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Bulb Placement Effects on Growth Performance and Yield of Shallot (*Allium Cepa* L. Aggregatum Group)

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Abstract: *The effects of bulb placements on shallot production were evaluated for two seasons (rainy and dry) using local shallot cultivar, DZ-sht-78. The experiment was conducted at Debre Zeit Agricultural Research Center on two types of soils characterized as light soils (sandy clay loam) and Vertisol (black clay soil). Bulb placement treatments were planting at the top, side, base of the ridges, and flat land planting followed by top, side, basal ridge placement after sprouting, and flat land planting across and along the slope followed by immediate ridging. Side ridge placement of shallot bulbs consistently yielded higher than all other treatments and significantly higher than the conventional practices. The ranges of the yield differences, however, narrowed under the moist condition of the vertisol in wetter season. The study showed little yield differences between bulb placements in wetter season as compared to yield differences in the drier season and in the light soil. The result pointed the importance of using appropriate bulb placement practice for bulb crops production by taking into account the soil type, moisture availability, and the slope of the land. In the absence of supply of adequate irrigation water and good distribution of rain, bulb crops have to be grown on side ridges using all possible means of soil conservation techniques.*

Keywords: *Conventional planting, flat land, growing season, ridge and furrow, soil types.*

INTRODUCTION

Shallot (*Allium cepa* L. aggregatum group) is the favourite and a widely grown condimental crop in Ethiopia. It is used daily in almost every house as a seasoning spice in the preparation of local dishes such as Wot (a stew) eaten with Injera (Ethiopian fluffy bread). Regardless of the effect on growth and overall performance of shallot, traditional bulb placement or planting practices of shallot have been employed in Ethiopia. The established practice at Debre Zeit Agricultural Research Center was planting bulbs on flat land and the ridge was established by piling up inter-row soils on the row where the bulbs are planted while in the surrounding farmers' fields bulbs are planted on flat land and the ridge is constructed during cultivation (personal observations). Many other farmers use flat land planting and flooding is used to irrigate the field. On the other hand, Klein et al (2007) indicated the suitability of ridge planting system to furrow irrigated crops in preserving soil moisture and controlling erosion. Furthermore, Ali (1998) showed the effect of planting sides on establishment, growth and yield of garlic.

Several advantages of ridge planting are reported, which includes greater soil exposure to sunlight for faster soil warming and drying (REAP, 1990) thereby allowing quicker germination and early growth which in turn provides an opportunity for early harvest. Ridge planting prevents flooding of crops on clay soils, and favours good drainage and aeration for strong crop growth (Yara, 2005; DARCOFenews, 2005). According to Marcinek, et al (2013), performance from tulip cultivation on ridges was superior as compared with flat land cultivation.

The results of shallot field observation in Ethiopia indicated clear inconsistency in growth and a decline in yield of vegetables in general and that of shallot in particular. The practice of land preparation of the area associated with the characteristics of soils and the methods of bulb placement were assumed to be the major factors contributing to the inconsistency in growth and general performances. Tillage practices in corn and wheat production indicated that soil and soil moisture situations, the wet and cool climatic conditions during the growing periods and seed placement are believed to be the major factors affecting production of the crop (Herbek, et al. 1986; Izaurralde, et al. 1986). Different land preparation and bulb placement methods in relation to irrigation methods were found to affect yield of onions in Brazil (Currah & Proctor, 1990). According to Agro- techniques (2015), seedlings are usually transplanted in flat beds further reflecting that transplanting on raised beds or on both sides of ridges is, however, better for *kharif* or rainy season crops. On the other hand,

AgriInfo.in (2015) advocated the use of flat bed planting, since more onion yield is obtained from flat land planting than ridges & furrow. It was also indicated that flat bed planting accommodates more plant, and uniform size & compact bulb of onion which have good keeping quality in storage & transport could be obtained from flat bed (leveled)planting since there is equal distribution of water & fertilizers.

