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Original Paper

Responses of onion plant growth and seed yield to mother bulb production conditions

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The late planting of onions practiced by farmers has decreased the yield and quality of onion seed. This experiment was conducted during 2019 and 2020 at agricultural research farm of Kabul University to study the effect of mother bulb production conditions on subsequent plant growth and seed yield and quality. The study was designed in Randomized Complete Block Design and data for different agronomic traits, flowering habits, seed yield and seed quality were recorded. The recorded data were statistically analyzed with STAR software. The highest leaf area per plant (994.38 cm^2) and leaf area index (0.83) were recorded for the plants obtained from mother bulbs grown on 10th March in deep ploughed flat beds. The highest number of flowering stalks per plant (3.83) was recorded for the plants produced from the mother bulbs grown on 10th March in shallow ploughed double row raised beds, it was on far with the plants obtained from the mother bulbs grown on 10th March in deep ploughed flat beds. The highest seed yield (737.27 kg ha^{-1}) was recorded for the plants obtained from mother bulbs grown on 10th March in shallow ploughed flat beds. This was on far with the seed yield of the plants obtained from the mother bulbs grown on 10th March in deep ploughed flat beds. The results reveal that, mother bulbs produced under early planting dates and deep ploughed flat-bed conditions are more appropriate to produce vigorous plants and higher seed yield of onion.

Keywords: flowering stalks, growth response, seed germination, seed yield

1 Introduction

Onion (*Allium cepa* L.) belonging to the Alliaceae family is a biennial herbaceous monocotyledon plant with $2n = 2x = 16$ chromosomes (Tungland, 2018). It is typically grown as annual for bulb production and biennial for seed production (Gupta et al., 2003). Onions is a commercial vegetable crops, during 2019, it was ranked 403rd most traded product in the world (Onions HS, 2019). According to (FAOSTAT, 2019), during 2019 the global onion production reached to 100 million metric tons from an area of 5.2 million hectares. Onion is highly cross pollinated crop and production of pure seed at local farmers level is very difficult. Although access to high quality onion seed is a continuous demand of farming community but due to its cross-pollinating nature the lack of quality seed for local onion varieties is very tangible.

Onion seed yield depends on cultivar, physiological age, vernalization, bulb size, environmental conditions and cultural practices under which the seed is produced. The quality of seed is dependent on genotype, location, growing season, seed production method and plant protection measures (Currah, 1981; Desalegne & Aklilu, 2003; Khokhar, 2009).

The quality of mother bulb influences plant growth, seed yield and seed quality of onion. The bulb quality is influenced by growing conditions under which it is produced. The bulbs produced in early planting dates have large size and results in vigorous plant growth and higher seed production capacity in subsequent season (Ashagrie et al., 2014; Mehri et al., 2015; Mishra et al., 2002; Mollah et al., 2015; Mosleh UD Deen, 2008).

Large bulbs have larger food supply and water resources as compare to the smaller once which enables them to

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develop vigorous plants and produce higher seed yield (Ali et al., 1998). The highest plant height, number of leaves per plant, number of flower stalks per plant, flower stalk diameter, flower stalk height, number of seeds per umbel, 1000-seed weight and seed yield were recorded for large bulbs produced in early planting dates (Hussain et al., 2001; Khodadadi, 2012; Reghin et al., 2005; Tesfaye et al., 2018).

Tillage depth and land preparation are also important factors which affects the quality of mother bulbs. The deep ploughed flatbeds are more suitable for production of high quality large bulbs (Feitosa et al., 2020; Gami et al., 2013; Salari et al., 2020).

The farmers in temperate regions of Afghanistan commonly sow onion seed in late April and transplant the seedlings in late June. However, the planting date can be advanced to early May with the nursery established in early March. The current practiced delay in planting date usually leads to production of small sized bulbs which subsequently reduces the quality and yield of onion seed. Considering the findings of early studies, the present investigation was carried out to evaluate the effect of mother bulb production conditions on subsequent plant growth, seed yield and seed quality.

2 Material and methods

The investigation was carried out during 2019 and 2020 at the Agriculture Research Farm of Kabul University, Kabul, Afghanistan. The experiment site is located at latitude 34.5184° N and longitude 69.1394° E with an elevation of 1810 meter above mean sea level. Hashimi et al. (2021) analyzed the soil of the study field in 2019 and reported that, it is sandy clay loam in texture. They stated that, the soil is alkaline in nature having over 10 percent calcium carbonate and its pH is 8.1. They further reported that, the organic carbon of the soil is 0.46 percent and plant available nitrogen, phosphorous and potassium are 140, 32 and 554 kg ha^{-1} respectively. The region falls under dry temperate climatic zone of Afghanistan (Salari et al., 2020). The common growing season in Kabul is from April to November. The average monthly weather data on temperature (°C), relative humidity (%), day length (hours) and rainfall (mm) during the experimental period is presented in Table 1.

