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Effect of Planting Methods on Maturity and Yield of Onion (*Allium cepa* var cepa) in the Central Rift Valley of Ethiopia

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Abstract

Onion dry bulb are commonly established in the field either by direct sowing of seeds to the field, or by transplanting seedling from seedbed or from sets depending on the growing conditions of the specific region. However, the potential of the different methods have not been tested particularly in the potential onion producing areas of Ethiopia. Field experiments were conducted at Melkassa Research Center of Ethiopian Institute of Agricultural Research to investigate the effect of different planting methods on maturity and dry bulb yield of onion in two different seasons in 2008/09. The experiment consisted of three planting methods of onion, namely direct seeding to the field, transplanting of seedlings and planting sets, and three onion cultivars (Adama Red, Bombay Red and Nasik Red), arranged in factorial split plot design with three replications. Cultivars were assigned to the main plot and planting methods to the sub-plot. Data on days to maturity, dry bulb yield, bulb weight and bulb diameter were collected. Planting methods and cultivars showed statistically significant difference ($P<0.01$) both for earliness and dry bulb yield. However, their interaction was not significant. Sets planting resulted in higher yield (39.1 t ha^{-1}) followed by transplants (36.3 t ha^{-1}) and direct seeding (19.5 t ha^{-1}). The cultivar 'Bombay Red' (33.3 t ha^{-1}) gave significantly higher yield than 'Adama Red' (31.1 t ha^{-1}) and 'Nasik Red' (30.2 t ha^{-1}). Sets matured earlier (94 days) than transplants (104 days) and direct sown (135 days). The overall result indicated that in addition to the current transplanting practice onion establishment from set may also be a good option for dry bulb production in the Central Rift Valley areas of Ethiopia where earliness and high yield are important parameters considered by onion growers.

Key words: onion, planting method, sets, transplantings, direct seeding, bulb yield.

Introduction

Ethiopia has great potential to produce various vegetable crops including onion (*Allium cepa*) throughout the year for both local consumption and export. Though onion is a relatively new bulb crop in the agricultural system of Ethiopia, because of its high yield potential, availability of desirable cultivars, ease of propagation, as well as high domestic and export markets in fresh and processed forms, it has become popular among producers. However, the productivity of onion in Ethiopia is lower than the world and Africa average. According to FAO[1] (2007) report the average yield tones ha^{-} for the world, Europe, Asia, American, Africa and Ethiopia are 17.05, 15.7, 20.64, 10.47, 12.14 and 10, respectively. According to CSA (2007) the total land area under onion production is 21391.75 hectares and 778669 households owning the land under onion production with total production of 1.8 million tones of dry bulbs and productivity of 8.34 tones ha^{-1}. Even though the yield of onion is low compared to other countries, the dry bulb and seed production technologies have significantly changed the life of many farmers, in the rift valley region (Lemma *et al*, 2008).

Onion gives business options on seed, dry bulb, and seedling production. Onion is one of the few vegetable crops that can be kept for relatively longer periods and can withstand the rough handling from field harvesting to final delivery to consumers. Hence, onion dry bulb can be stored for long time and can be marketed at times when the prices are in favor of the growers. As a result, there is less risk of over-production of onion than of most other vegetables.

Onion dry bulb are commonly established in the field either by direct sowing of seeds to the field, or by transplanting seedlings from seedbed or from sets depending on the growing conditions of the specific locations. Sowing seeds directly into the field where the crop is to be grown is considered an economical method of producing particularly where there is limited availability of labor for transplanting, high labor cost, or limited availability of facilities for raising transplants (Brewster, 2002). Sets and transplants are practiced in areas where the season is not long enough for proper bulb development. Transplants are noted to have more advantages on economic use of seed, selecting healthy and vigorous seedlings, saving weeding and watering efforts during the early weeks of plant growth, and enabling the

[1] The report include shallot

farmers to attend the seedlings in a compact area (Lemma and Shimeles, 2003). Unlike seedlings and seeds, sets are small dry bulbs of 2 to 3 g in size, adapt to short growing seasons and are more tolerant to harsh environments. Sets are earlier and produce heavier crops than either seeds or seedlings (Seetohul and Hanoomanjee, 1999). Sets are probably the most convenient and safest type of planting material for either small scale or commercial onion production as the emerging plant will be very strong, vigorous and easily established under stressed conditions. They are important especially to catch the early market (O'connor, 1994).

