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Participatory Evaluation and Demonstration of Onion Spacing in Irrigated Agriculture at Kencho Kebele in Uba Debre Tsehay Woreda, Southern Ethiopia

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ይህ ምርምር ጥናት ሥራ ለሁለት ተከታታይ ዓመታት በተሳትፏዊ ተከላ ርቀት ለተሻለ ሽንኩርት ምርት በአነስተኛ መስኖ በሚል በአርባምንጭ ግብርና ምርምር ማዕከል የተሰራ ነዉ። ሙከራዉ የተካሄደዉ በአራት ተከላ ርቀት ማለትም በ8 ሳ.ሜ፣ በ10 ሳ.ሜ፣ በ12 ሳ.ሜ እና አርሶ አደሩ በለመደዉ ወይም እራሱ በሚተክለዉ ነዉ። የሌሎች ግብአቶች አሰጣጥ ማለትም ማደበሪያ፣ የሪያ፣ ዉሃ፣ ኬሚካልና አረም ቁጥጥር ሥራ ለሁሉም ተከላ ርቀት ተመሳሳይ ናቸዉ። ከአራቱም ሽንኩርት ተከላ ርቀቶች የተሻለ ምርት ዉጤት የተገኘዉ በ10 ሳ.ሜ (17.178 ቶን በሄክታር) እና 12 ሳ.ሜ (17.740 ቶን በሄክታር) ነዉ። በዚህ ጥናት አርሶ አደር በእራሱ ልምድ በአማካይ ተከላ ርቀት 7.3 ሳ.ሜ የተገኘዉ ምርት ዝቅተኛ ዉጤት (11.464 ቶን በሄክታር) ሆኖ ተገኝቷል። እንደ ኮምፕዩተር ፕሮግራም ትንተና ከአርሶ አደር ተከላ ርቀት ዉጭ፤ በሌሎቹ ተከላ ርቀቶች ምንም ዓይነት ልዩነት አልታየም። ምንም እንኳን የተገኘዉ ምርት ዉጤት በአማካይ አነስተኛ ቢሆንም፤ በወቅታዊ ገበያ አንፃር በአንድ ኪሎ ግራም 34 ብርና በሄክታር 532,831 ብር በመሸጥ አርሶ አደሩ ከሌሎቹ ጊዜያት የተሻለ ገቢ ያገኝበት ጥናት ነዉ። ይህ ዋጋ ጭማሬ የታየዉ፣ በወቅቱ ከተመረተዉ አነስተኛ ምርት መጠን መሆኑ ታዉቋል። ከዚህ ጥናት መነሻ፤ ተሳትፏዊ አነስተኛ መስኖ ሥራ ላልተጠበቀዉ አየር ንብረት ለዉጥም ሆነ ምግብ ዋስትናን ለማረጋገጥ ጉልህ አስተዋፅኦ እንዳለዉ ታይቷል። ስለዚህ በተሳትፏዊ አነስተኛ መስኖ ሥራ ሽንኩርት በጥሩ ሁኔታ በተዘጋጀ ማሳ በ10 ሳ.ሜ ተከላ ርቀት ቢተከል፤ ምረትና ምርታማነትን ሳይቀንስ አርሶ አደሩን ይበልጥ ዉጤታማ ያደርገዋል።

Abstract

*This study was conducted for two consecutive years to find optimum onion spacing under full irrigation, which allows the maximum yield of onion at Kencho kebele of Uba debretsehay woreda Gofa Zone Southern, Ethiopia through the support of the Participatory Small-scale Irrigation Development Program(PASID II). The experiment has four levels of onion planting spacing (8cm, 10cm, 12cm, and Farmer's practice or planting with own practice), laid down in Randomized Completed Block Design (RCBD) with four Replications. The same amount of irrigation water (*416.56mm) which is 100%ETc *was applied for all treatments in the five-day intervals during the study. There was no significant difference among treatment spacing 8cm,10cm, and 12cm on the total yield of onion (16.304 t/ha,17.178 t/ha, and 17.740 t/ha), respectively. The only statistical difference was observed between the three treatments and farmer practice which is 7.3cm (11.464t/ha) on average spacing. Accordingly, farmers' (FREG) were very profitable from the study in both years. Of course, the yield obtained from the study was very low as compared to the potential yield of Red Creole variety in Ethiopia. As a result, farmers were earned a seasonal income of 34ETB/kg which was very costly, and 532,831ETB/ha on average from seasonal production. This implies that low production potential, but makes high profitable for the farmers during the season. So the PASIDP has vital economic values on the livelihood of farmers and even good training for neighborhood farmers. Therefore it was recommended that application appropriate onion spacing of 10cm with a properly managed field irrigation system makes it highly profitable with marketable yield under full irrigation (100%ETc).*