Using double rows of 40 cm between water furrows, 20 cm between rows on the bed (ridge) and 10 cm between plants is the recommended practice for onion production around Melkassa in Ethiopia (Aklilu & Dessalenge, 2015). Likewise, the recommendation for shallot production using bulb-lets is the same except the spacing between plants is 20 cm (Getahun et al, 2003). Yet, research based information on the position of bulb placement is locally unavailable.

This study was undertaken to determine the effects of different practices of bulb placement on the growth and yield of shallot with an ultimate objective of adopting appropriate bulb placement for the area.

MATERIALS AND METHODS

Effects of bulb placement treatments on shallot production were evaluated using randomized complete block design in four replications. The study was carried out for two seasons (rainy and dry) using local shallot cultivar, DZ-sht-78. The treatments were:

1. Top ridge planting (TRP)
2. Side ridge planting (SRP)
3. Base ridge planting (BRP)
4. Flat land planting followed by top ridge placement after sprouting (FLP+TR)
5. Flat land planting followed by side ridge placement after sprouting (FLP+SR)
6. Flat land planting followed by base ridge placement after sprouting (FLP+BR)
7. Flat land planting across the slope followed by immediate ridging (CAS+TR)
8. Flat land planting with the slope followed by immediate ridging (CWS+TR)

The experiment was conducted at Debre Zeit Agricultural research Center on two types of soils characterized as light soils (sandy clay loam) with an average of about 1.0 % slope and Vertisol (black clay soil) with less than 1.0% slope. The light soil contains 2.5% organic matter, 2.7% exchangeable sodium. The pH and cation exchangeable capacity were 7.2 and 33%, respectively. The Vertisol contains 2.0% organic matter, 0.8 % exchangeable sodium with the pH and cation exchangeable capacity being 6.5 and 47%, respectively (Mamo and Killham, 1986). Land was prepared to a fine tilth through repeated ploughing and levelling the experimental plot. Following land preparation the different placement treatments were established. Ridges of 20 centimetre (cm) width and 25cm height along with 20 cm furrow width were prepared for top, side and basal ridge planting and bulbs were planted accordingly. For top ridge planting, bulbs were planted at top of the ridge , i.e, at 25 cm height from the furrow. For side and basal ridge plantings, bulbs were planted at 12.5 and 0 cm height of the ridges, respectively.

For flat land planting followed by top, side and base ridge placements, bulbs were first planted and left to sprout. In this practice, planting was made on levelled flat plots using the recommended spacing of 40 cm inter row and 20 cm intra-raw spacing. After full sprouting of bulbs in the field (seedling emergence), ridges were constructed. The growing plants were allowed to develop on top, side and base of the ridges by lifting the soil between the rows to form the ridges.

Placement of the bulbs across and along the slope of the land was carried out by first planting the bulbs on flat land and immediately establishing the ridges. These were conventional practices commonly used by farmers in the vicinity of Debre Zeit agricultural research centre.

For the dry season evaluation, the experimental field was established in late January and for rainy season evaluation, in early August. The spacing used was 40 and 20 cm between rows and pants, respectively. Only one raw (line) was planted on a ridge. The plot size was 2.4m x 2.4m and contained 40 plants for evaluation (2 x 1.6m^2 effective plot), and 32 plants for guard rows. The experimental design was randomized complete block with four replications. For dry season production, irrigation was applied within seven to ten days interval depending on the weather and moisture availability in the soil. Di-ammonium phosphate (DAP)and Urea fertilizers at the rate of 200 and 150 kg/ha, respectively were applied. DAP fertilizer was applied once at planting while Urea was

applied in two splits- at planting and 11/2 months after planting. The conventional practice of hand weeding and cultivation (hoeing and earthing up) was performed throughout the field evaluation period.

Stand count and record for disease attack were made during the vegetative phase. Bulb count and measurement on shoot mass and fresh bulb yield were also accomplished. Data was subjected to analysis of variance and least significance difference (LSD) was used to compare treatment means when there was statistically significant difference ($P<0.05$).

