



(RESEARCH ARTICLE)



Effect of planting space on bulb yield and yield components of onion (*Allium cepa* L.) in Gamo Zone, South Ethiopia

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Abstract

The experiment was conducted at Arba Minch Zuria and Mirab Abaya districts during 2020 and 2021 cropping seasons to determine the best planting pattern for bulb yield and yield components of onion and to identify optimum planting space for onion production. It consisted of 12 treatments (20x5, 30x5, 40x5, 20x10, 30x10, 40x10cm, 30x15x5, 40x20x5, 50x25x5, 30x15x10, 40x20x10 and 50x25x10cm inter and intra row spacing) and arranged in Randomized Complete Block Design with three replications. The results revealed that plant height, bulb diameter, marketable and unmarketable bulb yield were significantly affected by planting space. The highest marketable bulb yield was obtained from 30x15*5cm without significant variation with 20x5cm, 30x15*10cm and 50x25*5cm spacing at both locations. The lowest marketable bulb yield was recorded from planting space of 40x10cm and 30x5cm at two locations. From this study, it was also observed that the use of single and double row at 20x5cm (inter and intra row, respectively) and 30x15x5cm planting space, respectively resulted better onion bulb yield in study areas. Based on partial budget analysis, growing of onion under double row planting pattern at the planting space of 30x15x5cm gave maximum net benefit and marginal rate of return at both locations. Therefore, double row planting pattern at 30x15x5cm planting space could be optimum to obtain better onion bulb yield and highest net benefit and recommended for small-scale onion growers in the study areas and other areas with similar agro-ecological conditions.

Keywords: Bulb production; Onion; Planting pattern; Plant population; Spacing

1. Introduction

Onion (*Allium cepa* L.) belongs to the family *Alliaceae* [1] and it is one of the most important vegetable crops cultivated widely in the most parts of the world. In Ethiopia, the crop grows in varied agro-ecological conditions both under rainfed and irrigation production system throughout the year [2]. Onion is one of the most common vegetable crops produced by smallholder farmers in Arba Minch Zuria and Mirab Abaya districts (study areas) of Gamo zone, South Ethiopia where there is immense potentials for onion and other vegetable crops production.

According to Central Statistical Agency [2] report, total bulb production of onion was 420,967.04 tons from an area of 52,616.24ha in 2020/2021 cropping season. Total area covered by onion is increasing from time to time in different parts of the country due to its vital role in small-scale production systems as it serves as source of income and helps to improve the livelihood of the producers. However, the average bulb yield of onion is not more than 8.0 tons ha⁻¹ both in Ethiopia and in the study areas [2], which is by far low as compared to the crop potential (30.0 tons ha⁻¹) [3].

Agronomic practices applied and growing environments partly affect the bulb yield and quality of onion [4]. Planting space (inter and intra-row spacing) is one of the agronomic practices that determine bulb size and productivity of onion [5, 6, 7, 8]. Small-scale farmers in Arba Minch and Mirab Abaya areas use 40x10cm spacing for both single and double planting pattern which resulted in undesirable onion bulb size (over and undersized bulb, respectively) without

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considering planting population difference in the two planting patterns. Therefore, this study was conducted to determine the best planting pattern (single or double row planting pattern) for growth, bulb yield and yield components of onion and to identify optimum planting space for onion bulb production in Arba Minch Zuria and Mirab Abaya districts, South Ethiopia.

2. Materials and Methods

2.1. Description of the study areas

The experiment was conducted at Arba Minch Zuria (Chano Mille kebele) and Mirab Abaya (Omo Lante kebele) districts of Gamo Zone, South Ethiopia in 2020 and 2021 cropping seasons under supplementary irrigation. The specific experimental site in Mirab Abaya district is geographically positioned at 6°09'51" N latitude and 37°38'33" E longitude with an altitude of 1235 meter above sea level whereas that of Arba Minch Zuria district is positioned at 6°06'84" N latitude and 37°35'12" E longitude with an altitude of 1216 meter above sea level. The two experimental areas received annual rainfall ranging from 801 to 1600mm with temperature of 15.1 to 25.0 °C during the cropping seasons. The soil type of Arba Minch Zuria is clay whereas that of Mirab Abaya is sandy loam.

