

# Maximizing Bulb Yield and Quality of Onion (*Allium Cepa* L.) Through Agronomic Management of Phosphorus Fertilizer and Transplanting Date Under Irrigation in Alaba, Ethiopia

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## Abstract

Bulb yield and quality of the onion is constrained by a number of factors, including inappropriate transplanting age and poor fertilizer management practices. Therefore, a field experiment was conducted to determine the best transplanting date on quality, combined with phosphorus level, on onion yield of onion. The study was conducted at Alaba, Ethiopia, during 2018/19 season. The treatments consisted of four phosphorus levels, i.e. 0, 20, 40 and 60 kg.ha<sup>-1</sup> and three transplanting days, i.e., 42, 49 and 56 days, from sowing. The experiment was laid out in randomized complete block design with four replications. The result showed that transplanting date and phosphorus rate significantly affected bulb dry weight, and marketable bulb yield which includes medium and large sized bulbs. Among these parameters, marketable bulb yield was also significantly affected by the interaction of transplanting days and phosphorus rate. In this study, onion fertilized with P at 60 kg.ha<sup>-1</sup> transplanted at 56 days had the highest marketable bulb yield. The economic analysis revealed that the highest net benefit with the lowest cost of production was obtained from the application of P at 40 kg.ha<sup>-1</sup> transplanted at date of 56 days. The marginal rate of return for this treatment was economically feasible for producing bulb in the districts.

Key words: bulb size distribution, soil sampling, economic analysis, net benefit.

## Introduction

The average nutrient depletion in East Africa, particularly of Ethiopia is estimated to be around 47 to 88 kg.ha<sup>-1</sup> per year in general and 100 kg. ha<sup>-1</sup> per year in particular on the highlands (Henao and

Baanante, 1999). Major factors contributing to such depletion are soil erosion, fixation of phosphorus (P), leading to unavailability to the crops; the problem is further accelerated by deleterious land use practices resulting from high population pressure. N, P, and K are the most important of the essential nutrients to plants because they are required in large quantities. The deficiency of these elements is manifested in the significant reduction in growth and development of the plants (Tisdale et al., 1995). Phosphorus deficiency is one of the largest constraints to crop production in many tropical soils, owing to low native content and high P fixation capacity of the soil (Fairhurst et al., 1999), therefore, P fertilization is usually recommended in these soils. Phosphorus is essential for root development and when the availability is limited, plant growth is usually reduced. P deficiency in onion reduce root and leaf growth, bulb size and yield and can also delay maturation (Brewster, 1994).

Onions are generally established by bare root transplants. Compared to direct seeding, transplanted onions provide an immediate and complete stand. Transplanting age is one of the important factors, which influences the growth, yield and quality of crop. Proper age of seedling can produce better yield of bulb (Singh and Chaure, 1999). Nationally, more than 675,624 million private peasant holders have grown onion on about 2,624,782.85 million ha of land and 91.43 million quintals of production (CSA, 2018/19).

Efficient investigation on fertilization to improve the quality parameters are still lacking. Onion bulb producers in the area use comprehensive recommendation of phosphorus fertilizer which was recommended at country level. Despite area increase, the average productivity of onion is low and, at present, the national average yield is as low as 10.75 t.ha<sup>-1</sup> as compared to many African countries and the world average yield of 17.30 t.ha<sup>-1</sup>

(FAO, 2010) due to lack of information on appropriate phosphorus fertilizers and irrigation regimes (Pathak, 1994), soil physical and chemical characteristics, and disease and pest problems (Abbey and Joyce, 2004). On the other hand farmers transplant onion based on their own judgment on the size of seedlings which critically influence bulb productivity and quality. Both late and early date transplanting of seedlings may have significant influence on survival, bulb size and quality of bulb yield. Photoperiod and temperature may be the key factors to regulate the garlic bulb development. The plants at early stage can withstand the freezing temperature. Bose et al. (1993) reported that 20 to 25°C temperature was optimal for onion seed germination. For an optimal vegetative growth lower temperature and short photoperiod are required, while relatively higher temperature and long photoperiod are needed for bulb development. It requires 13 to 21°C for vegetative growth before bulb formation and 15.5 to 25.1°C temperatures for growth and development of bulb. Previous studies have reported that exposure to prolonged daylight and temperatures higher than 20°C improve garlic bulb production and quality (Grubben et al., 2004). In addition, vernalization accomplishment provided with prolonged daylight and high temperature may enhance garlic growth and development (Wu et al., 2015). In view of the existing problem, this study was conducted to examine the influence of transplanting date and phosphorus levels on quality and bulb yield.