RESULTS AND DISCUSSION

Result from light soil indicated that side ridge planting (SRP) produced the highest fresh bulb yield in the dry season (3881g/3.2m^2) while the lowest fresh bulb yield was from flat land planting with the slope followed by immediate ridging (CWS+TR). On the other hand, the highest shoot mass (731g/3.2m^2) and bulb count (334/3.2m^2) were recorded from flat land planting followed by base ridge placement after sprouting (FLP+BR) (Table 1). Flat land planting followed by side ridge placement after sprouting (FLP+SR) gave the highest fresh bulb yield (3033g/3.2m^2) from light soil in the rainy season, where as both shoot mass and bulb count were highest from SRP (Table 1). In the rainy season, the lowest shoot mass, bulb count and fresh bulb yield from light soil were obtained from flat land planting across the slope followed by immediate ridging (CAS+TR). In comparison with flat land cultivation, Marcinek, et al (2013) also showed that cultivation of tulips on the ridges led to production of 7.5% more of daughter bulbs and 8.2% of commercial bulbs. They also reported that weight of daughter bulbs was higher in ridge cultivation on average by 10.8%, and the weight of commercial bulbs on average by 14% in relation to flat cultivation.

Table 1. *Effects of different bulb placement methods on stand count, shoot biomass, bulb count and fresh yield per plot (3.2m^2) on light soil*

Bulb Placement	Stand Count (No)	Shoot mass (g)	Bulb count (No)	Fresh bulb yield (g)	Downy attack (1 - 5 scale)*
Dry season					
TRP	31^{a}	713^{a}	318^{ab}	3314^{abc}	2.5^{b}
SRP	32^{a}	536^{ab}	261^{bc}	3881^{a}	2.8^{b}
BRP	34^{a}	592^{ab}	256^{bc}	3270^{abc}	5.0^{a}
FLP+TR	31^{a}	493^{ab}	282^{abc}	3396^{ab}	3.0^{b}
FLP+SR	31^{a}	490^{ab}	232^{c}	3078^{abc}	3.5^{b}
FLP+BR	32^{a}	731^{a}	334^{a}	3249^{abc}	2.8^{b}
CAS+TR	23^{b}	374^{b}	156^{d}	2492^{bc}	2.0^{b}
CWS+TR	23^{b}	354^{b}	149^{d}	2411^{c}	2.0^{b}
Average	30	535.5	248	3136	2.9
CV%	14.48	32.68	16.30	18.42	33.12
LSD at 0.05	6.33	257.30	59.57	849.53	1.43
Rainy season					
TRP	35^{ab}	524^{bc}	381^{a}	2774^{ab}	2.8
SRP	38^{a}	694^{a}	387^{a}	2670^{ab}	2.3
BRP	36^{ab}	516^{bc}	278^{abc}	2533^{ab}	3.3
FLP+TR	37^{a}	469^{cd}	350^{ab}	2441^{ab}	2.5
FLP+SR	37^{a}	535^{bc}	334^{ab}	3033^{a}	2.3
FLP+BR	37^{a}	634^{ab}	352^{ab}	2370^{ab}	2.8
CAS+TR	24^{c}	268^{e}	175^{c}	1633^{b}	3.3
CWS+TR	32^{b}	345de	262^{bc}	2500^{ab}	3.3
Average	35	498	315	2494	2.8
C.V%	8.89	17.25	22.69	30.46	21.71
LSD at 0.05	4.54	126.42	105.05	1117.37	0.89

Means followed by the same letter (S) within a column are not significantly different at $P<0.05$

* 1= low infestation, 5 = high infestation

SRP produced the highest fresh bulb yield (4647g/3.2m^2) in the dry season from Vertisol while BRP and TRP gave the highest bulb count (376) and shoot mass (384g/3.2m^2), respectively (Table 2).