Depending on the specific growing conditions, various onion producing countries use different planting methods because of their effect on maturity, as well as quantity and quality of the produce (Warid and Loaiza, 1993; Seetohul and Hanoomanjee, 1999; Massiha *et al*, 2001; Resemann *et al*, 2008). The effect of planting methods on maturity and yield is expected to vary with cultivars, location and growing conditions. Ahmed and Hassan (1978) reported that in Sudan transplanting method delayed the maturity of "Shendi Red" and "Dongola White Imp" onion cultivars by 17 days whereas transplanting method did not delay maturity of the cultivar "Nasi".

Experiences in the Rift Valley areas of Ethiopia shows, onion producers normally use transplanting and some growers have started direct seeding practice. However, the use of set is not yet well realized in the onion industry of the country. Due to short rainy season in these areas, growers buy the seedlings from other areas to catch the short season. The handling and transportation of seedlings are harsh, in which sets could be better due to its high reserve food for ease of establishment and earliness. Sets and seedlings are a big business in many developed countries (Serra and Currah, 2002). However, information on onion planting method suitable to the production practices in Central Rift Valley of Ethiopia is lacking. Therefore, the objective of this study was to investigate the effect of different onion planting methods on maturity and yield of onion cultivars and recommend options to growers.

Material and Methods

The experiments were conducted for two seasons in 2008/09. The first experiment lasted between July and December 2008 and the second experiment between October 2008 and March 2009 under irrigation at Melkassa Research Center of the Ethiopian Institute of Agricultural Research

(EIAR). The experiment consisted of two factors each with three levels: planting methods (direct seeding, transplanting and sets) and onion cultivars (Adama red, Bombay red and Nasik red), arranged in factorial split-plot design with three replications. The cultivars were assigned in the main plots and the planting methods to the sub-plots. The plot size was 9 m^2 (3 m x 3 m) with 10 single rows per plot and 30 plants per row with a total of 300 plants per plot. Spacing between water furrows, plant rows and plants was 40 cm, 20 cm and 10 cm, respectively. Plots and blocks were separated by 1 m and 1.5 m alleys, respectively.

For treatment involving sets, seeds were seeded on seedbed 30 days earlier than seeds sown for transplanting. Sets and seedlings were ready for transplanting 74 and 44 days after sowing, respectively. Sets with 2-3 cm in diameter were selected for planting. Sets, seedlings and seed were planted in the field on the same date. Plants from direct sowing were thinned 40 days after sowing to maintain the spacing between plants at 10 cm. For set and transplanting treatments, Diammonium phosphate (DAP) was side-dressed at a rate of 200 kg/ha at field planting, and Urea was side dressed at 50 kg/ha twice, at the time of field planting and 45 days after transplanting. Similarly, for direct sowing DAP at 200 kg/ha was applied at seeding, and Urea at 50 kg/ha was applied 40 days after seeding, at thinning, and one month later. All plots were irrigated twice a week from field planting until full bulb development, and weekly thereafter until 15 days before harvest. Every standard cultural practice such as weeding, hoeing, disease and pest monitoring and management were followed regularly. Ridomil G. MZ, 68% at a rate of 3.25 kg/ha in 700 liters and Selecron 72% at a rate of 3 liter per ha in 600 liters of water were applied to control purple blotch and thrips, respectively.

Days to maturity were determined and hence harvesting was made when 50% of the plants top of each plot fell. The central four rows of each plot were harvested and the weight recorded for yield. Bulbs weighing higher than 20 g and without signs of split, bolt and decay were considered marketable and the rest as unmarketable. Ten marketable bulbs were randomly selected from each plot to determine the bulb diameter and average dry bulb weight. Bulb diameter was measured using caliper while bulb weight was determined using sensitive balance with a precision of 0.1 g.

