainy season that supplemental irrigation is necessary and was done immediately after the end of rainy season. The ginger irrigated from September to December 2020 were the tallest while those irrigated from September to December 2020 and from September 2020 to January 2021 have the highest number of tillers at 6th MAP because of the availability of moisture supplied which is necessary for the vegetative growth of the ginger. Likewise, the ginger irrigated for five months from September 2020 to January 2021 has the highest yield per hill and per hectare due to the availability of moisture throughout the rhizome formation stage.

Acknowledgment

We wish to extend our heartfelt gratitude to the University President, Dr. Jaime I. Manuel, Jr.; the University Vice President for Research and Extension, Dr. Angelina Gonzales; the University Director for Research, Prof. Keneth G. Bayani; the Campus Chancellor, Dr. Junifer Rey E. Tabafunda and to the head of the Campus Research Unit, Dr. Minerva J. Tabafunda for their technical and financial support during the conduct of the study.

Declaration of interest

The authors declare that there is no conflict of interest.

References

Business Diary Ph. 2018. Ginger production guide. http://businessdiary.com.ph/2955/ginger-productio

Chaudhary V, Kumar M. 2018. Effect of silver color plastic mulch on vegetative growth and yield of ginger (*Zingiber officinale* Rosc.) Under drip irrigation system. Journal of Pharmacognosy and Phytochemistry **SP5,** 13-16.

Gatabazi A, Marais D, Steyn M, Araya H, du Plooy C, Ncube B, Mokgehle S. 2022. Effect of water regimes and harvest times on yield and phytochemical accumulation of two ginger species. Scientia Horticulturae **304,** 111353.

Hajare HV, Raman NS, Dharkar ERJ. 2008. New Technique for Evaluation of Crop Water Requirement. *WSEAS* Transactions on Environment and Development **5(4),** May 2008. ISSN: 1790-5079.

Islam MA, Rahim MA, Iqbal TMT. 2015. Effect of Irrigation and Mulching on Growth and Yield of Ginger. Bangladesh Agronomy Journal **18(1),** 27-36.

Jayashree E, Kandiannan K, Prasath D, Rashid P, Sasikumar B, Senthil KCM, Srinivasan V, Suseela BR, Thankamani CK. 2015. Ginger (extension pamphlet). Indian Institute of Spices Research, Kozhikode p 12.

Jia X, Scherer TF, Steele DD. 2007. Crop Water Requirement for Major Crops in North Dakota and its Vicinity Area. 2007 American Society of Agricultural and Biological Engineers/CSBE North Central Intersectional Conference. Sponsored by the Red River Valley Section of American Society of Agricultural and Biological Engineers, North Dakota State University, Fargo, North Dakota, USA October 12-13, 2007.

Khanna B. 2012. What is the importance of Irrigation. http://www.preservearticles.

Kun X. 1999. The influences of mulching with straw on the field microclimate and ginger growth. China Vegetables **5(5-8),** 14.

Oregon State University. 2022. Describe the importance of irrigation in producing forages. Forage Information System. Corvallis, OR 97331.

Owusu-Sekyere JD, Asante P, Osei-Bonsu P. 2010. Water Requirement, Deficit Irrigation and Crop. Coefficient of Hot Pepper (*Capsicum frutescens*) Using Irrigation Interval of Four (4) Days. ARPN Journal of Agricultural and Biological Science **5(5),** September 2010.

Pereira JRD, Carvalho JA, Paiva PDO, Silva DJS, Souza AMG, Souza KJ. 2009. Growth and production of gladiolus floral stems under different soil water tensions. (In Portuguese.) Ciencia Agrotecnolohia. **33(4),** 965-970. https://doi.org/10.1590/S1413-70 542009000400004.

Prasad PV, Staggenborg SA, Ristic Z. 2008. Impacts of drought and/or heat stress on physiological, developmental, growth, and yield processes of crop plants. In Response of Crops to Limited Water: Understanding and Modeling Water Stress Effects on Plant Growth Processes; American Society of Agronomy: Madison, WI, USA pp. 301-355.

Reddy CR, Reddy SR. 1993. Scheduling irrigation for peanuts with variable amounts of available water. Agricultural Water Management **23,** 1-9.

Rockstrom J, Hatibu N, Oweis T, Wani SP. 2007. Managing water in rain-fed agriculture. In: Molden D, editor. Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture. London, UK: Earthscan pp. 315-348.

Sharma HD, Sharma V. 2012. Production technology of ginger under changing climate. In: Bhardwaj ML, Dev Sharma H, Kumar M, Kumar R, Kansal S, Thakur K, Singh SP, Kumar D, Kumari S, Gupta M and Sharma V (eds). Vegetable Production Under Changing Climate Scenario 44-52.

United States Department of Agriculture. 2007. North Dakota Agricultural Statistics. http://www.nass.usda.gov/statistics_by_state/North

Wani SP, Pathak P, Sreedevi TK, Singh HP, Singh P. 2003b. Efficient management of rainwater for increased crop productivity and groundwater recharge in Asia. In: Kijne JW, Barker R, Molden D, editors. Water Productivity in Agriculture: Limits and Opportunities for Improvement. Wallingford, UK: CAB International; 2003b pp. 199-215.

Weiss EA. 2002. Spice Crops. CAB International Publishing, Oxon, UK.