During 2018 and 2019 the onion bulbs were produced under 18 different growing conditions (Table 2) and during subsequent years (2019 and 2020) they were used for seed production. During the winter season the bulbs were stored under common ventilated storage conditions to obtain proper vernalization. The bulbs for seed production were selected considering true to type, color, shape, size and with preferably of single center.

The experiment was laid out in Randomized Complete Block Design (RCBD) with eighteen treatments each replicated three times. The treatments were the growing conditions under which the mother bulbs were produced (Table 2).

Table 1 Average monthly weather data of Kabul, Afghanistan During 2019 and 2020

Month	Maximum temperature (^{0}C)			Minimum temperature (^{0}C)			Relative humidity (%)			Day length (hours)*			Rainfall (mm)		
	2019	2020	mean	2019	2020	mean	2019	2020	mean	2019	2020	mean	2019	2020	mean
January	2.2	0.1	1.1	-8.7	-10.4	-9.5	61.8	66.3	64.1	10.1	10.1	10.1	92.7	41.6	67.1
February	1.0	7.2	4.1	-9.9	-4.8	-7.4	72.8	56.8	64.8	11.0	11.0	11.0	69.7	44.9	57.3
March	7.4	8.1	7.8	-3.5	-2.7	-3.1	66.4	69.8	68.1	11.6	11.6	11.6	51.2	187.0	119.1
April	17.3	14.6	15.9	4.1	2.2	3.2	60.8	66.8	63.8	13.1	13.1	13.1	40.5	179.2	109.8
May	21.4	19.5	20.4	5.5	5.5	5.5	42.8	59.1	51.0	14.0	14.0	14.0	29.1	48.5	38.8
June	25.2	25.6	25.4	8.4	9.0	8.7	32.6	37.5	35.0	14.3	14.3	14.3	4.2	7.6	5.9
July	31.1	28.0	29.6	13.4	11.6	12.5	25.5	32.6	29.0	14.2	14.2	14.2	8.4	6.8	7.6
August	29.1	29.7	29.4	11.8	12.3	12.1	24.7	30.3	27.5	13.3	13.3	13.3	12.7	5.8	9.3
September	27.2	24.8	26.0	9.3	7.2	8.3	21.7	24.5	23.1	12.3	12.3	12.3	0.9	15.2	8.0
October	18.2	16.9	17.5	4.3	0.6	2.5	38.6	33.3	36.0	11.2	11.2	11.2	16.7	53.0	34.8
November	9.6	9.9	9.8	-1.7	-2.9	-2.3	51.8	46.3	49.1	10.3	10.3	10.3	39.9	51.6	45.7
December	7.4	4.7	6.1	-3.8	-6.6	-5.2	43.2	56.5	49.9	9.5	9.5	9.5	7.1	29.9	18.5

Source: POWER Data Access Viewer, 2021; *Sunrise and Sunset in Afghanistan, 2021

Table 2 Treatment details

Treatment	Treatment details (the mother bulb production conditions)
T1	deep plough × flatbed × 10th May
T2	deep plough × flatbed × 1st June
T3	deep plough × flatbed × 20th June (farmer practice)
T4	deep plough × single row raised bed × 10th May
T5	deep plough × single row raised bed × 1st June
T6	deep plough × single row raised bed × 20th June
T7	deep plough × double row raised bed × 10th May
T8	deep plough × double row raised bed × 1st June
T9	deep plough × double row raised bed × 20th June
T10	shallow plough × flatbed × 10th May
T11	shallow plough × flatbed × 1st June
T12	shallow plough × flatbed × 20th June
T13	shallow plough × single row raised bed × 10th May
T14	shallow plough × single row raised bed × 1st June
T15	shallow plough × single row raised bed × 20th June
T16	shallow plough × double row raised bed × 10th May
T17	shallow plough × double row raised bed × 1st June
T18	shallow plough × double row raised bed × 20th June