2.2. Experimental treatments, design and management

The experiment consisted of twelve treatments (six single and six double planting patterns) namely; single planting pattern in a spacing of 20x5cm, 30x5cm, 40x5cm, 20x10cm, 30x10cm and 40x10cm, and double planting pattern in a spacing of 30x15x5cm, 40x20*5cm, 50x25*5cm, 30x15*10cm, 40x20*10cm and 50x25*10cm. It was carried-out in a Randomized Complete Block Design with three replications having a plot size of 4m x 3m for each experimental unit.

Bombay Red onion variety, which is recommended and widely produced variety by the smallholder farmers in the study areas [9, 10] due to its medium bulb size, early maturity, high bulb yield and attractive bulb skin color [4], was used for the experiment. All agronomic practices except planting space were applied uniformly to all plots as per the recommendation for onion bulb production [4, 11].

2.3. Partial budget analysis

Partial budget analysis was used to determine the economic feasibility of appropriate planting space for onion production based on the description given by CIMMYT [12]. It was done using the prevailing market prices for inputs at planting and for output at the time when onion bulb yield was harvested. Average marketable onion bulb yield for each treatment in each location, adjusted yield, gross field benefit and total costs that vary due to treatments were considered for partial budget analysis. The average marketable onion bulb yield was adjusted downwards by 10%, taking into consideration that farmers could get 10% less bulb yield [12]. The minimum acceptable marginal rate of return used in this study was assumed to be 100% for farmers' recommendation domain (i.e., for each one birr investment, farmers supposed to recover one birr and plus more). The marketable onion bulb yield from the planting space 40cmx10cm which is currently farmer practice (control plot) in the study areas taken as a reference and the bulb yield increment at different treatments that received different planting spaces (increase over the control) considered for partial budget analysis evaluation. The farm-gate price of marketable bulb yield of onion in the local market of the study areas was 35.00 Ethiopian Birr kg⁻¹ at the harvesting time. Finally, treatment that gave the maximum net benefit with acceptable marginal rate of return selected. In general, the partial budget analysis was carried-out based on the formula developed by CIMMYT [12] and calculated as follows:

Gross average marketable bulb yield (kg ha⁻¹) (AvY): was an average marketable onion bulb yield of each treatment. Adjusted yield (AjY): was the average marketable bulb yield adjusted downward by a 10% to reflect the difference between the experimental yield and yield of farmers. $AjY = AvY - (AvY \times 0.1)$. Gross field benefit (GFB): was computed by multiplying farm gate price that farmers receive for the marketable bulb yield when they sale it as adjusted yield. $GFB = AjY \times \text{farm gate price for the marketable onion bulb yield}$. Total variable costs (TVC): the seed cost and labor cost for planting and harvesting were considered to estimate total variable costs for this experiment. The costs of other production practices such as for land preparation, weeding and pest management were considered as the same or constant among the proposed treatments. Net benefit (NB): was calculated by subtracting the total variable costs from gross field benefit for each treatment for each location. $NB = GFB - TVC$. Marginal rate of return (MRR %): was calculated by dividing change in net benefit by change in total variable costs. $MRR(\%) = \frac{\Delta NB}{\Delta TVC} \times 100$; Where, MRR = Marginal rate of return in percent, ΔNB and ΔTVC = change in net benefit and change in total variable costs, respectively.

2.4. Data collection and analysis

Data on plant height, bulb diameter, bulb length, marketable and unmarketable bulb yield were collected. The collected data were subjected to Analysis of Variance (ANOVA) using SAS statistical software package version 9.2 [13]. Treatment means that differed significantly were separated by using Least Significant Difference test at 5% significance level. As the error variances for the parameters considered in this study at two locations were heterogeneous, the data were presented separately for each location whereas that of the two years was homogenous so the combined data were presented.

3. Results and Discussions

Analysis of variance result indicated that all the parameters (except bulb length) considered in this study were significantly affected by the treatments at the two study areas, Mirab Abaya and Arba Minch Zuria districts. The tallest plant height was observed in single row planting pattern at the spacing of 20x10cm and 30x5cm without significant variation with other treatments except double row planting at 40x20x10cm spacing, which resulted the shortest onion plant in Mirab Abaya district (Table 1). Similarly, the highest plant height of onion recorded at 40x5cm in Arba Minch Zuria district (Table 2).