## Materials and Methods

### *Description of Study Area*

The study was conducted at Alaba Woreda during the 2018/19 dry season under irrigated condition. The site is located 240 km south of Addis Ababa city and 44 km west of Zeway town in the vicinity of Abidjata and Shalla lakes. It is situated between 7° 65' N latitude and 38° 56' E longitudes and at an altitude of 1800 meters above sea level in the agro ecology of dry plateau of the Eastern part of the Ethiopian rift valley system. High amount of rainfall is received in the month of July and August. While the mean annual rainfall is 900 mm per year, the annual mean minimum and maximum temperatures are 15 °C and 32 °C, respectively (Agerie and Afework, 2013).

### *Planting Material, Treatments and Experimental Design*

The onion cultivar for this study was “Bombay Red”. The variety is widely accepted by farmers for its early maturity and higher bulb yield. It was released by Melkasa Agricultural Research Center (MARC)

in 1980. “Bombay Red” is well adapted to areas of 700-2000 meter above sea level (EARO, 2004). The experiment was contained of 4 x 3 factorial combinations involving phosphorus level and transplanting date. Four P levels (0, 20, 40, and 60 kg P.ha<sup>-1</sup>) and three transplanting days (42, 49 and 56) were laid out in randomized complete block design with four replications. Each treatment arrangement was allocated randomly to the experimental units within a block. Double row planting was done on ridges of about 15 cm height adopting recommended spacing of 40 cm between water furrows, 20 cm between rows on the ridge and 10 cm between plants within the row. The unit plot size of the experiment was 2 m x 2 m (4 m<sup>2</sup>). The blocks and plot were parted by a distance of 1.0 m and 0.5 m, respectively.

### *Experimental Field Management*

Seedlings were raised in a nursery at Alage ATVET College demonstration site on beds with size of 1 m x 10 m, seeds were sown on December 15, 2018. The seed was drilled in well pulverized bed in rows 10 cm apart and lightly covered with soil in the required transplanting date. Before transplanting seedlings, the experimental field was ploughed and leveled by tractor; ridges and plots were prepared manually. A three to four days irrigation interval was maintained for the first four weeks. Thereafter, irrigation was applied at seven days interval until fifteen days remaining to harvest, when irrigation was stopped completely (EARO, 2004).

Fertilizer was applied according to the recommendation for onion in the study area, i.e., half 50 kg.ha<sup>-1</sup> dose of N was applied uniformly to all plots during transplanting. The remaining half 50 kg.ha<sup>-1</sup> of nitrogen was side-dressed 45 days after transplanting for all plots (EARO, 2004; SARC, 2008; Anisuzzaman et al., 2009). Phosphorus (TSP) was applied as a single application as per specified rates at the time of transplanting based on the treatments. For the control of disease (purple blotch) and insect pest (onion thrips) the fungicides, a.i. mancozeb (3 kg.ha<sup>-1</sup>), oxathiapiprolin (Ridomil at 3.5 kg.ha<sup>-1</sup>) and the insecticide profenofos (Selecron 720 EC at 0.5 L.ha<sup>-1</sup>) were used, respectively. All other agronomic practices were applied uniformly for all the plots as per the recommendation made for the crop (EARO, 2004).