The recommended dosage of inorganic fertilizer (nitrogen at 90 kg ha^{-1}, phosphorus at 60 kg ha^{-1} and potassium at 45 kg ha^{-1}) and farm yard manure at 15 t ha^{-1} were applied to all the plots. The plots were irrigated using common flood irrigation. Considering the climatic conditions, the frequency of irrigation was decided once in each 7–10 days. The plants were grown with rows spaced 0.4 m apart and an in-row plant distance of 0.3 m. The weeds were controlled manually by hand weeding. To prevent fungal diseases especially powdery mildew, the leaves were sprayed with 0.2% Mancozeb fungicide solution especially during the rainy season. The umbels were harvested when capsules started partial opening and were dried under shade in a well-ventilated place. Threshing of seed was done manually with the help of human labor. The seed were dried under shade till 6 to 7% moisture level is attained.

The data on growth parameters was recorded at 40, 50 and 60 days after planting. The numbers of leaves per plant in the selected three plants were counted in each treatment. The length of the leaf was measured in cm from the base to tip of the leaf. Using the millimeter graph paper method given by (Pandey & Singh, 2011), the leaf area was recorded from randomly labeled three plants in each treatment and was presented as square centimeter per plant. Leaf area index (LAI) was estimated by dividing the actual leaf area per plant by land area occupied by the same plant (spread of the plant) by using the formula (1) as given by (Watson, 1952):

$$LAI = \frac{\text{leaf area per plant } (cm^2)}{\text{land area occupied by each plant } (cm^2)} \quad (1)$$

The number of flower stalks in the selected three plants were counted in each treatment. The length of flower stalk was measured in centimeters from the base to tip of the stalk at the time of harvest. Seed yield for each treatment was recorded in gram per plot and presented in kilograms per hectare. One hundred seeds from each treatment were manually counted and weighed with the help of high precision mg scale (0.001 g).

One hundred seeds from each treatment were placed in petri dishes on top of absorbent paper and required amount of distilled water were sprayed on it. The petri dishes were kept under optimum environmental conditions for germination and the optimum temperature, relative humidity and light were ensured for the period. The number of seed germinated within two weeks period were counted and presented as percent germination. The germination test was conducted twice, the first germination test was conducted at initial stage after the seed threshing and drying process completed

and the second test was conducted after six months of storage when the onion sowing season started.

The data was analyzed with the help of Statistical Tools for Agricultural Research (STAR) (Products – Quantitative Genetics and Biometrics Cluster, 2021). After calculation of Analysis of Variance (ANOVA), Least Significant Difference (LSD) was calculated to find the difference among treatments. Level of significance used is at p = 0.05.

3 Results and discussion

3.1 Number of leaves per plant

The large sized bulbs produced in early planting dates recorded higher number of leaves per plant however, their difference with other treatments was not statistically significant (Figure 1). The uniform growing conditions applied to all treatments might be the possible reason for non-significant difference of number leaves per plant.

3.2 Leaf length

The leaf length in all treatments was recorded between 31–34 cm (Figure 2) however, the difference was statistically non-significant. The uniform growing conditions applied to all treatments might be the possible reason for non-significant difference between leaf length of plants.

3.3 Leaf area per plant

During season 2019 and mean of season 2019 and 2020 the effect of mother bulb production conditions was found significant on leaf area per plant at early growth stage (40 days after planting) (Table 3). Based on mean values of two seasons, the highest leaf area per plant (994.38 cm^2) was recorded for the plants obtained from mother bulbs grown on 10th March in deep ploughed flat beds. The lowest leaf area per plant (596.12 cm^2) was recorded for the plants obtained from mother bulbs grown on 20th April in shallow ploughed single row raised beds.