Highest bulb diameter was recorded when onion seedlings were planted at a spacing of 40x10cm apart from two rows and seedlings whereas the lowest bulb diameter was observed in 30x15*5cm at Mirab Abaya location. The same trend was also observed at Arba Minch Zuria location. As planting space increases, the bulb diameter also increased at both single and double row planting patterns at both locations although there is some inconsistency in some treatments (Table 1 and Table 2). The higher plant height and bulb diameter at wider inter and intra row spacing might due to better availability of space between plants and rows to get enough soil moisture, nutrients and light without competition for better crop growth and bulb development. It was also reported that the wider planting space, the higher plant height and bulb diameter in onion crop [5, 8, 14]. Similarly, the results of this study also agrees with Awas *et al.* [6] and Tegen *et al.* [7] who reported that height of onion plants and bulb diameter increased under the combination of wider inter and intra row spacing.

The highest marketable bulb yield was obtained from inter and intra row spacing of 30x15*5cm without significant variation with 20x5cm, 30x15*10cm and 50x25*5cm spacing at Mirab Abaya district. Similarly, highest marketable bulb yield was recorded at 30x15*5cm, which is at par with 30x15*10cm and 20x5cm treatments at Arba Minch Zuria district. The lowest marketable bulb yield was produced from inter and intra row space of 40x10cm and 30x5cm at Mirab Abaya and Arba Minch Zuria districts, respectively (Table 1 and Table 2). This indicated that marketable bulb yield is determined by planting density. This is in line with Kantoneet *al.* [5], Awas *et al.* [6] and Kahsay *et al.* [15] who reported that the increase of plant density to some extent increased the marketable bulb yield of onion.

Table 1 Mean values of yield and yield related parameters of onion as affected by intra and inter row spacing in single and double row planting patterns at Mirab Abaya, Gamo Zone, South Ethiopia during 2020 and 2021 cropping seasons

| Treatments | PH (cm) | BD (cm) | BL (cm) | MBY (kg/ha) | UMY (kg/ha) |
|------------------------------------|---------------------|---------------------|---------|----------------------|----------------------|
| Single row planting pattern | | | | | |
| 20x5cm | 56.93 ^{ab} | 19.77 ^b | 8.067 | 45972 ^{ab} | 191.7 ^{cd} |
| 30x5cm | 61.00 ^a | 20.27 ^b | 7.267 | 39583 ^{bc} | 153.3 ^{de} |
| 40x5cm | 60.4 ^{ab} | 21.00 ^{ab} | 8.533 | 27500 ^{ef} | 75.8 ^{ghi} |
| 20x10cm | 61.00 ^a | 20.97 ^{ab} | 7.30 | 35694 ^{c-e} | 119.2 ^{efg} |
| 30x10cm | 59.8 ^{ab} | 22.67 ^{ab} | 8.00 | 26389 ^f | 34.7 ⁱ |
| 40x10cm | 57.2 ^{ab} | 26.57 ^a | 7.97 | 20833 ^f | 262.5 ^b |
| Double row planting pattern | | | | | |
| 30x15*5cm | 56.33 ^b | 19.30 ^b | 7.37 | 48750 ^a | 338 ^a |
| 40x20*5cm | 60.6 ^{ab} | 22.03 ^{ab} | 8.10 | 29444 ^{d-f} | 105 ^{efgh} |
| 50x25*5cm | 59.00 ^{ab} | 19.87 ^b | 7.50 | 41250 ^{a-c} | 210 ^c |

| | | | | | |
|------------|---------------------|---------------------|-------|---------------------|---------------------|
| 30x15*10cm | 56.80 ^{ab} | 21.27 ^{ab} | 7.40 | 45833 ^{ab} | 126.7 ^{ef} |
| 40x20*10cm | 56.47 ^b | 21.67 ^{ab} | 8.27 | 36806 ^{cd} | 58.7 ^{hi} |
| 50*25*10cm | 59.33 ^{ab} | 21.03 ^{ab} | 8.07 | 27639 ^{ef} | 90 ^{fgh} |
| LSD (0.05) | 4.38 | 5.71 | NS | 8747.30 | 48.74 |
| CV (%) | 4.40 | 15.80 | 11.40 | 14.60 | 19.6 |

Mean values in the same column with different letters represent significant variation among treatment at 5% probability level. PH = Plant height; BD = bulb diameter; BL = bulb length; MBY = Marketable bulb yield; UMBY = Unmarketable bulb yield; CV = Coefficient of variation (%); LSD = Least significant difference at $p < 0.05$ probability level; and NS = Not significant.