Data were checked for normality and constant variance assumptions before subjecting to the analysis of variance (ANOVA). The analysis was performed using the SAS package (SAS, 2001). When significant differences were observed in the ANOVA, mean separation was performed using Student-Newman-Keuls (SNK) test.

Results and Discussion

The data from two seasons was pooled in the analysis variance for planting methods. Differences among cultivars and among planting methods were significant for all the parameters measured. However, interaction effect between cultivars and planting methods was not significant for any of the parameters measured.

Yield

Total dry bulb*:* Sets gave significantly (P<0.001) higher total yield (39.1 tons ha^{-1}) than both transplanting (36.3 t ha^{-1}) and direct seeding (19.5 t ha^{-1}) methods (Tables 1). Yield of the set planted onion was nearly double of the yield obtained from direct seeding (Table 1). Several reports worldwide agree with this result (Torres *et al*., 1986; Pessala, 1990; Warid and Loaiza, 1993; Seetohul and Hanoomanjee, 1999; Massiha *et al*., 2001). On the other hand, in Sudan, direct seeding gave significantly higher yield compared to transplanting, with mean total yield of 14.5 t ha^{-1} and 6.6 t ha^{-1} for direct seeding and transplanting, respectively (Ahmed and Hassan, 1978). Gaafer *et al*. (1979) also reported that direct sown onion produced a higher total yield but lower yields of export quality onion than transplanted onion in Egypt. Among onion cultivars, Bombay Red (33.3 t ha^{-1}) gave significantly (P<0.05) higher total yield than Adama Red (31.4 t ha^{-1}) and Nasik Red (30.2 t ha^{-1}) (Table 1).

Marketable dry bulb*:* Transplanting with 29.2 t ha^{-1} resulted in significantly higher (P<0.001) marketable yield than sets (23.5 t ha^{-1}) and direct sown (18.5 t ha^{-1}) (Table 2). This agrees with reports of Warid and Loazia (1993) who reported that in Mexico transplanting method increased marketable yield of onion by 8 t ha^{-1} over the direct sown onion. Torres *et al*. (1986) also reported a yield of 20.3 to 35.8 t ha^{-1} from transplanted onion compared to 10.3 t ha^{-1} from direct sown onion in Brazil. Massiha *et al*. (2001) also reported a higher marketable yield than direct sown onion. Significantly higher (P<0.05) marketable yield were recorded from Adama Red (25.1 t ha^{-1}) and Bombay Red (24.7 t ha^{-1}) than Nasik Red (21.4 t ha^{-1}) (Table 2).

Table 1. Effect of different onion planting methods on total yield of three different onion cultivars at Melkassa, 2008/09

Planting Methods	Cultivars			
	Adama Red	Bombay Red	Nasik Red	Mean
Direct sowing	18.2	20.4	19.9	19.5c
Transplanting	36.0	38.7	34.3	36.3b
Set planting	40.0	40.9	36.4	39.1a
Mean	31.4B	33.3A	30.2B	

Means with the same lower or upper case letter are not significantly different from each other at 5% level of significance.
Means with lower case letters represent values for planting methods effects and means with upper case letters represent values for cultivars effects

Table 2. Effect of different onion planting methods on marketable yield of three different onion cultivars at Melkassa, 2008/09

Planting Methods	Cultivars			
	Adama Red	Bombay Red	Nasik Red	Mean
Direct sowing	17.6	19.3	18.5	18.5c
Transplanting	30.6	30.9	26.0	29.2a
Set planting	27.1	24.0	19.5	23.5b
Mean	25.1A	24.7A	21.4B	

Means with the same lower or upper case letter are not significantly different from each other at 5% level of significance.
Means with lower case letters represent values for planting methods effects and means with upper case letters represent values for cultivars effects