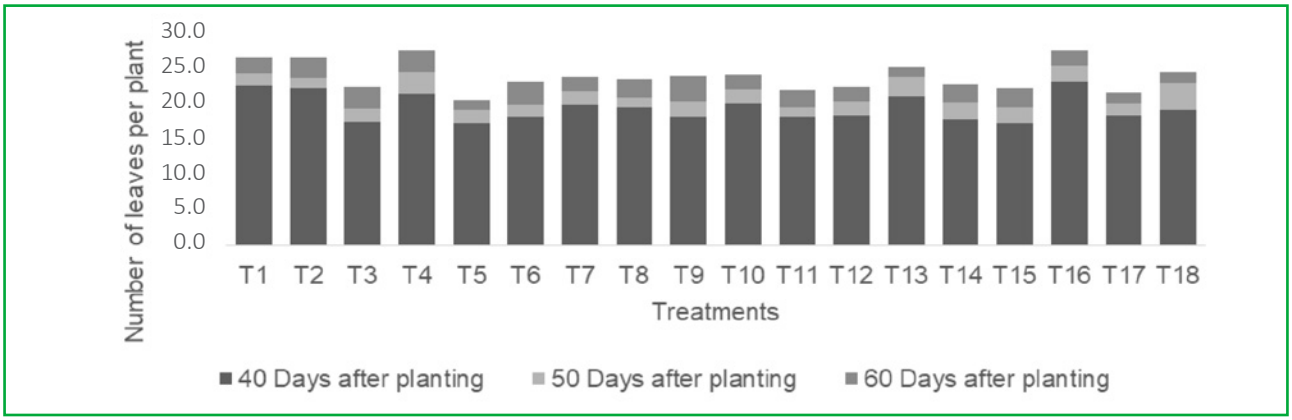

Figure 1 Number of leaves per plant as influenced by mother bulb production conditions of safid e paisaye onion (pooled mean of season 2019 and 2020)

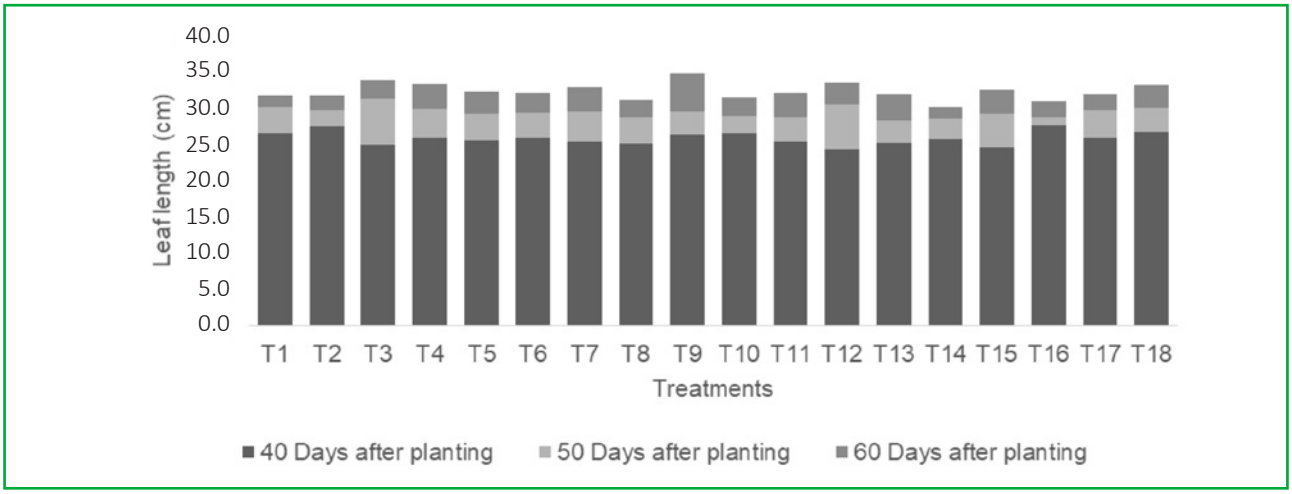

Figure 2 Leaf length (cm) as influenced by mother bulb production conditions of safid e paisaye onion (pooled mean of season 2019 and 2020)

Table 3 Leaf area per plant (cm^2) of Safid E Paisaye Onion as influenced by mother bulb production conditions