### *Soil Sampling*

Before planting soil sample was taken randomly in a diagonal fashion from the experimental field at the depth of 0-30 cm for determination of physical and chemical properties of the soil. Nine soil samples were

collected using an auger from the whole experimental field and combined to form a composite sample in a bucket. From this mixture, a sample weighing one kg was packed in to a plastic bag. The soil samples were also analyzed for soil texture, total nitrogen, cation exchange capacity (CEC), exchangeable potassium, organic carbon and available phosphorous. All the analyses were made at Zeway soil and water analysis laboratory in Batu Town.

### Data Collection

Dry weight, total soluble solid, sprouting (%), rotting (%) and pyruvate concentration were recorded from twelve sample bulbs randomly taken from six central middle rows of each experimental plot. However, all plants in each net plot were harvested to collect data for bulb yield.

Measurements were conducted on the following parameter:

- **Marketable bulb yield (t.ha<sup>-1</sup>):** onion bulbs which are not under sized, free from physiological disorder and pest damaged bulbs. It was determined from weight of bulbs harvested from the middle of the plot using digital sensitive balance and expressed in t.ha<sup>-1</sup>.
- **Bulb dry weight (%):** The fresh weights of the sampled bulbs were measured and oven dried at 70 °C for 72 hours to reach the constant weight. Then, the dry weight was determined by dividing the oven dried bulb samples by their respective fresh weights.

$$\% \text{ of bulb dry matter content} = \frac{\text{constant dry weight of bulb}}{\text{fresh weight of bulb}} \times 100$$

- **Bulb size distribution of marketable bulbs (t.ha<sup>-1</sup>):** calculated based on the weight of bulbs from categories of bulb size for small (20 - 50 g), medium (50 – 100 g), and large (100 -160 g) which were recorded per net plot and converted to t.ha<sup>-1</sup>.
- **Undersized bulb yield (t.ha<sup>-1</sup>):** under sized bulbs (< 20 g) were recorded as unmarketable bulbs per net plot and converted to t.ha<sup>-1</sup> (Lemma and Shimeles, 2003).

### Data Analysis

The collected data were subjected to analysis of variance (ANOVA) using SAS (version 9.2) software. Least Significant Difference (LSD) at 5% probability level was carried out for mean separation. The mean bulb yield data were adjusted down by 10% and subjected to economic analysis (CIMMYT, 1988). The cost of 100 kg phosphorus (TSP) was 1200 Ethiopian birr and onion price of 400 Eth. birr per 100 kg was used for the net benefit analysis (100 Ethiopian birr is

about USD \$ 1.9 as of April 2022). The gross benefit was calculated as bulb yield (kg.ha<sup>-1</sup>) multiplied by bulb yield price that farmers receive for the sale of the crop (40 Eth. Birr.kg<sup>-1</sup>). Total costs that varied for each treatments was calculated and treatments were ranked in order of ascending total variable cost and dominance analysis was used to eliminate those treatments costing more but producing a lower net benefit than the next lowest cost treatment. Net benefit was calculated by subtracting the total variable cost from the gross benefit. Then the marginal rate of return was calculated using the procedures described by CIMMYT (1988) as follows:  $MRR\frac{1}{4} = (\text{change in net benefit}/\text{change in total variable cost}) \times 100$ .

## Results and Discussion

### Soil Physico-Chemical Properties

The soil had particle size distribution of 18% sand, 36% silt and 46% clay at the depth of 0 - 30 cm. The results revealed that the texture of the composite soil sample from the site was silty clay loam. The pH was slightly alkaline (pH=7.83), which is above the optimum pH range for onion production. According to the rating of Walkley and Black (1954) and Dewis and Freitas (1975), the soil of the study area is medium in organic carbon (2.10%) as well as total nitrogen (0.17%), respectively. The cation exchange capacity (CEC) (28.62 meq per 100g) of the experimental soil is also high according to the rating of Jackson (1975), and low in phosphorus (3.87 mg.kg<sup>-1</sup>).

