Performance of Trickle Irrigation System on Growth and Yield of Garlic in Case Rabi and Kharif Seasons, Wonkakebele, Ethiopia

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Author’s contribution
The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

Trickle irrigation is one and only of the water saving, progressive and advanced irrigation methods over gravity irrigation. In the point view of this, the research was lead to study the efficiency of Trickle irrigation over gravity irrigation in growth and yield of garlic in case Rabi & Kharif periods, wonka kebele, Ethiopia. The results indicated that trickle irrigation was well achieved greater over gravity irrigation method in terms of greater crop morphology, yield and quality of bulb. Trickle irrigation method documented maximum crop height (67.77 cm & 62.85), amount of leaves (10.25 & 8.00) and neck thickness (1.63 cm & 1.40 cm) in both Rabi and Kharif periods. The bulb equatorial and polar diameter, higher gross product in addition to marketable product achieved in trickle irrigation method. In trickle irrigation method, the gross product and marketable product improved by 12.54% and 22.63%, respectively in Rabi periods over gravity irrigation method and better water use productivity & as well saved 29.40% & 29.20% water for the period of Rabi & Kharif periods, respectively.

Keywords: Kharif; rabi; trickle; garlic; irrigation.

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1. INTRODUCTION

Farming has been the heart of the Ethiopian gross domestic product (GDP) for era's [1]. Agronomic production was rising constantly in the last two years, even if the population was also growing over time. Irrigation development has been played energetic role for improved farming productivity particularly in the semi-arid and arid areas of northern Ethiopia. However, water is being disappearing by much environmental and socioeconomic variability. Water shortage is likely to increase meaningfully as the requirement for food production and industrial use is at an increasing rate. The attention given for improving agricultural water management is also non-sufficient. This clearly suggests that enhancing water productivity is important in poverty reduction and future economic development endeavors in the semi-arid areas of the country. Resourceful water application based on the crop water requirement with optimal crop productivity is also needed to sustain profitable growths [2]. Ethiopia is the 12th biggest producer of garlic and china is the first largest producer of garlic. Garlic is cultivated in two different periods namely Kharif, & Rabi. The soil moisture level affects the quality of bulb and yield which is greatly influenced by the type of irrigation method. Garlic is a shallow rooted crop needs light but everyday irrigation either by flood, sprinkler, or trickle irrigation method. The productivity of garlic in Ethiopia is 151,684 ton year\(^{-1}\) which is low compared to world average. Handling the quantity of applied irrigation water is critical to succeed best yield and quality. Majority of the garlic product grown in Ethiopia is under gravity irrigation, which is comparatively low-cost, but unproductive in the amount of water use. Irrigating the crop via trickle method is an innovative practice to develop agricultural productivity and to improving the productivity of water consumptive use [3,4,5]. Trickle irrigation advances itself to automation, more so than either gravity or sprinkler irrigation method. Keeping this in mind, an investigation was intended on garlic to study the viability of Garlic production under trickle irrigation method.

The growth parameters of garlic mainly depends on the time of planting as the vegetative growth is stimulated under a short photoperiod and low temperature and bulb production is enhanced by a long photoperiod and high Temperature. Sowing date and plant age significantly influence the various growth and developmental traits of garlic bulb. Parameters including morphological (Plant height, fresh weight and pseudostem diameter), bulb attributes (diameter, weight, height and bulbing index), growth period and bulb quality related traits (total soluble solid (TSS), contents of soluble protein, soluble sugar, total sugar, glucose, sucrose, fructose, starch, total phenol and total flavonoid).