Treatment	Days after planting								
	40			50			60		
	2019	2020	mean	2019	2020	mean	2019	2020	mean
T1	1219.4 a	769.3	994.4 a	1317.3	1350.0	1333.6	1840.2	1494.2	1667.2
T2	1054.1 ab	889.1	971.6 a	1092.5	1331.2	1211.9	1333.0	1914.8	1623.9
T3	536.0 e	752.9	644.4 bc	777.5	1418.8	1098.2	1102.7	2197.3	1650.0
T4	864.9 abcde	807.5	836.2 ab	1003.4	1401.2	1202.3	1467.2	1964.0	1715.6
T5	739.2 bcde	564.7	651.9 bc	818.7	973.5	896.1	1125.1	1345.5	1235.3
T6	578.5 de	718.9	648.7 bc	623.9	1086.5	855.2	882.0	2027.2	1454.6
T7	822.8 bcde	590.7	706.7 bc	981.8	1211.4	1096.6	1373.1	1871.1	1622.1
T8	694.7 cde	698.6	696.7 bc	795.5	1081.3	938.4	1155.4	1737.7	1446.5
T9	829.4 bcde	531.3	680.4 bc	896.6	994.6	945.6	1230.2	2063.7	1646.9
T10	913.3 abcd	725.8	819.6 abc	995.8	1208.7	1102.2	1368.3	1591.9	1480.1
T11	553.6 e	866.5	710.1 bc	686.6	1287.6	987.1	1099.4	1869.1	1484.2
T12	789.8 bcde	515.6	652.7 bc	929.9	1077.0	1003.5	1404.8	1697.0	1550.9
T13	784.4 bcde	801.3	792.9 abc	916.2	1386.0	1151.1	1172.8	2028.7	1600.7
T14	748.0 bcde	626.4	687.2 bc	877.4	1002.2	939.8	1264.0	1408.4	1336.2
T15	573.0 de	619.3	596.1 c	626.5	1085.0	855.7	942.9	1761.8	1352.3
T16	956.4 abc	950.8	953.6 a	1088.9	1241.1	1165.0	1381.1	1634.4	1507.7
T17	798.0 bcde	531.9	664.9 bc	895.5	904.2	899.9	1234.4	1392.9	1313.7
T18	889.1 abcde	700.8	795.0 abc	973.3	1212.4	1092.9	1285.4	1779.9	1532.6
F-test	*	N.S.	*	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Sem (±)	33.48		22.63						
LSD	355.23		233.57						
CV (%)	26.86		18.76						

* and N.S. stands for significant and non-significant, respectively. Means within the same column followed by the same letter are not significantly different, according to LSD at 0.05 level

This might be due to the larger size of mother bulbs produced under early planting date conditions. The authors (Khokhar, 2009; Mosleh UD Deen, 2008) also reported that, the plants obtained from large sized bulbs has more vigorous growth as compare to those obtained from small sized mother bulbs.

3.4 Leaf area index

The leaf area index is strongly dependent on leaf area per plant. Similar to leaf area per plant the leaf area index was also significantly influenced by mother bulb production conditions in early growth stage (40 days after planting) during season 2019 and mean of season 2019 and 2020 (Table 4). Based on mean values of two seasons, the highest leaf area index (0.83) was recorded for the plants obtained from mother bulbs grown on 10th March in deep ploughed flat beds. The lowest leaf area index (0.49) was recorded for the plants obtained from mother bulbs grown on 20th April in shallow ploughed single row raised beds.

The larger size of mother bulbs produced under early planting date might be the possible reason for this. The authors (Ali et al., 1998; Khodadadi, 2012; Tesfaye et al., 2018) also reported that, the plants obtained from large sized bulbs are vigorous than those obtained from small sized mother bulbs.

3.5 Number of flowering stalks per plant

The effect of mother bulb production conditions was found significant on number of flowering stalks per plant at later growth stage (60 days after planting) for the mean values of season 2019 and 2020 (Table 5). The highest number of flowering stalks per plant (3.83) were recorded for the plants produced from the mother bulbs grown on 10th March in shallow ploughed double row raised beds, it was on far with the plants obtained from the mother bulbs grown on 10th March in deep ploughed

Table 4 Leaf area index of Safid E Paisaye Onion as influenced by mother bulb production conditions

Treatment	Days after planting								
	40			50			60		
	2019	2020	mean	2019	2020	mean	2019	2020	mean
T1	1.02 a	0.64	0.83 a	1.10	1.12	1.11	1.53	1.24	1.39
T2	0.88 ab	0.74	0.81 a	0.91	1.11	1.01	1.11	1.60	1.35
T3	0.44 f	0.63	0.53 bc	0.65	1.18	0.92	0.92	1.83	1.38
T4	0.72 abcdef	0.67	0.69 ab	0.84	1.17	1.00	1.22	1.64	1.43
T5	0.62 bcdef	0.47	0.54 bc	0.68	0.81	0.75	0.94	1.12	1.03
T6	0.48 def	0.60	0.54 bc	0.52	0.91	0.71	0.73	1.69	1.21
T7	0.69 bcdef	0.49	0.59 bc	0.82	1.01	0.91	1.14	1.56	1.35
T8	0.58 cdef	0.58	0.58 bc	0.66	0.90	0.78	0.96	1.45	1.21
T9	0.69 bcdef	0.44	0.56 bc	0.75	0.83	0.79	1.02	1.72	1.37
T10	0.76 abcd	0.61	0.68 abc	0.83	1.01	0.92	1.14	1.33	1.24
T11	0.46 ef	0.72	0.59 bc	0.57	1.08	0.83	0.92	1.56	1.24
T12	0.66 bcdef	0.43	0.54 bc	0.77	0.90	0.84	1.17	1.42	1.29
T13	0.65 bcdef	0.67	0.66 abc	0.76	1.16	0.96	0.98	1.69	1.34
T14	0.62 bcdef	0.52	0.57 bc	0.73	0.84	0.79	1.05	1.18	1.12
T15	0.48 def	0.52	0.49 c	0.52	0.90	0.71	0.79	1.47	1.13
T16	0.80 abc	0.79	0.79 a	0.91	1.03	0.97	1.15	1.36	1.26
T17	0.66 bcdef	0.44	0.55 bc	0.75	0.75	0.75	1.03	1.16	1.10
T18	0.74 abcde	0.59	0.66 abc	0.81	1.01	0.91	1.07	1.49	1.28
F-test	*	N.S.	*	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Sem (±)	0.03		0.02						
LSD	0.29		0.19						
CV (%)	26.76		18.88						