### Bulb Dry Weight

Phosphorus (P < 0.001) and transplanting day (P < 0.05) significantly affected mean onion bulb dry weight, however, the interaction effect did not show significant differences (P > 0.05). This study indicated that, increasing the rate of phosphorus from nil to 20 kg P.ha<sup>-1</sup> did not significantly increased the bulb dry weight of onion. However, increasing the rate of phosphorus further from 20 to 40 kg.ha<sup>-1</sup> increased the dry weight. There was no significant differences in the plant dry weight as phosphorus rate increased from 40 to 60 kg.ha<sup>-1</sup>. Bulb dry weight of onion treated with phosphorus at 40 kg.ha<sup>-1</sup> exceeded those treated with nil and 20 kg.ha<sup>-1</sup> by about 15 and 13%, respectively. Similar observations were reported by Woldetsadik (2003) who reported that on a clay soil in a sub-humid tropical environment of Ethiopia, increased application of P slightly increased bulb dry weight onion (*Allium ascalonicum*). Similar results were reported by Tibebe et al. (2014).

Significant differences were observed among the

transplanting dates; onion transplanted at 56 days had the highest (13.46) bulb dry weight, while the lowest (11.78) bulb dry weight was obtained when onion was transplanted at 42 days. However, no statically significant difference was observed between 49 and 56 days of transplanting date (Table 1). The dry weight of different dates of transplanting varied possibly due to variation of growth patterns and photosynthesis at growing phases. The results of the present study are in agreement with Latif et al. (2010) and Sultana (2015) who reported that dry weight of onion bulb was significantly influenced by the date of transplanting.

#### Total Soluble Solid (%)

Phosphorus fertilization and transplanting date and their interaction did not significantly ( $P > 0.05$ ) affect the formation of total soluble solid (%) of bulb (Table 1). This means there was minimal direct effect of fertilization on the formation of total soluble solid in onion bulbs.

#### Pyruvate Concentration

Pyruvate concentration of bulb was significantly ( $P < 0.05$ ) affected by the transplanting days, but not significantly affected by the phosphorus levels and interaction effects of the treatments. The pyruvic acid (pyruvate) concentration of bulbs was significantly increased when transplanting date was delayed from

49 to 56 days, i.e., by about 10 and 11%, respectively, over the 42 days. Randle and Ketter (1998) reported that to a large extent, the concentrations of pyruvate in onions are determined by the genetics of the cultivar. However, the growing environment can greatly influence the pungency intensity for any given cultivar (Randle and Ketter, 1998).

#### Bulb Sprouting Percentage

Sprouting of bulb was significantly ( $P < 0.05$ ) affected by the phosphorus fertilizer treatments, but not significantly affected by the transplanting date and interaction effects of the treatments. Phosphorus fertilization significantly increased sprouting of onion bulbs from lowest to highest rate (Table 1). Application of P at 60 kg.ha<sup>-1</sup> increased sprouting of onion bulbs by about 53% over the control. Contrary to the current finding, Singh et al. (1998) reported that increasing the applications of P fertilizer from 25 to 100 kg.ha<sup>-1</sup> resulted in decreased weight loss of sprouting and rotting in bulb stored for up to 160 days in India. Previous studies reported that the addition of K and P had no effect on the storage life of onions (Rabinowitch and Brewster, 1990).

#### Small-Sized Bulb Yield (20-50 g)

The analysis of variance of small bulb size distribution of onion showed that phosphorus fertilizer application had a significant influence ( $P < 0.001$ ). However,

Table 1. Effects of phosphorus rates and transplanting date on mean bulb dry matter content (%), total soluble solid (%), pyruvate concentration, sprouting (%) and rotting (%).