2. METHODOLOGY

2.1 Description of the Study Area

2.1.1 Location

The Wonka Kebele is extend between approximately 10°10′00″ and 10°40′00″N latitude and 37°30′00″ and 37°54′00″E longitude. Maximum and minimum elevation of the area 2720 -3456 m.a.s.l. [6] respectively. Addis-Ababa to Bahir-Dar main asphalt road passes through the study area within the major town of Debre Markose which provides the main access to the study area. There are also adequate network of seasonal and all-weather roads within the area. Considering the climate stations in the catchment for a period of 2010-2018 the mean annual rainfall amount ranges between 1157.7 to 1753.0 mm, and the mean monthly rainfall amount of the catchment ranges from 11.4 to 326.8 mm as shown in Fig. 1. The mean monthly maximum and minimum temperature of the study area is 27.8°C and 13.0°C respectively. The maximum temperature ranges from 20.1 to 27.8°C. Highest maximum temperature is observed in the month of March. The month of July is characterized by lowest maximum temperature. The minimum temperature ranges from 10.0°C to 13.0°C. Highest minimum temperature is observed in the month of April. The month of December is characterized by lowest minimum temperature as shown in Fig. 2. The relative humidity, sunshine hour and wind speed of the study area ranges from 40 to 90%, 3.4 to 9.3 hours per day and 1.1 to 1.5 m/s respectively.

2.2 Research Design

A ground experimental test was applied for the period of Rabi, 2017-18 & 2018-19 & Kharif 2018 & 2019 under wonka kebele small scale irrigation development to study the productivity of garlic under trickle irrigation method over gravity irrigation on variety for Rabi & for Kharif. During experimental test dated climatological data has given in Fig. 1. The physical and chemical soil characteristics in the study area were described in the Table 1.
Fig. 1. Monthly average precipitation (mm) of the watershed

Fig. 2. Mean monthly minimum and maximum temperature (°C) of the watershed

Table 1. Physical and chemical soil characteristics of soil

<table>
<thead>
<tr>
<th>Physical properties</th>
<th>Chemical properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Texture</td>
<td>PWP</td>
</tr>
<tr>
<td>Clay</td>
<td>24.6%</td>
</tr>
</tbody>
</table>

The 55-60 days aged seedlings were transplanted in the month of October for Rabi & for Kharif 45-50 days old seedlings were relocated in June. The trickle irrigation was organized in broad based furrow system at spacing of 10 × 15 cm in both trickle & gravity irrigation method. Broad based furrow system of 1.20 m upper width with 0.45 m furrow keeping 15 cm height, each broad based furrow system requires of two trickle laterals 17 mm size within built dripper. The interval between two inbuilt emitters was 50 cm and the discharge rate is 4 L/hr. The broad based furrow system was ready with a broad based furrow system former
attached behind a tractor. Single bed size was kept as 45.0 m x 1.2 m in 6 replications and positioned down in Random Block Design (RBD). The size of each individual bed & furrow was 1.2 and 0.45 m, respectively; thus the width of 1 unit of broad based furrow system was 1.65 m instantaneously the crop raised up under gravity irrigation method was organized in flatbed system in four rows, single bed size was 5.0 x 2.0 m, single row contains 8 beds. Before transplanting of seedlings organic fertilizers i.e. vermicompost @ 10 t ha$^{-1}$ along with Tricoderma viride 5 kg ha$^{-1}$ mixed with Azotobacter 10 kg ha$^{-1}$ applied in soil in both BBF and flatbeds. The suggested dosage of chemical fertilizers NPKS was 100:50:30:30 kg ha$^{-1}$. Fifty percent of N and 100% P, K and S applied at basal remaining 50% N applied in two separations at 30 & 45 days after relocating in flood irrigation flatbed system. Whereas, in trickle irrigation method compost application was done with trickle irrigation method 7 separations with 7 days breaks per day 2-3 hr. 1$^{st}$ irrigation was operated instantly after transplanting and light irrigation was done 3 days after transplanting for better and uniform initial launch of crop. Suggested crop production and fortification practices were followed as and when required to get in good physical shape crop. Succeeding serious protections were taken while conducting the test viz. irrigation interval followed consistently; the operating pressure of trickle irrigation method was 1.0 -1.5 kg cm$^{-2}$. In both the systems, irrigation was stopped at 15-20 days before collecting the crop. The corms were collected at full stage of maturity. After appropriate preserving and neck cutting, the observations on product and product contributing characters and marketable bulb yield, percent of A(>6.5 cm), B (4.5- 6.5 cm) and C (<4.5 cm) grade bulbs on weight basis separately documented and amount of water applied was correspondingly measured.