Keywords: Onion spacing, Irrigation, and Yield

Introduction

Onion is considered as one of the most important vegetable crops produced on large scale in Ethiopia. It also occupies an economically important place among vegetables in the country. The area under onion is increasing from time to time mainly due to its high profitability per unit area and ease of production, and the increases in small scale irrigation areas. The crop is produced both under rain fed season and under irrigation during off season. In many areas of the country, the off season crop (under irrigation) constitutes much of the area under onion production (Olani and Fikre, 2010). The unavailability of quality onion seeds is greatly responsible for low yield in this region (Bokshi *et al.,* 1989). The onion's seed size and weight affect the final yield (Gamiely *et.al*., 1990). Furthermore, high quality seed is the critical input on which all other inputs depend for their potential yield. Bulb size and plant spacing are the key factors in producing quality onion seeds (Mirshekari and Mobasher, 2006). Therefore, the present study was conducted to demonstrate the optimum Onion spacing on the growth and yield under irrigation for better yield production of Red Creole variety in the study area.

Materials and Methods

Description of study area

The study was conducted in Low land agro ecology of Kencho Kebele, Uba Debre-tsehay woreda, Gofa Zone, on Sisole irrigation Scheme Southern Ethiopia. The irrigation scheme is funded by IFAD-PASIDP government and community that irrigate potential command area of 130ha. Total beneficiaries of scheme were 254HH from both Kencho and Zaba kebeles and 8km far from Beto the main city of Uba Debre-tsehay Woreda. The project consumed was total cost of 2,455, 690. 71 birr. The study area was geographically located at latitude of 6 °25′4″ N and longitude of 36° 52′41″ E with altitude of 1070 m. a. s. l . In most cases onion widely grown in the mid and high altitude areas of 700 to 2400 m a. s. l, but altitudes from 1200 to1800 m. a. s. l. are very suitable for onion production(Hussein and Ermias, 2011).

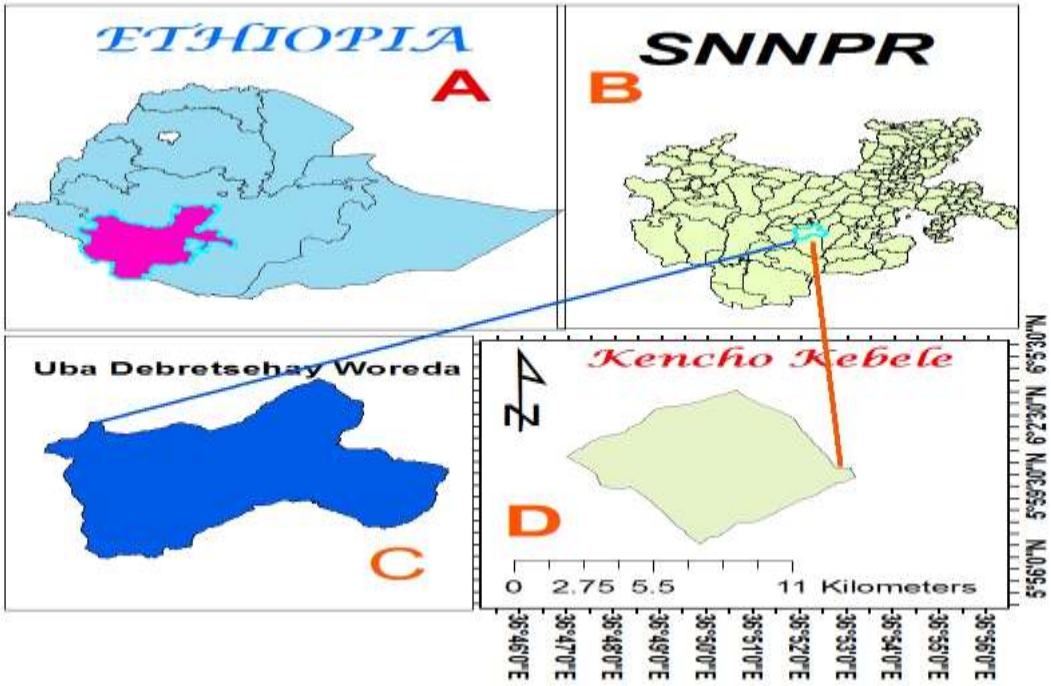

Figure: Map of Study Area

Climate data

Climatic parameters like maximum and minimum air temperature, relative humidity, wind speed, sunshine hours, solar radiation and rainfall were obtained from ClimWat for determination of irrigation schedule and crop water requirement for onion crop. Reference evapotranspiration (ET_O) is determined using these climatic parameters.