Treatments	Bulb dry matter content (%)	Total soluble solids (%)	Pyruvate (μmole ml <sup>-1</sup> )	Sprouting (%)	Rotting (%)
P (kg.ha <sup>-1</sup> )					
0	11.67b	12.05	21.23	1.13b	2.55
20	11.83b	11.96	20.91	1.53ab	2.54
40	13.44a	12.29	19.56	1.61ab	2.83
60	14.26a	12.13	20.96	1.73a	2.75
LSD (0.05)	1.25	0.37	0.53	0.39	0.22
Significance level	**	ns	ns	**	ns
Transplanting days <sup>1)</sup>					
42	11.78b	12.01	19.41c	1.11	2.83a
49	12.69a	12.13	19.82ab	1.21	2.74ab
56	13.46a	12.00	21.38a	1.31	2.32c
LSD (0.05)	0.89	0.27	1.44	0.32	0.42
Significance level	*	ns	*	ns	*
CV (%)	9.53	6.05	12.09	17.67	14.11

Note: <sup>1)</sup> Number of days are calculated from December 15, 2018. Means followed by the same letters within a column are not significantly different at ( $P < 0.05$ ), LSD 0.05, ns= non-significant.

neither the main effect of transplanting date nor its interaction with phosphorus influenced this parameter of onion. Increasing the phosphorus application rate significantly decreased the production of small sized bulb yield as presented in Table 2. Thus, the highest small sized bulb yield was obtained from the control onion. In contrast, the lowest small sized bulb yield of onion was recorded in response to the application of higher phosphorus rate at 60 kg.ha<sup>-1</sup> and 40 kg.ha<sup>-1</sup>. For instance, the small sized bulb yield obtained in the control exceeded small sized bulb yield of plants grown with 60 kg.ha<sup>-1</sup> application by 96% (Table 2). The increment in small size bulb yield of onion in response to the application of nil phosphorus rates may have resulted in reduction in below ground bulb size like bulb weight, bulb length and bulb diameter due, likely caused by lacking of the major nutrients.

#### Medium-Sized Bulb Yield (50-100 g)

Phosphorus fertilizer rate and transplanting date exhibited highly significant ( $P < 0.001$ ) effects on medium bulb size yield of onion, but it was not significantly influenced by the interaction effect of those treatments. This study indicated that, the production of medium sized bulb yield of onion was significantly increased by increasing the phosphorus application rate though the upper two rates were statistically at par. Hence, higher medium sized bulb yields were achieved from onion plants grown with

the application of P at 60 kg.ha<sup>-1</sup> or 40 kg.ha<sup>-1</sup>. On the other hand, zero application of phosphorus produced the lowest medium sized bulb yield (Table 2). This result is in agreement to the findings of Brewster (1994) who reported that increased phosphorus rates used to improve bulb size and increased the number of marketable bulbs in onion. Significant differences were observed among the transplanting date treatments; 56 days of transplanting date gave the highest medium sized bulb yield whereas the lowest medium sized bulb yield was obtained under 42 days of transplanting date (Table 2). The bulb size from 49 and 56 days age were not statistically different. The results are similar to the finding of Deepika (2013) who reported that yield of medium bulbs increased at optimum transplanting seedling age.

#### Large-Sized Bulb Yield (100-160 g)

The analysis of variance showed that phosphorus rate ( $P < 0.001$ ) significantly affected onion large sized bulb yield. However, neither the main effect of transplanting date nor its interaction with phosphorus influenced this parameter of onion. Similar to medium sized bulb yield, large sized bulb yield increased significantly in response to the increased application of phosphorus rate (Table 2). The maximum large sized bulb yield was obtained in response to the application of P at 60 kg.ha<sup>-1</sup>, but no significant difference was observed with application rate of P

Table 2. Main effect of phosphorus rates and transplanting dates on small size bulb yield, medium size bulb yield, large size bulb yield, over size bulb yield and under sized bulb yield.

