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EFFECT OF TRANSPLANTING DATES ON THE GROWTH AND YIELD OF ONION (*Allium cepa* L.) VARIETIES IN THE RAINY SEASON OF THE ALGEZIRA SCHEME IN SUDAN

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ABSTRACT

This study was carried out in Wad Elgatra and Abu Ajab of the Algezira scheme during the 2020 and 2021 rainy seasons to investigate the effect of transplanting date and variety on the growth and yield of onions. The experiment was carried out based on a split plot design with the transplanting date in the main plot, and variety in the subplot, and replicated three times. Data on growth, yield, and yield components were collected and analyzed using Mstatc. Tukey's Honestly Significant Difference Test was used to separate means at a 5% level of probability. Late August transplanting increased leaf area plant^{-1}, neck diameter, fresh weight plant^{-1}, bulb marketable weight, while the early August transplanting recorded the lowest leaf area plant^{-1}, neck diameter, fresh weight plant^{-1}, bulb marketable weight. The highest bulb fresh weight and bulb yield were recorded by the mid-August transplanting. Transplanting in mid-August had a higher bulb yield (37.18 t ha^{-1}) in 2021 at Wad Elgatra, while late August transplanting produced the least (5.26 t ha^{-1}) in 2020 at Abu Ajab. Baftaim recorded the leaf area plant^{-1}, neck diameter, fresh weight plant^{-1}, bulb marketable weight, and bulb yield. Saggai recorded the greater bulb fresh weight. Abuferawa had the least potential for growth and yield in the experiment. The interaction between mid-August and Baftaim at Wad Elgatra recorded the highest yield (19.53 t ha^{-1}) in 2020; however, the interaction between late August and Abuferawa at Wad Elgatra produced a lower yield (8.79 t ha^{-1}). Based on the findings, it could be suggested that farmers in the study area, should adopt the cultivation of Baftaim and Saggai during the early and mid-August to achieve higher and marketable onion yield productivity in the Sudan Republic.

Keywords: Onion bulb yield, Transplanting date, Variety, Leaf area plant^{-1}.

Introduction

Onion (*Allium cepa* L.) belongs to the family *Alliaceae* or Amaryllidaceous, which is one of the most important monocotyledonous crops (Baloch, 1994; Rabinowitch and Currah, 2002). World production of onion increases annually due to the development of high-yielding open-pollinated and hybrid varieties, improved technologies of

production, control of pests and diseases, harvesting, processing techniques, and storage facilities (Nabi *et al*., 2010). Onion is produced in almost all regions of Sudan except the southern region. The main production season for onion is the winter; the period from October to April even though small-scale early-season crops are produced from June to January and late crops are cultivated from November to June. Onion growth is dependent on environmental conditions such as temperature, photoperiod, and relative humidity (Brewater, 2008).

Transplanting dates of onion seedlings means the effect of edaphic factors and environmental conditions on a large scale on growth, bulb yield, and bulb quality, which differ widely from one region to another. Thus, determined optimum transplanting dates have a vital role in maximizing growth, bulb yield, and quality (Ansari, 2007). Onion production is greatly influenced by the transplanting date, which is one of the most important factors that greatly influence the growth and yield of onions. Early planting gives the longest growth cycle (Elkashif *et al*., 2018).
Almost all onion genotypes grown at present in Sudan are of local origin and they are named after localities famous for their production or where seeds are traditionally produced such as Kamlin, Seleim, Hilalliya, Fadasi, Abuferawa, and Saggai. Famous and popular cultivars in Sudan are Saggai, Kamlin yellow, and Nassi (Mohamed *et al*, 2003). Onion cultivars vary in bulb colour (white, yellow, or red), shape (flattened, round, and globular to the spindle or cylindrical), size (small< 3.0 cm, medium 3- 4.5 cm, or large > 4.5 cm), and weight too large (100-160g), medium (50-100g) and small (21-50g), and in pungency. Onions are grouped into short days that require an average of 10 - 12 hours and long days of 14 hours or more for bulbing. Relatively high temperatures and long photoperiods are required for bulb formation (Dawar *et al*., 2007). The main varieties of onion grown in Sudan include "Saggai", which is red, "Kamlin" which is yellow, and "Hillo" which is white. Variety trials carried out in the Algezira Research Station (GRS) to test the performance of local and imported cultivars indicated that imported cultivars were superior to local ones concerning yield, but their dry matter percentage was very low. Generally, the local varieties are well adapted to local conditions and give higher dry weight compared with imported varieties. Baftaim (S) which is big size bulbs, globe shape, solid, pungent, high in dry matter (±16%), free from the phenomena of early bolters and doubles, it's of moderate resistance to thrips, pink root rot, and onion yellow dwarf virus. It needs ±153 days to mature and it is the most productive cultivar in Sudan (Mohamedali, 2009). Abuferawa, which is early maturity, high dry matter percentage (±24%), pungent, and good storability under open storage facilities (Mohamedali., 2007).

MATERIALS AND METHODS

The experiment was conducted during the rainy seasons of 2020 and 2021, at the experimental farm of Wad Elgatra, and Abu Ajab in the Algezira scheme. The experimental site at longitude and latitude of 14° 32´N, 32° 27´E, and 14° 47´ N, 32° 75´ E, respectively. The treatments consisted of three transplanting dates (early August, mid-August, and late August) and three varieties Saggai, Baftaim, and Abuferawa. The treatments were laid out in a spilt plot design with three replications. In both experiments, seedlings of Agrifound light were raised in nursery beds for 8 weeks before transplanting. The nursery was prepared by constructing raised seedbeds to which

adequate quantities of 20g NPK 15:15:15 were applied. The onion seeds were sown on seed beds (size 2x1m) in lines spaced at 15cm distance and lightly covered with a thin layer of compost and dry soil. The beds were then covered with paddy mulch and watered lightly. The mulch was removed as soon as the seed germinated to expose them to sunlight. Watering was sustained lightly but regularly until the seedling was ready for transplanting eight weeks later. The experimental field was cleaned; plowed, harrowed, and raised beds of size 2 x 2 m (4 m^2) were constructed. Transplanting of the healthy seedlings into the raised beds was done in early August, mid-August, and late August in 2020 and 2021.