Table 2. *Effects of different bulb placement methods on stand count, shoot biomass, bulb count and fresh yield per plot (3.2m^2) on Vertisol*

Bulb Placement	Stand Count (No)	Shoot mass (g)	Bulb count (No)	Fresh bulb yield (g)	Downy attack (1 - 5 scale)*
Dry season					
TRP	25^{ab}	384^{a}	242^{abc}	4359^{ab}	1.0^{c}
SRP	28^{a}	306^{ab}	326^{ab}	4647^{a}	1.3^{bc}
BRP	27^{ab}	214^{b}	376^{a}	4564^{a}	1.8^{ab}
FLP+TR	30^{a}	287^{ab}	274^{abc}	3949^{abc}	1.3^{bc}
FLP+SR	26^{ab}	242^{ab}	275^{abc}	3896^{abc}	1.3^{bc}
FLP+BR	29^{a}	247^{ab}	292^{abc}	3517^{abc}	2.3^{a}
CAS+TR	19^{c}	272^{ab}	166^{c}	2743^{c}	1.0^{c}
CWS+TR	21^{bc}	233^{b}	194^{bc}	3098^{c}	1.3^{bc}
Average	26	273	268	3847	1.4
C.V%	14.58	32.73	34.81	22.55	30.73
LSD at 0.05	5.53	131.56	137.30	1275.87	0.62
Rainy season					
TRP	36	934	716^{a}	5436	2.8^{a}
SRP	38	705	618^{ab}	6734	2.3^{ab}
BRP	35	579	554^{bc}	5787	2.8^{a}
FLP+TR	35	436	547^{bc}	5921	1.5^{ab}
FLP+SR	36	769	562^{bc}	5494	2.3^{ab}
FLP+BR	36	452	586^{abc}	5350	1.3^{b}
CAS+TR	35	720	550^{bc}	6701	1.8^{ab}
CWS+TR	36	583	455^{c}	5302	2.8^{a}
Average	36	647	574	5841	2.2
C.V%	6.38	62.59	16.79	18.16	37.05
LSD at 0.05	3.38	595.92	141.62	1559.87	1.18

Means followed by the same letter (S) within a column are not significantly different at P<0.05

* 1= low infestation, 5 = high infestation

Overall average fresh bulb yield was high from vertisol when compared with light soil. Likewise fresh bulb yield in the rainy season was high as compared to yield in the dry season. The highest overall average fresh bulb yield was obtained from SRP (4483g/3.2m^2) followed by BRP (4039g/3.2m^2) where as the lowest was from CWS+TR (3328g/3.2m^2) followed by CAS+TR (3392g/3.2m^2) (Table 3).

Table 3. *Combined mean effect of different bulb placement methods on fresh bulb yield (weight in g/plot) of shallot.*

Bulb placement	Dry season	Rainy season	Light soil	Vertisol	Average
TRP	3837^{ab}	4105	3044^{ab}	4898^{ab}	3971^{abc}
SRP	4264^{a}	4702	3276^{a}	5691^{a}	4483^{a}
BRP	3917^{ab}	4160	2901^{ab}	5176^{ab}	4039^{ab}
FLP+TR	3672^{ab}	4181	2918^{ab}	4935^{ab}	3927^{abc}
FLP+SR	3488^{abc}	4264	3056^{ab}	4695^{ab}	3876^{abc}
FLP+BR	3384^{bcd}	3860	2810^{ab}	4434^{b}	3622^{bc}
CAS+TR	2618^{d}	4167	2063^{c}	4722^{ab}	3392^{bc}
CWS+TR	2754^{cd}	3901	2456^{bc}	4200^{b}	3328^{c}
Average	3492	4167	2815	4844	3830
C.V%	21.11	22.14	23.97	20.01	21.80
LSD at 0.05	743.7	931.0	681.1	977.8	587.1

Means followed by the same letter (S) within a column are not significantly different at P<0.05

The result showed an increase in bulb count but a reduction in shoot biomass and bulb yield of shallot grown on light sandy soil during the rainy season as compared to those grown in the dry season. The results from the vertisol were unidirectional favouring high performance of growth and yield in the rainy season. The relatively low number of stand count in the dry season from both light soil and Vertisol supports the fact that there was indeed low level of moisture in the soil which was critical for bulb sprouting and shoot growth. The magnitude of low yield was even more serious in the light soil

where water retention is poor relative to Vertisol. According to Gebrekidan (2003) flat bed planting produced the lowest grain yield while furrow and ridge with closed end tied ridge planting in furrows gave the highest sorghum yield mainly due to water conservation efficiency of the practice.