* and N.S. stands for significant and non-significant, respectively. Means within the same column followed by the same letter are not significantly different, according to LSD at 0.05 level

flat beds. The lowest number of flowering stalks per plant (2.39) were observed for the plants obtained from the mother bulbs grown on 20th April in deep ploughed flat beds.

The larger size of mother bulbs produced under early planting date might be the possible reason for this. The authors (Ashagrie et al., 2014; Hussain et al., 2001; Rafieipour et al., 2011; Reghin et al., 2005) also reported that, the plants obtained from large sized bulbs produces higher number of flowering stalks as compare to those obtained from small sized mother bulbs.

3.6 Length of flowering stalk

The length of flowering stalks in all treatments was recorded between 66–77 cm (Figure 3). The difference was not statistically significant. The uniformity of growing conditions applied in common to all treatments might be the possible reason for this.

3.6 Seed yield

During both season 2019 and season 2020 and the mean of both seasons the effect of mother bulb production conditions was found significant on seed yield (Table 6). Based on mean values of two seasons, the highest seed yield (737.27 kg ha^{-1}) was recorded for the plants obtained from mother bulbs grown on 10th March in shallow ploughed flat beds. This was on far with the seed yield of the plants obtained from the mother bulbs grown on 10th March in deep ploughed flat beds. The lowest seed yield (454.86 kg ha^{-1}) was recorded for the plants obtained from mother bulbs grown on 1st April in deep ploughed flat beds.

The plants obtained from large sized mother bulbs had stronger growth and higher number of flowing stalks, this might be the possible reason for higher seed yield obtained from mother bulbs produced under early planting date conditions. The authors (Ali et al., 1998;

Table 5 Number of flowering stalks per plant as influenced by mother bulb production conditions of Safid E Paisaye Onion

Treatment	Days after planting								
	40			50			60		
	2019	2020	mean	2019	2020	mean	2019	2020	mean
T1	3.33	0.00	1.67	3.44	3.11	3.28	3.89	3.67	3.78 a
T2	4.00	0.00	2.00	4.22	2.67	3.44	4.22	3.11	3.67 abc
T3	2.11	0.11	1.11	2.11	2.56	2.33	2.22	2.56	2.39 f
T4	2.89	0.11	1.50	3.00	3.22	3.11	3.22	4.22	3.72 ab
T5	2.44	0.00	1.22	2.56	2.34	2.45	2.67	2.89	2.78 ef
T6	1.78	0.00	0.89	2.00	2.78	2.39	2.22	3.56	2.89 def
T7	2.67	0.00	1.33	2.89	2.78	2.83	3.11	3.11	3.11 abcdef
T8	2.56	0.67	1.61	2.56	2.67	2.61	2.78	2.78	2.78 ef
T9	2.33	0.22	1.28	3.33	1.67	2.50	3.33	2.67	3.00 bcdef
T10	3.33	0.11	1.72	3.67	2.55	3.11	3.78	3.44	3.61 abcd
T11	2.55	0.00	1.28	2.66	2.78	2.72	2.78	3.11	2.94 cdef
T12	2.44	0.22	1.33	2.67	2.11	2.39	2.78	2.67	2.72 ef
T13	2.78	0.00	1.39	3.11	3.33	3.22	3.44	3.67	3.55 abcd
T14	2.44	0.11	1.28	2.89	2.67	2.78	3.11	3.55	3.33 abcde
T15	2.78	0.11	1.44	2.78	1.89	2.33	3.11	2.78	2.94 cdef
T16	2.89	0.11	1.50	3.22	2.67	2.94	3.22	4.45	3.83 a
T17	2.78	0.11	1.44	3.00	2.33	2.67	3.00	3.33	3.16 abcde
T18	2.67	0.00	1.33	3.11	2.22	2.67	3.22	3.11	3.17 abcde
F-test	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	**
Sem (±)									0.07
LSD									0.73
CV (%)									13.82