Table 2 Mean values of yield and related parameters of onion as affected by inter and intra-row spacing in single and double row planting pattern at Arba Minch Zuria district, Gamo Zone, South Ethiopia during 2020 and 2021 cropping seasons

| Treatments | PH (cm) | BD (cm) | BL (cm) | MBY (kg/ha) | UMBY (kg/ha) |
|------------------------------------|---------------------|---------------------|---------|-----------------------|---------------------|
| Single row planting pattern | | | | | |
| 20x5cm | 51.20 ^{ab} | 15.80 ^c | 4.65 | 13,924 ^{a-d} | 809.4 ^b |
| 30x5cm | 47.40 ^b | 17.20 ^{bc} | 5.50 | 4062 ^f | 237.5 ^g |
| 40x5cm | 53.80 ^a | 17.47 ^b | 5.40 | 10,972 ^b | 447.9 ^f |
| 20x10cm | 50.20 ^{ab} | 17.73 ^b | 4.93 | 6819 ^f | 225 ^g |
| 30x10cm | 48.93 ^{ab} | 18.37 ^{ab} | 5.57 | 8021 ^{d-f} | 365.6 ^{fg} |
| 40x10cm | 52.23 ^{ab} | 17.63 ^b | 5.13 | 7257 ^{ef} | 416.7 ^f |
| Double row planting pattern | | | | | |
| 30x15*5cm | 51.27 ^{ab} | 17.80 ^b | 5.03 | 17,431 ^a | 1477.8 ^a |
| 40x20*5cm | 53.47 ^a | 17.47 ^b | 4.97 | 13,125 ^{abc} | 777.8 ^{bc} |
| 50x25*5cm | 50.70 ^{ab} | 17.60 ^b | 5.15 | 12,500 ^{abc} | 619.8 ^{cd} |
| 30x15*10cm | 52.90 ^{ab} | 19.35 ^a | 5.50 | 15,521 ^{ab} | 250 ^g |
| 40x20*10cm | 50.00 ^{ab} | 17.03 ^{bc} | 5.13 | 13,333 ^{ab} | 450 ^{ef} |
| 50x25*10cm | 52.60 ^{ab} | 18.07 ^{ab} | 5.13 | 9028 ^{bc-f} | 606.9 ^{de} |
| LSD(0.05) | 5.79 | 1.50 | NS | 5935.70 | 503.2 |
| CV (%) | 6.70 | 5.10 | 9.20 | 29.60 | 16.8 |

Mean values in the same column with different letters represent significant variation at 5% probability level. PH = Plant height; BD = bulb diameter; BL = bulb length; MBY = Marketable bulb yield; UMBY = Unmarketable bulb yield; CV = Coefficient of variation (%); LSD = Least significant difference at $p < 0.05$ probability level; and NS = Not significant.

Crop growers may or may not be benefited due to increased production costs for higher production of the crop. Hence, it is necessary to estimate net benefit and marginal rate of return obtained from various alternative treatments by using partial budget analysis (CIMMYT, 1988).

The partial budget analysis was estimated for 12 treatments in each location and results are presented in Table 3 and Table 4 for Mirab Abaya and Arba Minch zuria districts, respectively. In this study, the use of 40x10cm planting space was considered as the existing practice at both locations. Each planting space was compared with the existing practice to identify which planting space provides highest net benefit to the onion growers.

The highest adjusted marketable bulb yield of 43,875.0 and 15,687.9 kg ha⁻¹ was obtained from the same planting space (30x15x5cm) at Mirab Abaya and Arba Minch zuria districts, respectively followed by 41,374.8 and 13,968.9 kg ha⁻¹ obtained from 20x5cm at Mirab Abaya and from 30x15*10cm at Arba Minch zuria, respectively. The maximum net benefit was obtained from double row planting pattern at the spacing of 30x15x5cm in both locations. In contrast, the minimum adjusted marketable onion bulb yield and minimum net benefit was obtained from single row planting

pattern at planting space of 40x10cm and 30x5cm at Mirab Abaya and Arba Minch zuria districts, respectively (Table 3 and Table 4).