3. RESULTS AND DISCUSSION

The research output showed all growth & yield factors of garlic were meaning fully influenced by irrigation methods. The peak crop height i.e. 67.77 cm and 62.85 cm was documented in trickle irrigation raised up bed system during Rabi 7 Kharif periods, respectively, where as in gravity irrigation flatbed system crop height was 66.50 cm & 55.52 cm. Amount of leaves & neck thickness were moreover higher in trickle irrigation method in both Rabi (10.25/ plant & 1.63 cm) & Kharif (8.0/ plant and 1.40 cm) periods than gravity irrigation method both Rabi (8.55/ plant & 1.14 cm) and Kharif (7.00/ plant & 0.97 cm) periods (Table 1) that point out that in trickle irrigation raised bed system crop obtain satisfactory situations for extension of root system in that way crop growth and vigor is high. The outcomes of the research were similar with the outcomes of [7,8,9] for crop growth.
Trickle irrigation provided that require quantity of water to the crop in small quantities distributed at given irrigation intervals as required by the crop, and water losses via deep percolation & evaporation were less than with gravity irrigation and as well as water is conveyed at or beneath ground level, so that soaking of the undergrowth is not a difficult. Trickle irrigation affected the size of garlic bulb, highest bulb equatorial (6.23 cm & 5.33 cm) in Rabi period as well as polar bulb diameter (4.54 cm & 4.03 cm) were documented in trickle irrigation and the lowest bulb diameter were documented from the gravity irrigation for the period of Rabi & Kharif, respectively. Photosynthesis zone bring about highest crop height & large amount of leaves indications to big bulb diameter and income. The highest overall bulb income (34.00 & 23.40 t ha\(^{-1}\)) & salable yield (32.99 & 21.03 t ha\(^{-1}\)) were documented in trickle irrigation method in both Rabi & Kharif periods, whereas as in gravity irrigation lowest gross product (29.84 & 20.59 t ha\(^{-1}\)) in addition to saleable product (27.08 & 16.99 t ha\(^{-1}\)) was documented. The gross product & saleable product improved 18.30% & 24.50%, in that order over gravity irrigation. Trickle irrigation with fertilizer application of NPK nutrients with consistent allows optimum crop growth resulted in well photosynthesis levels and higher carbohydrates accumulation in sink region. It was proved from the outcomes existing in this study is inclusive and similar with previous investigators [10,11,12]. The outcomes further shown that trickle irrigation method delivered lower bolting (0.66%) & doubles (2.32%) as paralleled with gravity irrigation method & it was saw that for the period of Kharif period bolting did not documented in any treatments since the mean minimum temperature is above 17°C is not suitable to initiate bolting, however doubles were documented (Table 2). The study area originates under shadow of a northwest monsoon; hence the unpredictable summer monsoon practiced by this region groups in last part of June & covers till the 2nd week of October. The average precipitation ranged from 549.0 mm to 863.0 mm for the period of 2017 to 2019. Precipitation was overlapped with bulb beginning & bulb development phases, due to heavy rain fall for the period of Kharif period poor bulb development was saw. This is the reason & other climatic reasons for the period of Kharif period 36.33% product reduced as matched with Rabi, yet by practicing trickle irrigation system in Kharif period significant product was improved over gravity irrigation method because trickle irrigation raised bed system up to some amount eliminate excess water & remove extra water due to slow & steady overflow water as compared with gravity irrigation method flatbed system where crop was affected. Over all during Kharif period in trickle irrigation method, the gross product and marketable yield improved 14.37% & 18.35%, correspondingly. It was proved from the outcomes, correctly intended & managed trickle irrigation raised bed has many benefits over gravity irrigation including: Eradication of overflow loss, higher consistency of spreading water over the area, high water usage efficiency, flexibility in fertilizer, reduce weed growth & prevent crop disease for the period of rainy period. The investigation outcomes were further shown that maximum ‘A’ grade (>6.0 cm) bulb (63.07%), ‘B’ grade (4.0-6.0 cm) bulb (24.82%) and lower ‘C’ grade (<4.0 cm) bulb (12.10%) were documented in trickle irrigation method for the period of Rabi period & in Kharif also higher ‘A’ grade bulb (28.97%), ‘B’ grade bulb (36.28%) & lower ‘C’ grade bulb (34.76%) documented in trickle irrigation method (Table 3). Trickle irrigation confirms best development, healthier bulbing and initial adulthood of crops by guaranteeing best soil moisture content, air, water & nutrients throughout the crop growing seasons causing constant bulb achieved is directly interrelated to the maximum bulb size & production, whereas in gravity irrigation method yield reduced due to deep percolation & water is lost beyond the active absorption zone of the root system as an garlic was shallow rooted crop. These outcomes were similar with the outcomes of [13,14].