Fresh bulb yields from SRP were higher than those from all other bulb placement treatments except on light soil in the rainy season (Tables 1 & 2). Similarly, onion planting on sides of ridges or on beds at 45 X 30-45 cm spacing was recommended by Gopalakrishnan (2007). Singh, RK & Gupta, RK (2013) have also recommended planting on raised beds or on both sides of ridges in BBF (Broad Band Furrow) system for better bulb development and yield.

During the dry season, fresh bulb yield from SRP was also significantly different from fresh bulb yield for CAS+TR and CWS+TR in both soil types. However, no significant difference in fresh bulb yield was observed between SRP and other bulb placement treatments in the wetter season. Allotment & Gardens (2014) recommended planting potato tubers into the top of the ridge at the normal spacing of 30cm for early varieties and 40cm for main crop varieties, further indicating that plants above the ground level do not get waterlogged and rot in wet weather. Pilot studies with ridge planting of various crops resulted in a dramatic yield increase when maize and soybean were planted on ridges (DARCOFenews, 2005)

Fresh bulb yields for the conventional bulb placement increased with soil wetness and yield for CAS+TR ranked second to SRP on Vertisol soil during the rainy season. In contrast, CAS+TR showed a drastic yield decrease (although not statistically significant) on the light soil in the rainy season as compared to other treatments.

Even though, there appeared to exist growth and fresh bulb yield variation among bulb placement treatments on light soil and in dry season on Vertisol, growth and fresh bulb yield variations among treatments in the rainy season on Vertisol were absent except for bulb count. The SRP treatment, however, ranked up well with the top best treatments for most favourable growth characteristics recorded and it was the top performer for stand count and the second top for bulb count. Tnau (2015) also recommended, after plowing the land to a fine tilth and forming ridges and furrows at 45 cm spacing, planting bulbs on both the sides of the ridges at 10 cm apart. Furthermore, Currah & Proctor (1990) in their review of the production practice in the tropics indicated the advantages of side ridge planting in salt affected soils.

There was no significant difference among bulb placement treatments in the rainy season as compared to the dry season. However, similar trend was not observed on the soil types.

FLP+BR, FLP+TR, CAS+TR and CWS+TR treatments were inferior in yield performance on both soil types. SRP was consistently high yielder over seasons and soil types, and when the overall average yield performances of the treatments were considered. In conformity with this result Agro-techniques (2015) reported better performance of onion transplanted on raised beds or on both sides of ridges for *kharif* or rainy season crops. Side ridge planting was also found to be beneficial in salt affected soils (Currah &Proctor, 1990). BRP followed by TRP were the next top yielders after SRP (Table 3). Low yield in the conventional planting methods (CAS+TR and CWS+TR) was partly due to low sprouting owing to immediate ridging after planting.

CONCLUSION

Although soil types and seasonal conditions resulted in wide ranges of crop responses, side ridge placement of shallot bulb consistently yielded higher than all other treatments and significantly higher than the conventional practices. The ranges of the yield differences, however, narrowed under the moist condition of the vertisol in wetter season.

Shallot, like other bulb crops, being shallow rooted and surface soil feeder, responds variably to soil moisture contents which in turn is dependent on soil texture for moisture retention. Vertisol with slow internal drainage mechanism and high water retention capacity appeared to be favourable for high bulb production. This study, in support of this characteristics, also showed little yield differences between bulb placements in wetter season as compared to yield differences in the drier season and in the light soil. The result pointed the importance of using appropriate bulb placement practice for bulb crops production by taking into account the soil type, moisture availability, and the slope of the land. In the absence of supply of adequate irrigation water and good distribution of rain, bulb crops have to be grown on side ridges using all possible means of soil conservation techniques.

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