** and N.S. stands for highly significant and non-significant, respectively. Means within the same column followed by the same letter are not significantly different, according to LSD at 0.05 level

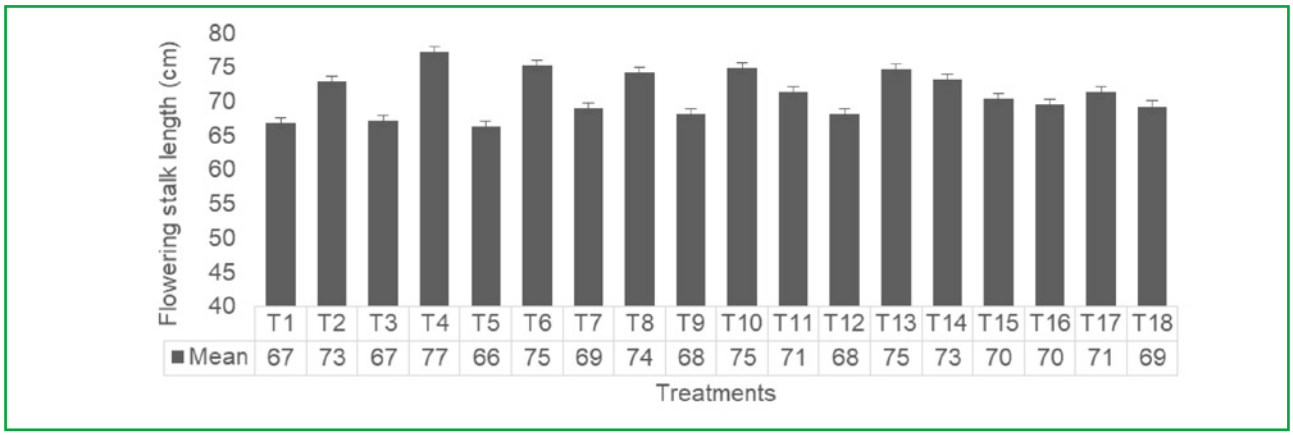

Figure 3 Length of flowering stalk as influenced by mother bulb production conditions of safid e paisaye onion (pooled mean of season 2019 and 2020)

Table 6 Seed Yield and 100 Seed Weight as Influenced by Mother Bulb Production Conditions of Safid E Paisaye Onion

Treatment	Seed yield (kg ha^{-1})			100 Seed weight (g)		
	2019	2020	mean	2019	2020	mean
T1	534.72 bc	719.90 abcdef	627.31 abc	0.55	0.42 cdef	0.49
T2	386.57 d	523.14 defg	454.86 e	0.51	0.56 a	0.54
T3	386.57 d	754.63 abcde	570.60 bcde	0.52	0.52 abcd	0.52
T4	516.20 bcd	953.70 a	734.95 a	0.60	0.53 abc	0.57
T5	476.85 bcd	446.76 g	461.80 de	0.57	0.41 ef	0.49
T6	421.29 cd	925.92 ab	673.61 ab	0.47	0.41 def	0.44
T7	520.83 bcd	761.57 abcd	641.20 abc	0.56	0.48 abcdef	0.52
T8	435.18 cd	775.46 abcd	605.32 abcd	0.60	0.49 abcde	0.55
T9	432.87 cd	493.05 efg	462.96 de	0.61	0.46 abcdef	0.54
T10	678.24 a	796.29 abc	737.27 a	0.50	0.54 ab	0.52
T11	525.46 bc	587.96 cdefg	556.71 bcde	0.58	0.47 abcdef	0.53
T12	462.03 bcd	657.41 cdefg	559.72 bcde	0.60	0.37 f	0.49
T13	488.42 bcd	673.61 bcdefg	581.02 bcde	0.58	0.37 f	0.48
T14	446.76 bcd	465.28 fg	456.02 e	0.60	0.53 abc	0.57
T15	442.13 cd	717.59 abcdef	579.86 bcde	0.53	0.57 a	0.55
T16	452.31 bcd	537.03 cdefg	494.67 cde	0.53	0.41 def	0.47
T17	549.54 abc	618.05 cdefg	583.80 bcde	0.49	0.43 bcdef	0.46
T18	577.12 ab	643.51 cdefg	610.32 abc	0.50	0.52 abcde	0.51
F-test	*	*	**	N.S.	**	N.S.
Sem (±)	13.34	27.81	15.83		0.01	
LSD	134.87	265.90	146.66		0.11	
CV (%)	16.75	23.94	15.31		14.49	