Onion growers/producers may have different criteria for adoption of production technologies or preference of production technologies such as the technology with higher net benefit, high benefit to cost ratio and high yield, but most of the growers prefer to obtain the combination of high yield with high net benefit. Therefore, it is necessary to estimate marginal rate of return to check the current technology (planting space) could allow minimum economic return. Marginal rate of return was estimated to identify the treatment that has the minimum acceptable rate of return to recommend the technology to the onion growers [12]. In this regard, the highest marginal rate of return (MRR) of 113.80% and 74.20% obtained from 30x15x5cm at Mirab Abaya and Arba Minch zuria districts, respectively (Table 4 and Table 6). This suggested that growing of onion under double row planting pattern at the planting space of 30x15x5cm at both locations could be recommended to growers since the growers would have more than one birr return in an increase of one Birr of the production cost.

Table 3 Partial budget analysis of onion production under different planting spaces at Mirab Abaya, South Ethiopia during 2020 and 2021 cropping seasons.

| Treatments | AvY (kg ha ⁻¹) | AjY (kg ha ⁻¹) | TVC (ETB ha ⁻¹) | GFB (ETB ha ⁻¹) | NB (ETB ha ⁻¹) | Dominancy |
|------------|----------------------------|----------------------------|-----------------------------|-----------------------------|----------------------------|-----------|
| 40x10cm | 20,833.0 | 18,749.7 | 2,800 | 656,239.5 | 653,439.5 | |
| 50x25*5cm | 41,250.0 | 37,125.0 | 3,500 | 1,299,375.0 | 1,295,875.0 | |
| 40x5cm | 27,500.0 | 24,750.0 | 3,550 | 866,250.0 | 862,700.0 | D |
| 30x10cm | 26,389.0 | 23,750.1 | 4,100 | 831,253.5 | 827,153.5 | D |
| 30x5cm | 39,583.0 | 35,624.7 | 4,500 | 1,246,865.0 | 1,242,365.0 | D |
| 50x25*10cm | 27,639.0 | 24,875.1 | 4,600 | 870,628.5 | 866,028.5 | D |
| 20x10cm | 35,694.0 | 32,124.6 | 5,550 | 1,124,361.0 | 1,118,811.0 | D |
| 40x20*10cm | 36,806.0 | 33,125.4 | 5,600 | 1,159,389.0 | 1,153,789.0 | D |
| 40x20*5cm | 29,444.0 | 26,499.6 | 7,100 | 927,486.0 | 920,386.0 | D |
| 30x15*10cm | 45,833.0 | 41,249.7 | 8,200 | 1,443,740.0 | 1,435,540.0 | |
| 30x15x5cm | 48,750.0 | 43,875.0 | 9,000 | 1,535,625.0 | 1,526,625.0 | |
| 20x5cm | 45,972.0 | 41,374.8 | 11,100 | 1,448,118.0 | 1,437,018.0 | D |

AvY: average marketable bulb yield (kg ha⁻¹); AjY: Adjusted yield; TVC: Total variable costs; GFB: Gross field benefit; NB: Net benefit; D: dominated.

Table 4 Marginal rate of return for onion production under different planting spaces at Mirab Abaya, South Ethiopia during 2020 and 2021 cropping seasons

| Treatments | AvY (kg ha ⁻¹) | AjY (kg ha ⁻¹) | TVC (ETB ha ⁻¹) | GFB (ETB ha ⁻¹) | NB (ETB ha ⁻¹) | MRR% |
|------------|----------------------------|----------------------------|-----------------------------|-----------------------------|----------------------------|--------|
| 40x10cm | 20,833.0 | 18,749.7 | 2,800 | 656,239.5 | 653,439.5 | - |
| 50x25*5cm | 41,250.0 | 37,125.0 | 3,500 | 1,299,375.0 | 1,295,875.0 | 91.77 |
| 30x15*10cm | 45,833.0 | 41,249.7 | 8,200 | 1,443,740.0 | 1,435,540.0 | 29.70 |
| 30x15x5cm | 48,750.0 | 43,875.0 | 9,000 | 1,535,625.0 | 1,526,625.0 | 113.80 |

AvY: gross average marketable bulb yield (kg ha⁻¹); AjY: Adjusted bulb yield; TVC: Total variable costs; GFB: Gross field benefit; NB: Net benefit; MRR %: Marginal rate of return in percent.