Planting methods but not cultivars showed significant ($P < 0.05$) effect on the proportion of the different classes of marketable bulb weight. Hence the data were pooled to show the effect of planting methods on the proportion of different bulb size groups of the marketable onion bulbs (Figure 1). Proportion of the bigger sized groups (> 160 g and 100-160 g) was significantly higher in transplanted and set planted onion than direct sown with insignificant difference between them. Proportion of bulbs fell in these groups from direct sown onion did not exceed 10%. On the other hand, proportion of bulbs with smaller size (< 100 g) was significantly higher in direct sown onion accounting for over 90% of bulb sizes than both transplanted and set planted (Figure 1). In general, bigger sized bulbs were obtained from transplanted and set planted onion and smaller ones from direct seeding. The results of this study agree with the finding of Pessela (1990) who reported that direct seeding gave lower bulb size than transplanted onions. Ahmed and Hassan (1978) also reported that direct seeding gave high percent (86%) of medium and small bulb where as transplanting gave 63% of larger bulb. O'connor (2003) also stated that larger bulb size can be easily achieved using sets. The average bulb weight and diameter from the ten randomly selected bulbs of the marketable group corroborated the observation on the effect of the different planting methods on bulb size (Table 5).

Direct seeding resulted in significantly (P<0.001) lower bulb diameter than both sets and transplanted seedlings. Several researchers reported a higher percentage of large bulbs (higher than 5 cm diameter) from transplanted onion than direct sown (Gaafer *et al.*, 1979; Ramtohul and Splittstoesser, 1979; Massiha *et al.*, 2001) and attributed to stronger photosynthetic efficiency and vigorous vegetative growth in set and transplanted onions than direct sown. Sets and transplanting resulted in significantly (P<0.001) higher average bulb weight than direct seeding. Due to better establishment and leaf area index (LAI) in transplants and sets during the early growth, bulb weight in both transplanted and sets onion was nearly seven-fold of bulb weight recorded from direct sown onion (Table 5). Khokhar *et al*. (1990) reported a bulb weight ranging between 80.5 and 441.4 g from transplanted onion compared to bulb weight ranging between 20.8 and 177.9 g from direct seeding onion. Massiha *et al.* (2001) also reported transplanting method produced larger, more homogenous bulbs than direct seeding.

In this study, set planted onion showed a significantly higher total yield than transplanted onion but less marketable yield than transplanting. This was due to higher weight of unmarketable bulb as a result of large number of splits and bolters (Table 4). Unmarketable bulbs were classified by reasons as split, decay, bolters and under size. The percentage of splits, bolters and under size differed significantly with planting methods (Table 4). The factor that contributed most to the observed level of unmarketable yield in direct sowing was undersized bulb. On the other hand, bolters and split bulbs were responsible for the observed high unmarketable yield in transplanting and set planting methods. Sets and transplanted which have already developed flower buds tend to split as shallot at transplanting compared to direct seeded one. In addition, the cooler climate prevailing in the production period also contributes for development of bolters and splits. Although sets had significantly higher unmarketable yield than transplanting (Table 3) due to higher percentage of split and the economic significance may be low in the export and international market, it is acceptable in the local market as consumers are familiar with such characters in shallot (Lemma and Shimeles, 2003).

Table 3. Effect of different onion planting methods on unmarketable yield of three different onion cultivars at Melkassa, 2008/09

Planting Methods	Cultivars			
	Adama Red	Bombay Red	Nasik Red	Mean
Direct sowing	0.7	1.1	1.4	1.0c
Transplanting	5.4	7.8	8.3	7.2b
Set planting	12.9	16.9	16.9	15.6a
	6.3B	**8.6A**	**8.9A**	

Means with the same lower or upper case letter are not significantly different from each other at 5% level of significance.
*Means with lower case letters represent values for planting methods effects and means with upper case letters represent values for cultivars effects

Table 4: Type and contribution of defects to unmarketable bulb yield in relation to planting methods of onion at Melkassa, 2008/09

Planting Method	Unmarketable Yield by reason (%)			
	Split	Decay	Bolters	Under size
Direct seeding	49b	2	0.0c	49a
Transplanting	77a	0	22.77a	0.23b
Sets	78a	0	21a	0.42b

Means in a column with the same letter are not significantly different from each other at 5% level of significance.