*, ** and N.S. stands for significant, highly significant and non-significant, respectively. Means within the same column followed by the same letter are not significantly different, according to LSD at 0.05 level

Aminpour & Mortazavibak, 2004; Ashagrie et al., 2014; Morozowska & Hołubowicz, 2009; Rafieipour et al., 2011) also reported that, the plants obtained from large sized bulbs produces higher seed yield as compare to those obtained from small sized mother bulbs.

3.7 Weight of 100 seeds

During season 2020 the effect of mother bulb production conditions was significant on weight of 100 seeds (Table 6). The highest weight of 100 seeds (0.57 g) was recorded for the plants obtained from the mother bulbs grown on 20th April in shallow ploughed single row raised beds. The lowest weight of 100 seeds (0.37 g) was recorded for the plants obtained from the mother bulbs grown on 20th April in shallow ploughed flat beds, this was on par with the results obtained for the plants produced from the mother bulbs grown on 10 March in shallow ploughed single row raised beds.

The treatments which recorded higher weight of 100 seeds had produced less seed yield. The less seed yield might be the possible reason for relatively larger seeds because the plant had enough resources for enlargement of lesser number of seeds. Similar results were recorded by the authors (Khokhar, 2014; Tesfaye et al., 2018).

3.8 Seed germination

At initial stage the seed germination was above 95 percent in all treatments. The germination percentage has decreased with increase in storage period however during 6 moths of storage period the seed germination capacity in all treatments was above 90 percent (Figure 4). The difference between treatments was statistically non-significant which might be due to uniformity in growing conditions under which the seeds were produced.

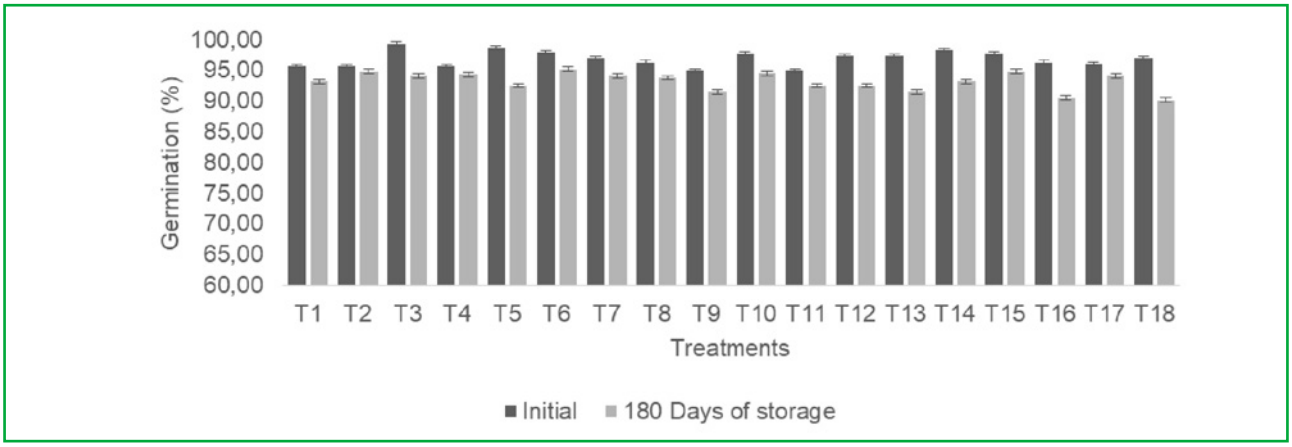

Figure 4 Seed germination of safid e paisaye onion as influenced by mother bulb production conditions (pooled mean of season 2019 and 2020)

4 Conclusions

Based on the findings of this study it is concluded that, mother bulbs produced under early planting dates and deep ploughed flat-bed conditions are more appropriate to produce vigorous plants and higher seed yield of onion.

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