The advantage of trickle irrigation method over gravity irrigation were indicated in Table 2, that applied water in trickle system is very lower in two periods as compare with gravity irrigation method. The 61.29 ha cm\(^{-1}\) and 56.65 ha cm\(^{-1}\) amount of water was applied in the trickle irrigation during Rabi & Kharif, respectively whereas in flood system 86.55 ha cm\(^{-1}\) and 77.63 ha cm\(^{-1}\), respectively. Thus, the drip system could save 29.40% and 27.20% water for the period of Rabi & Kharif, respectively. The main whys and where forces recognized for the water savings include reduced irrigation runoff from the field, irrigation of a smaller portion of the soil volume, reduced irrigation runoff from the field, no sheet erosion of top soil surface and controlled deep percolation losses below the crop root zone, which enables higher water use efficiency in trickle irrigation raised bed system, which was 561.99 kg ha\(^{-1}\) mm for Rabi and 419.99 kg ha\(^{-1}\) mm for Kharif (Fig. 5).
outcomes were the same matched with outcomes of [15,16]. According to water consumptive use of crop valued that throughout Rabi period 1000 lit of water is used up for production of 5.63 kg and 3.55 kg of garlic in trickle and gravity irrigation method, respectively. Whereas in Kharif period 1000 liter of water by trickle irrigation method products 4.19 kg, while in gravity irrigation method product is 2.77 kg, consequently trickle irrigation method more appropriate for shallow rooted garlic crop. The Cost and Benefits ratio also high in trickle irrigation method (1:2.69) while in gravity irrigation method it is 1: 1.68. The Cost and Benefits ratio in trickle recommended that even though greater investment cost of the trickle irrigation, the trickle irrigation is more cost-effective than irrigation via gravity.

According to the outcomes obtained from during Rabi & Kharif periods of the outcome of trickle irrigation on yield, yield components and morphological characteristics of garlic, and also the water use productivity and proper water saving. It summarized that trickle irrigation method was more meaningfully effect on all conducted factors as indicated Table 5. To accomplish a more production potential of garlic crop production, implementing trickle irrigation method must be sustained for the period of the both Rabi and Kharif periods of the studied area.