Table 5 Partial budget analysis for onion production under different planting spaces at Arba Minch zuria, South Ethiopia during 2020 and 2021 cropping seasons

| Treatments | AvY (kg ha ⁻¹) | AjY (kg ha ⁻¹) | TVC (ETB ha ⁻¹) | GFB (ETB ha ⁻¹) | NB (ETB ha ⁻¹) | Dominancy |
|------------|----------------------------|----------------------------|-----------------------------|-----------------------------|----------------------------|-----------|
| 40x10cm | 7,257.0 | 6531.3 | 2,800 | 228,595.5 | 225,795.5 | |
| 50x25*5cm | 12,500.0 | 11,250.0 | 3,500 | 393,750.0 | 390,250.0 | |
| 40x5cm | 10,972.0 | 9,874.8 | 3,550 | 345,618.0 | 342,068.0 | D |
| 30x10cm | 8,021.0 | 7,218.9 | 4,100 | 252,661.5 | 248,561.5 | D |
| 30x5cm | 4,062.0 | 3,655.8 | 4,500 | 127,953.0 | 123,453.0 | D |
| 50x25*10cm | 9,028.0 | 8,125.2 | 4,600 | 284,382.0 | 279,782.0 | D |
| 20x10cm | 6819.0 | 6137.1 | 5,550 | 214,798.5 | 209,248.5 | D |
| 40x20*10cm | 13,333.0 | 11,999.7 | 5,600 | 419,989.5 | 414,389.5 | |
| 40x20*5cm | 13,125.0 | 11,812.5 | 7,100 | 413,437.5 | 406,337.5 | D |
| 30x15*10cm | 15,521.0 | 13,968.9 | 8,200 | 488,911.5 | 480,711.5 | |
| 30x15x5cm | 17,431.0 | 15,687.9 | 9,000 | 549,076.5 | 540,076.5 | |
| 20x5cm | 13,924.0 | 12,531.6 | 11,100 | 438,606.0 | 427,506.0 | D |

AvY: average marketable bulb yield (kg ha⁻¹); AjY: Adjusted yield; TVC: Total variable costs; GFB: Gross field benefit; NB: Net benefit; D: dominated.

Table 6 Marginal rate of return for onion production under different planting spaces at Arba Minch zuria, South Ethiopia during 2020 and 2021 cropping seasons

| Treatments | AvY (kg ha ⁻¹) | AjY (kg ha ⁻¹) | TVC (ETB ha ⁻¹) | GFB (ETB ha ⁻¹) | NB (ETB ha ⁻¹) | MRR% |
|------------|----------------------------|----------------------------|-----------------------------|-----------------------------|----------------------------|-------|
| 40x10cm | 7,257.0 | 6,531.3 | 2,800 | 228,595.5 | 225,795.5 | |
| 50x25*5cm | 12,500.0 | 11,250.0 | 3,500 | 393,750.0 | 390,250.0 | 23.93 |
| 40x20*10cm | 13,333.0 | 11,999.7 | 5,600 | 419,989.5 | 414,389.5 | 11.49 |
| 30x15*10cm | 15,521.0 | 13,968.9 | 8,200 | 488,911.5 | 480,711.5 | 25.50 |
| 30x15x5cm | 17,431.0 | 15,687.9 | 9,000 | 549,076.5 | 540,076.5 | 74.20 |

AvY: gross average marketable bulb yield (kg ha⁻¹); AjY: Adjusted bulb yield; TVC: Total variable costs; GFB: Gross field benefit; NB: Net benefit; MRR %: Marginal rate of return in percent.

4. Conclusion and Recommendation

Bulb productivity and production of onion could be increased by using appropriate planting space if other improved production packages were applied properly to the crop. The findings of the current study showed that plant height, bulb diameter, marketable and unmarketable bulb yield of onion were significantly affected by planting space at the two study areas. The maximum marketable bulb yield of onion was recorded at spacing of 30x15*5cm in double row planting without significant variation with single row planting at a spacing of 20x5cm. It can be concluded that narrower planting space (20x5cm and 30x15x5cm in single and double row planting pattern, respectively) increased the productivity of onion bulb yield in Mirab Abaya and Arba Minch Zuria areas. Based on partial budget analysis, growing of onion under double row planting pattern at the planting space of 30x15x5cm at both locations would give maximum net benefit and marginal rate of return at both locations. Therefore, double row planting pattern at planting space of 30x15x5cm could be recommended for better onion bulb yield and higher net benefit in the study areas.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that they have no conflict of interest.