Table 1. Average climatic data of study area and ETo CROPWAT 8 output

Months	Minimum temp(°C)	Maximum temp(°C)	Relative Humidity (%)	Wind speed (km day^{-1})	Sunshine hours(hrs)	Rad MJ/m/day	ET_o (mm/day)
January	18.0	30.6	60	95	7.9	19.8	4.24
February	18.3	30.8	63	104	8.1	21.2	4.59
March	18.4	30.8	68	181	6.1	18.9	4.67
April	17.6	28.4	72	130	7.1	20.4	4.39
May	16.9	27.3	76	112	5.3	17.1	3.64
June	17.2	26.3	76	104	5.4	16.8	3.48
July	16.9	26.2	62	95	5.3	16.8	3.65
August	16.8	25.9	59	104	4.0	15.2	3.54
September	16.8	27.0	62	86	5.4	17.7	3.79
October	16.5	27.2	78	95	6.8	19.3	3.77
November	19.8	28.4	57	78	8.2	20.3	4.14
December	16.8	29.3	67	69	8.7	20.6	4.0
Average	**17.5**	**28.2**	**67**	**104**	**6.5**	**18.7**	**3.99**

Crop data

For optimum yield, onion requires 350 to 550mm amount of water throughout growing period. Maximum effective root zone depth (RZD) of onion ranges up to 0.6 m and has maximum allowable depletion of 25% (Andreas et al., 2002). Onion average Kc would be taken after adjustments have been made for initial, development, mid and late season stage to be 0.5, 0.78, 1.03 and 0.88 respectively (Doorenbos and Kassam, 1986). Yield data like economical yield, unmarketable yield and total yield was measured in the field.

Soil data

Composite soil sample was collected from depth of onion root zone to analyze physical and chemical properties. Soil physical and chemical properties like textural class, bulk density, field capacity, permanent wilting point, acidity and electric conductivity of the soil were measured in laboratory. Soil particle distribution of the study area were clay (14%), silt (14%) and sand (72%) and soil of the study area was Sandy loam with USDA soil textural classification. The soil moisture content at field capacity was 205mm/m and permanent wilting point was 90mm/m with bulk density of 1.36gm/cm^3 which is below the critical threshold level 1.4 g/cm^3 and it was suitable for crop root growth (Hunt and Gilkes, 1992). The pH Soil was 6.85 which is found to be little bit more than the optimum value for fertile and well-drained soil range (6.0 – 6.8) for onion under optimal ecological requirement (JICA *et.al*, 2009). The value of ECe (0.72dS/m) was lower considering the standard rates in literature for onion (Landon, 1991).

Fertilizer rate applied

Recommended Optimum fertilizer rate was used for all spacing's onion crop equally. The optimum rate of 105 kg N/ha, 115 kg P_2O_5/ha and 22.5 kg S/ha (300 kg NPS + 105 kg urea banded) was used for onion crop. Other management parts like weeding, chemical application, irrigation water application, Urea split application after 30days of transplanting are the same for all spacing treatments.

Crop water determination

Crop water requirement refers to the amount of water that needs to be supplied, while crop evapotranspiration refers to the amount of water that is lost through evapotranspiration (Allen *et al*., 1998). For the determination of crop water requirement, the effect of climate on crop water requirement, which is the reference crop evapotranspiration (ET_O) and the effect of crop characteristics (Kc) are important (Doorenbos and Pruitt, 1977). The long term and daily climate data like maximum and minimum air temperature, relative humidity, wind speed, sunshine hours, and rainfall data of the study area were collected to determine reference evapotranspiration, crop data like crop coefficient, growing season and development stage, effective root depth, critical depletion factor of tomato and

maximum infiltration rate and total available water of the soil was determined to calculate crop water requirement using CropWAT model.

$$ETc = ETo \times Kc \quad ---------- 1$$

Where:-ETc- crop evapotranspiration, Kc-crop coefficient, ET_O-reference evapotranspiration.