Treatments	Small size bulb yield (t.ha <sup>-1</sup> )	Medium size bulb yield (t.ha <sup>-1</sup> )	Large size bulb yield (t.ha <sup>-1</sup> )	Under sized bulb yield (t.ha <sup>-1</sup> )	Oversize bulb yield (t.ha <sup>-1</sup> )
P (kg.ha <sup>-1</sup> )					
0	5.93a	11.2c	5.02c	3.1a	1.75c
20	4.26b	21.37b	12.93b	1.80b	4.52b
40	3.16c	25.10a	23.36a	1.71b	6.15a
60	3.03c	26.12a	24.02a	1.42b	6.96a
LSD(0.05)	0.76	2.66	3.15	0.59	0.89
Significance level	**	**	**	**	**
Transplanting days					
42	4.17	18.15b	14.97	2.13	4.64
49	4.39	21.51a	16.76	1.92	4.78
56	3.72	23.16a	17.25	1.97	5.11
LSD (0.05)	0.66	2.30	2.73	0.51	0.77
Significance level	ns	**	ns	ns	ns
CV (%)	22.35	15.28	23.22	35.35	22.07

Note: <sup>1)</sup> Number of days are calculated from December 15, 2018. Means followed by the same letters within a column are not significantly different at  $P < 0.05$ , LSD at  $\alpha=0.05$ , ns = non-significant

at 40 kg.ha<sup>-1</sup>. On the other hand, the minimum value was achieved from the nil phosphorus rates.

#### Over-Sized Bulb Yield (>160g)

The analysis of variance showed that phosphorus rate ( $P < 0.001$ ) significantly affected over- sized bulb yield of onion. However, transplanting date and its interaction with phosphorus did not have significant effects. Similar to the large-sized bulb yield, oversized bulb yield increased significantly in response to the increased application of phosphorus rate (Table 2). The maximum oversized bulb yield was obtained in response to the application of P at 60 kg.ha<sup>-1</sup>, but no significant difference was observed with application of P at 40 kg.ha<sup>-1</sup>. On the other hand, the minimum value was achieved from the control treatment.

#### Under Size Bulb Yield (< 20 g)

Results from the analysis of variance revealed that the phosphorus fertilizer rate was found to be significant ( $P < 0.01$ ) on under sized bulb yield. However, the transplanting date and its interaction effect with phosphorus did not significantly affect under sized bulb yield of onion. The maximum under sized bulb yield was recorded when onion plants received no P fertilizer. Conversely, the minimum under-sized bulb yield was recorded at the rates of 20, 40 and 60 kg P.ha<sup>-1</sup> (Table 2). Phosphorus application decreased under sized bulb yield though effects were similar among the three rates. The increase in the yield of the under-sized bulbs under unfertilized plots might be related with lack of P, which may have reduced vegetative growth like leaf number and length and bulb size by decreasing synthesis and partitioning of photosynthetic to the bulbs (Ghaffor et al., 2003). Phosphorus is important for root development and when unavailable plant growth is usually reduced. Phosphorus deficiency in onions had been reported to reduce root and growth of leaf, size of bulb, yield and delay maturation (Abdissa et al., 2011).

#### Marketable Bulb Yield

Marketable bulb yield of onion was significantly affected ( $P < 0.001$ ) by phosphorus rates and transplanting days. There was a significant interaction of transplanting days and phosphorus on the marketable bulb yield of onion ( $P < 0.05$ ). Onion transplanted at 42 days and applied with 40 kg.ha<sup>-1</sup> phosphorus increased marketable bulb yield by about 100% compared to the without P; (Table 3). Further increase of phosphorus to 60 kg.ha<sup>-1</sup> did not increase the yield, rather it showed a drop by about 30% and leveled off with yields from control plots and those fertilized at 20 kg.ha<sup>-1</sup> phosphorus. At 49 transplanting date, the highest marketable bulb yield (43.74 t.ha<sup>-1</sup>) was produced at 60 kg.ha<sup>-1</sup> P while the lowest marketable bulb yield (26.08 t.ha<sup>-1</sup>) was obtained from control. When transplanting was conducted at 56 days, the control plot had notably reduced yield of marketable bulb (30.07 t.ha<sup>-1</sup>) as compared to the three phosphorus rates. The highest marketable bulb yield (46.23 t.ha<sup>-1</sup>) was recorded when onion was transplanted at 56 days combined with P at 60 kg.ha<sup>-1</sup>; though statically at par to that obtained from P at 40 kg.ha<sup>-1</sup>. (Table 3).