References

- [1] Griffiths G, Trueman L, Crowther T, Thomas B, Smith B. Onions a global benefit to health. *Phytother. Res.* 2002. 16: 603-615.
- [2] CSA (Central Statistical Agency of the Ethiopia). Report on Area, Production and Farm Management Practices of Crops (Private Peasant Holdings, Meher and Belg Seasons). Agricultural Sample Survey 2020/2021. Volume V, Statistical Bulletin 578. Addis Ababa, Ethiopia. 2021. pp 147.
- [3] Lemma D, Shimelis A. Research Experiences in Onion Production. Research Report Number 55, Ethiopian Agricultural Research Organization (EARO). Addis Ababa, Ethiopia. 2003. pp. 1-55.
- [4] Asfaw Z, Eshetu D. (eds). Production and management of major vegetable crops in Ethiopia. Addis Ababa, Ethiopia. Ethiopian Institute of Agricultural Research (EIAR), Addis Ababa, Ethiopia; KOPIA Ethiopia Centre, Addis Ababa, Ethiopia. Printed at Eth-Cana Printing Press. 2015. pp 149.
- [5] Kantone RAL, Abbey L, Hilla RG, Tabil MA, Jan ND. Density Affects Plant Development and Yield of Bulb Onion (*Allium cepa* L.) in Northern Ghana. *Journal of Vegetable Crop Production.* 2003. 8(2):15-25.
- [6] Awas G, Abdisa T, Tolessa K, Chali A. 2010. Effect of Intra-row Spacing on Yield of Three Onion (*Allium cepa* L.) Varieties at Adami Tulu Agricultural Research Center (Mid Rift Valley of Ethiopia). *Journal of Horticulture and Forestry.* 2010. 2(1): 007-011.
- [7] Tegen H, Jembere M, Mihiretu E. and Enyew A. Influences of Inter and Intra-row Spacing on Yield, Yield Component and Morphological Characteristics of Onion (*Allium cepa* L.) at Western Amhara Region. *African Journal of Agricultural Research.* 2016. 11(20):1797-1804.
- [8] Gebrekorkos G, Berhe H, Abera K. Effect of Inter and Intra-row Spacing on the Yield and Yield Components of Onion (*Allium cepa* L.) at Mehoni District, Northern Ethiopia. *African Journal of Plant Science.* 2017. 11(4): 86-91.
- [9] Mensa A, Sultan K, Chenchu D. Effect of weeding frequency and interval on onion (*Allium cepa* L.) bulb yield grown under irrigation condition at Arba Minch, Southern Ethiopia. *Journal of Agricultural Science and Practice.* 2020. 9(2): 91-102.
- [10] Gezahegn F, Alemayehu W. Evaluation of Onion (*Allium cepa* L.) varieties under Supplementary Irrigation at Arba Minch, Southern Ethiopia. Southern Agricultural Research Institute (SARI). Proceedings of the Workshop of Review of Completed Crop Research held at Butajira from June 10-13. 2019. Butajira, Ethiopia.
- [11] EARO (Ethiopian Agricultural Research Organization). Directory of Released Crop Varieties and their Recommended Cultural Practices. EARO, Addis Ababa, Ethiopia. 2004.
- [12] CIMMYT (International Maize and Wheat Improvement Center). From Agronomic Data to Farmer Recommendations: An Economics Training Manual. *Completely Revised Edition.* Mexico. D.F. 1988.
- [13] SAS (Statistical Analysis of Software). User's Guide. Version 9.2. NC. USA. 2009.
- [14] Sikder M, Mondal F, Mohammed D, Alam S, Amin B. Effect of spacing and depth of planting on growth and yield of onion. *J. Agroforestry Environ.* 2010. 4(2):105-108.
- [15] Kahsay Y, Belew D, Abay F. Effect of Intra-row Spacing on Yield and Quality of Some Varieties (*Allium cepa* L.) at Aksum, Northern Ethiopia. *African Journal of Plant Science.* 2013. 7(12): 613-622.