Irrigation water management

The bulk density is also the ratio of the oven-dried mass of soil to its volume for undisturbed soil condition and is expressed on a dry weight basis of the soil as (Blake, 1965):-

$$Bd = \left(\frac{Md}{V_C}\right) ---------- 2$$

Where: - Bd-bulk density, Md- dry mass of the soil, and Vc-volume of core sampling

The total available water (TAW), stored in a unit volume of soil will be determined by the expression.

$$TAW = \frac{(FC - PWP) * Bd * Dz}{100} ---------- 3$$

Where: - TAW-total available water, FC(% Vol)-field capacity, PWP(% Vol)-permanent wilting point, Bd (g/cm^3)-bulk density, and Dz(mm)-root depth.

For maximum crop production, the irrigation schedule should be fixed based on readily available soil water (RAW). The RAW could be computed from the expression:

$$RAW = (TAW * p) ---------- 4$$

Where, RAW in mm, P is in fraction for allowable/permissible soil moisture depletion for no stress and TAW is total available water in mm.

The depth of irrigation supplied at any time can be obtained from the equation

$$\text{Inet(mm)} = (\text{ETc}_{\text{mm}} - \text{Peff}_{\text{mm}}) ---------- 5$$

The gross irrigation requirement was obtained from the expression:

$$\text{GI} = \frac{\text{NI}}{\text{Ea}} ---------- 6$$

Where: - GI- gross irrigation, NI-net irrigation, and Ea- application efficiency but Ea=application efficiency of the furrows (60%) for properly constructed water distribution and proper prepared land water over the irrigated field(Hussein and Ermias, 2011).

The time required to deliver the desired depth of water into each furrow will be calculated using the equation:

$$t = \frac{A * dg}{6Q} \quad \text{---------- 7}$$

Where: - dg- gross depth of water applied (cm), t-application time (min), A-area of plot size (m^2), and Q-flow rate (discharge) (l/s).

The amount of irrigation water required to be applied at each irrigation application time was measured using calibrated three inch Parshall flume.

Experimental design

The experiment has four level of treatments with 8cm, 10cm, 12cm and farmers practice replicated with four times. Onion spacing of 10cm was used as reference and demonstration spacing. In sense of participatory evaluation and demonstration; farmers' used as replication. Treatments were arranged in straight with 10m*10m dimensions and 0.7m distance between plots. The distance between ridge and furrow was 20cm and 40cm respectively.

Variety: Red Creole

A popular variety which produces red, flat-round, globular bulbs
It has very pungent taste
Maturity: 130- 140 growing periods
Average weight of the bulb(g): 60- 70
Yield Potential: 300qt/ha

Statistical analysis

Data was analyzed using R-Software version 3.4.1 at probability of 5% confidence level. The factor of the experiment was considered as single factorial Randomized Complete Block Design (RCBD) for analysis.

Data Collection

Data like plant height, bulb weight, and bulb diameter, marketable, unmarketable and total yield were measured from the net harvested area of each plot in the field.

Results and Discussions

Determination of crop seasonal evapotranspiration

Crop water requirement is the total quantity of water, regardless of its sources, required by the crop in a given growing season (from the time it is sown to the time it is harvested) for compensating the evapotranspiration loss plus water used for digestion, photosynthesis, transportation of minerals and foods, and also for structural support. Determination of Water requirement of crops is essential for efficient management of irrigation water. The total seasonal crop evapotranspiration was found to be 416.56 mm which is 100% ETc applied in seven day irrigation interval for onion in the study area.

Table 3. Seasonal crop water requirement in each month

Months	Development stages	No-of days	Kc_ Values	ETo (mm/day)	ETc (mm/day)	ETc (mm/period)	ETc (mm/month)
January	Initial	20	0.5	4.24	2.12	42.4	42.4
February	Development	29	0.78	4.59	3.58	103.82	103.82
March		1	0.78	4.67	3.64	3.64	
	Mid	30	1.03	4.67	4.81	144.3	147.94
April		10	1.03	4.39	4.52	45.2	
	Late	20	0.88	4.39	3.86	77.2	122.4
Seasonal ETc							416.56