| Growth and yield parameters | Rabi | | | | | | Kharif |
|-----------------------------|-----|-----|-----------------|-----|-----------------|-----|
|                             | Trickle | Gravity | CD (P<0.05) | Trickle | Gravity | CD (P<0.05) |
| Plant height (cm)           | 67.77 | 66.50 | 1.16 | 62.8 | 55.52 | 5.92 |
| Number of Leaf plant¹       | 10.25 | 8.55 | 0.93 | 8.00 | 7.00 | 0.96 |
| Neck thickness (cm)         | 1.63  | 1.14  | 0.39 | 1.40 | 0.97 | 0.05 |
| Bolting (%)                 | 0.66  | 2.32  | 0.22 | 0.00 | 0.00 | 0.00 |
| Doubles (%)                 | 2.38  | 6.74  | 0.17 | 0.005 | 0.49 | 0.077 |
| Bulb equatorial dia. (cm)   | 6.23  | 5.33  | 0.33 | 5.25 | 4.56 | 0.26 |
| Bulb polar diameter (cm)    | 4.54  | 4.03  | 0.017 | 3.45 | 3.00 | N.S. |
| Gross yield (t ha⁻¹)        | 34.00 | 29.84 | 1.31 | 23.4 | 20.59 | 1.22 |
| Marketable yield (t ha⁻¹)   | 32.99 | 27.08 | 2.95 | 21.0 | 16.99 | 0.75 |
| A grade bulb (%)            | 63.87 | 54.58 | 1.72 | 29.99 | 16.00 | 3.39 |
| B grade bulb (%)            | 25.88 | 24.07 | 2.40 | 37.0 | 35.06 | 1.21 |
| C grade bulb (%)            | 13.14 | 23.77 | 6.32 | 35.0 | 48.96 | 2.29 |

Khairf = cropping season from July – October, Rabi = cropping season from October – March

Fig. 4. Product of garlic crop
Table 3. Advantage of trickle irrigation over gravity irrigation during Rabi & Kharif

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Rabi</th>
<th>Kharif</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross yield (%)</td>
<td>12.54</td>
<td>15.22</td>
</tr>
<tr>
<td>Marketable yield (%)</td>
<td>22.63</td>
<td>19.35</td>
</tr>
<tr>
<td>A grade bulb (%)</td>
<td>18.55</td>
<td>82.11</td>
</tr>
<tr>
<td>B grade bulb (%)</td>
<td>11.66</td>
<td>6.84</td>
</tr>
<tr>
<td>C grade bulb (- %)*</td>
<td>52.74</td>
<td>32.27</td>
</tr>
<tr>
<td>Water saving (%)</td>
<td>29.40</td>
<td>27.20</td>
</tr>
<tr>
<td>Water use efficiency (%)</td>
<td>70.27</td>
<td>55.99</td>
</tr>
</tbody>
</table>

Per cent decreased over gravity irrigation

Kharif = cropping season from July – October
Rabi = cropping season from October – March

4. CONCLUSION

Generally all growth & yield factors of garlic were meaningfully influenced by irrigation methods. In the growth parameters the maximum crop height was 67.77 cm and 62.85 cm was recorded in trickle irrigation raised up bed system during Rabi 7 Kharif season, respectively, these means the same irrigation method have different productivities in different season where as in gravity irrigation flatbed system crop height was 66.50 cm & 55.52 cm in the Rabi and Kharif season respectively. More over the number of leaves & neck thickness were higher in trickle irrigation method in both seasons i.e., Rabi 10.25/ plant & 1.63 cm & Kharif (8.0/ plant and 1.40 cm) periods than gravity irrigation method both Rabi (8.55/ plant & 1.14 cm) and Kharif (7.00/ plant & 0.97 cm) periods (Table 2).

Therefore, in trickle irrigation raised bed system crop obtain more satisfactory condition for extension of root system. Trickle irrigation provided that require quantity of water to the crop in small quantities distributed at given irrigation intervals as required by the crop, and water losses via deep percolation & evaporation were less than with gravity irrigation and as well as water is conveyed at or beneath ground level, so that soaking of the undergrowth is not a difficult.

Trickle irrigation affected the size of garlic bulb, highest bulb equatorial 6.23 cm & 5.33 cm) in Rabi period as well as polar bulb diameter 4.54
cm & 4.03 cm were documented in trickle irrigation and the lowest bulb diameter were documented from the gravity irrigation for the period of Rabi & Kharif, respectively.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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