Table 5: Effect of planting methods and cultivars on average bulb yield, bulb diameter, percent bulb dry matter and TSS of onion at Melkassa, 2008/9

Treatments	Days to maturity	Average bulb weight (g)	Bulb diameter (cm)
Cultivars (C)			
Adama Red	116A	96AB	6.6B
Bombay Red	106C	102A	6.8A
Nasik Red	111B	90B	6.2C
Planting methods (P)			
Direct seeding	137a	64b	5.8c
Transplanting	102b	112a	6.8b
Set planting	93c	112a	6.9a

Means with the same lower or upper case letter are not significantly different from each other at 5% level of significance.
Means with lower case letters represent values for planting methods effects and means with upper case letters represent values for cultivars effects

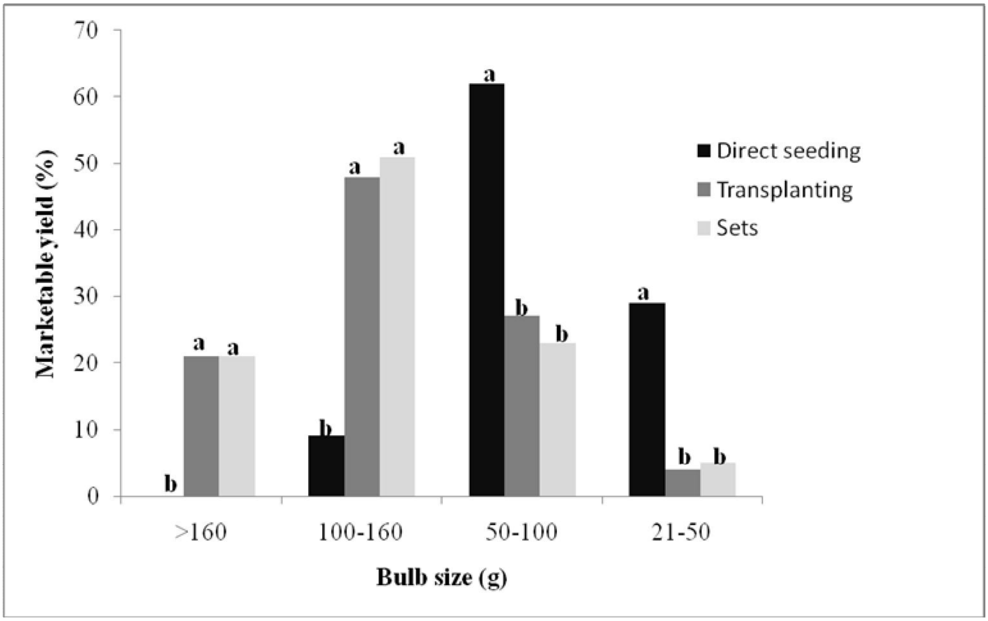

Fig. 1: Effect of planting methods on the proportion of different bulb weight classes of marketable onion bulb yield at Melkassa in 2008/09.
Means followed by the same letter are not statistically significant (P<0.05).

Days to maturity: The time to bulb maturation was significantly (P<0.001) affected by planting methods and cultivars. Maturity was significantly earlier in set planting and significantly more delayed in direct sowing than the other methods. Set planted onion matured 9 and 44 days earlier than transplanted and direct sown onion, respectively (Table 5). The result is in line with the finding of Vik (1974) who reported that transplanted onion matured 13 days earlier than direct sown. Massiha *et al.* (2001) also reported that earliness is considered as one of the advantages of transplanting method over direct sowing. However, report of Ahmed and Hassan (1978) disagree with this study and many other reports (Vik, 1974; O'connor, 1994; Massiha *et al.*, 2001); they reported that transplanting method delayed the maturity of two onion cultivars by 17 days. The total number of days starting from sowing in the seedbed up to harvest was 137, 146 and 167 for direct seeding, transplants and sets, respectively. Among cultivars, Bombay Red matured significantly earlier than Nasik Red while Nasik Red matured significantly earlier than Adama Red. Bombay Red matured 11 and 5 days earlier than Adama Red and Nasik Red, respectively (Table 5). This is in agreement with information on the characteristics of the varieties as described in the national variety registry document (MoA, 2004).

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