Response of onion to different plant spacing's under irrigation

Analysis of variance revealed that the effects of planting space resulted, not significant variation in marketable yield and total yield of onion. All parameters analyzed indicate no difference among treatments. Adding and reducing 2cm distance from recommended onion spacing 10cm can not affect the required parameters of the study. The result indicates that spacing taken above and below recommended and demonstrated spacing (10cm) as a package is too minimum distance. The difference was seen only the three treatments and farmers' practice. The average farmers' planting spacing was 7.3cm which is practiced by farmers by their own. As a result, marketable and total yield obtained was very low as compared to other treatment spacing's. But the farmers were very volunteer and participative in aspects of field work. Especially there is no significant difference among treatments for plant height, bulb diameter, bulb weight and unmarketable weight. Generally, on average good yield and relevant economic income was obtained. Consequently, FREGs' were very profitable from the program. Even though there was no significant difference observed between other treatments spacing and farmers practice of spacing, the program members were highly benefited economically. And also, numerical difference was seen among the three spacing with 8cm (16.304t/ha), 10cm (17.178t/ha) and 12cm (17.74t/ha) even

there was no statistical difference observed. Pictorial field performance was clearly seen in detail among treatments on graphical representation of figure 3 below.

Figure 2. Onion at development and harvesting time

Table 4. Combined two year mean values of different planting space for onion

Treatments	PH(cm)	BD(cm)	BW(gm)	MY(t/ha)	UMY(t/ha)	TY(t/ha)
1	45.494	5.3710	59.433	13.765 [a]	2.007	16.304[a]
2	48.977	4.9567	60.731	14.450 [a]	1.7328	17.178[a]
3	49.757	5.2696	62.085	14.925 [a]	2.8252	17.74[a]
4	45.025	5.1953	48.376	9.093[b]	2.3753	11.464[b]
CV	15.86	10.74	16.03	12.71	5.82	9.41
LSD	NS	NS	NS	2.08	NS	2.08

PH-Plant Height, BD-Bulb Diameter, BW-Bulb Weight, MY-Marketable Yield, UMY-Unmarketable Yield, TY-Total Yield

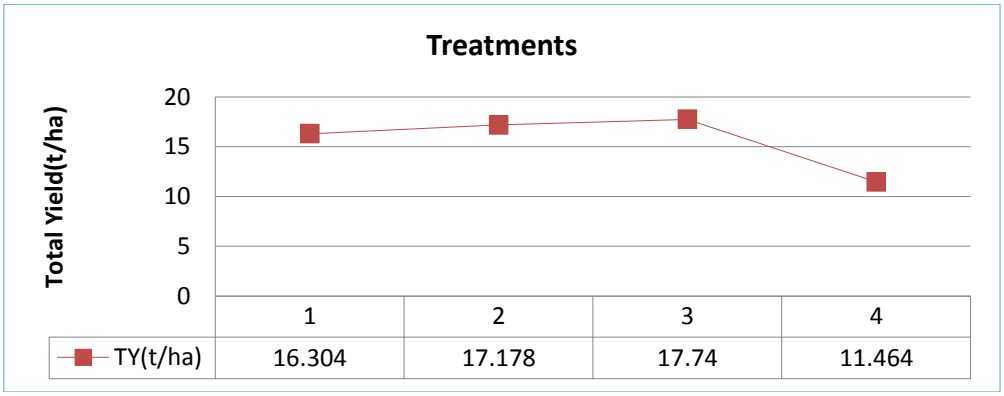

Figure 3. Graphical Representation of total yield and treatments

Conclusions and Recommendations

The study concluded that the yield of onion seeds (Red Creole variety) preferred and selected by the farmers them self was not significantly affected by the interaction effects of plant spacing. But farmers' were very profitable under both of study time and sell 34ETB/Kg and 532, 831ETB/ha on average from seasonal production. So the PASIDP has many economic values on livelihood of FREG members and even good training for neighborhoods farmers. Since they are market oriented and adjusted their crop calendar to harvest most probably for Easter holidays to obtain high profit from even low yield. Even though there was small numerical difference observed among total yield of treatment spacing's' with 8cm (16.304t/ha), 10cm (17.178t/ha) and 12cm (17.78t/ha); 10cm plant spacing taken as a demonstration was better than 12cm plant spacing in consideration of total plant population in ha. Therefore it was recommended that, application appropriate onion with proper managed field irrigation system makes highly profitable with marketable yield under full irrigation(100%ETc).

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