#### Economic Analysis

As a result of the present study, the costs for the different phosphorus rates were varied whereas transplanting, weeding, and harvest costs were similar for all treatment. To recommend the present result for the study area, it is necessary to estimate the minimum rate of return acceptable to producers in the recommendation domain. Based on economic analysis, maximum net benefit (139180 Birr) with MRR (119.83) was obtained from treatment combination of 40 kg.ha<sup>-1</sup> P with 56 transplanting date (Table 4). The marginal rate of return of the non-dominated treatment (Table 4) shows that 40 kg.ha<sup>-1</sup> P with 56 transplanting date record a positive marginal rate of

Table 3. Interaction effects of phosphorus rates and transplanting dates on marketable bulb yield (t. ha<sup>-1</sup>) of onion grown at Alaba woreda.

Transplanting days	P (kg.ha <sup>-1</sup> )			
	0	20	40	60
42	19.53g	31.15def	41.12ab	31.07def
49	26.08f	34.07cde	38.69bc	35.41cd
56	30.07ef	34.68cde	43.74a	46.23a
LSD (0.05)	4.43			
CV (%)	10.26			

Note: <sup>1)</sup> Number of days are calculated from December 15, 2018. Means followed by the same letters within a column or row are not significantly different at ( $P < 0.05$ ); LSD = least significance difference and CV (%) = coefficient of variation.

Table 4. Economic analysis for phosphorus rate and transplanting date experiments of bulb yield at Alaba Woreda.

Treatment	Average yield (t.ha <sup>-1</sup> )	Adjusted yield (t.ha <sup>-1</sup> )	Gross benefit (Birr.ha <sup>-1</sup> )	Variable cost (Birr.ha <sup>-1</sup> )	Net benefit (Birr.ha <sup>-1</sup> )	Marginal rate of return (%)
20 kg.ha <sup>-1</sup> P						
Transplanting days						
42	31.15	24.92	99,680	540	99,140 d	-
49	34.07	27.26	109,040	540	108,500 d	-
56	34.68	27.74	110,960	540	110,420	-
40 kg.ha <sup>-1</sup> P						
Transplanting days						
42	41.12	32.89	131,560	780	130,780 d	-
49	38.69	30.95	123,800	780	123,020 d	-
56	43.74	34.99	139,960	780	139,180	11,983
60 kg.ha <sup>-1</sup> P						
Transplanting days						
42	31.07	24.86	99,440	1,020	98,420 d	-
49	35.41	28.33	113,320	1,020	112,300 d	-
56	46.23	36.98	147,920	1,020	146,900	3,217
Without P						
Transplanting days						
42	19.53	15.62	62,480		62,480 d	-
49	26.08	22.94	91,760		91,760 d	-
56	30.07	24.06	96,240		96,240 d	-

Note: d= dominance, Birr=Ethiopian currency (100 Birr ~ US\$ 1.90)

return 119.83. According to CIMMYT (1988) on-farm economic analysis of major vegetable crop reported that MRR that is better when the MRR was >100 %. Our study had demonstrated that one treatment, 40 P kg.ha<sup>-1</sup> P with 56 transplanting date, record the highest MRR acceptance range, cost-effective, and economically feasible for the onion growers.

## Conclusions and Recommendation

The analysis of variance showed that medium size bulb yield, marketable bulb yield and bulb dry weight were significantly influenced by phosphorus rates and transplanting date. However, small size bulb yield, large size bulb yield, oversize bulb yield, and sprouting % were significantly affected only by the rates of phosphorus fertilizer. From this study, significantly higher bulb dry weight and medium size bulb yield were obtained at the transplanting date of 56 days and 40 kg.ha<sup>-1</sup> phosphorus. A maximum bulb yield and an economical onion production was obtained from onion transplanted at 56 days and

fertilized with P at 40 kg.ha<sup>-1</sup>. Therefore, this treatment could be used to improve productivity and net benefit of onion bulb at Alaba Woreda, and other areas with similar agro-ecologies.

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## Conflict of Interests

The authors have no conflicts of interests.

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