The transplanted seedling was watered immediately to minimize transplanting shock. NPK 15:15:15, and 80:50:50 kg/ha were applied to all experimental plots. Nitrogen was applied in two split doses of 40kg each, applied at transplanting, and the balance top-dressed using urea (46%N) at 4 weeks after the first dose. All the P and K were applied at seedling bed preparation. All fertilizers were incorporated into the soil to minimize losses. The plots were kept weeds-free throughout the experimental period. The hand weeding was done as and when required. While pests were kept under control by applying insecticide. Data was recorded on the leaf area $plant^{-1}$, neck diameter, fresh weight $plant^{-1}$, bulb marketable weight, bulb fresh weight, and onion bulb yield. Collected data was analyzed using the Mstatc statistical package. Tukey's Honestly Significant Difference Test was used to separate the means at a 5% probability level.

Results and Discussions

1. Leaf area $Plant^{-1}$ (cm^2)

The Transplanting date had significant effects on the leaf area $plant^{-1}$ in both seasons at locations (Table 1). At Wad Elgatra in 2020, the highest leaf area $plant^{-1}$ (1202.36 cm^2) was recorded for plants transplanted in late August, and the data was recorded at 90 DAT, whilst the lowest leaf area $plant^{-1}$ (21.18 cm^2) was obtained with the mid-August transplanting and for 30 DAT records. However, at Abu Ajab in 2021, the late August transplanting recorded the highest leaf area $plant^{-1}$ (996.78 cm^2) at 90 DAT, while the lowest leaf area $plant^{-1}$ (25.95 cm^2) was obtained from the mid-August transplanting and information recorded at 30 DAT. This significant-high leaf area observed might indicate that onion requires enough time to establish well in the nursery before being transplanted to the field to enable better photosynthetic active radiation interception. The finding is in line with that of (Deepak *et al*., 2014) who noticed that the transplanting date in late November recorded a higher leaf area $plant^{-1}$. Aboukhadrah *et al.* (2017) also found that transplanting dates significantly varied in their effects. The findings indicate that the mid-December transplanting date produced the tallest plant height, plant fresh and dry weight, and leaf area $plant^{-1}$.

Onion variety showed no significant effects on the leaf area plant^{-1} in both seasons and locations except at 60 DAT at Wad Elgatra and 30 DAT at Abu Ajab in 2020. The increase in leaf area plant^{-1} noticed was observed on Saggai (263.07 cm²) followed by Baftaim (233.02 cm²) while Abuferawa had the lowest at Wad Elgatra. However, at Abu Ajab in 2021, the Saggai recorded the highest leaf area plant^{-1} (66.71 cm^2), while the lowest leaf area plant^{-1} (56.86 cm^2) was recorded from Abuferawa at 30 DAT (Table 1). The observations suggest that different onion varieties could perform differently under the same environmental conditions as well and the same variety could respond differently to different environmental conditions tested with similar treatment. A related study by Idriss (2007) revealed significant differences among some tested local and introduced genotypes in terms of plant height, number of onion leaves, fresh weight per plant, yield, and other yield characteristics. In addition to this, (Mohamedali, 2009) reported Baftaim to have produced better vegetative growth, large bulb size, and high yields when compared with some onion genotypes; Saggai, Kamleen, and Abuferawa tested in different environments.

Table 1. Effects of Transplanting Date and Variety on Leaf Area Plant^{-1} (cm^2) of Onion at Wad Elgatra and Abu Ajab in 2020 and 2021 Rainy Seasons.

Treatments	Wad Elgatra (DAT)						Abu Ajab (DAT)					
	30		60		90		30		60		90	
	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
Transplanting Date (T)												
Early August	29.40a	29.21b	186.18b	209.30c	586.40 c	501.04c	69.87a	31.08b	254.60a	171.28c	475.04b	521.55c
Mid-August	21.81b	32.25b	237.55ab	334.01b	784.47b	814.58b	53.15b	25.95b	289.52a	345.10b	570.54b	721.42b
Late August	26.70ab	46.19a	275.48a	401.78a	1202.36a	1033.70a	59.86b	65.02a	151.83b	412.11a	789.11a	996.78a
Prob. level	0.022	0.001	0.008	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000
SE ±	6.73	3.741	28.048	15.647	149.718	140.828	12.228	18.273	30.253	187.862	182.539	141.551
Variety (V)												
Baftaim	25.54	34.73	233.02ab	302.41	882.29	756.99	59.31ab	40.06	226.33	311.11	631.76	787.61
Saggai	26.21	37.60	263.07a	325.12	838.06	802.85	66.71a	38.86	237.94	312.94	584.60	738.77
Abuferawa	26.17	35.32	203.12b	317.55	852.88	789.48	56.86b	43.12	231.67	304.44	618.34	713.37
Prob. level	0.114	0.408	0.000	0.762	0.603	0.531	0.008	0.306	0.266	0.155	0.906	0.110
SE ±	4.401	6.798	23.404	16.956	176.533	152.234	8.834	19.565	23.612	169.472	111.327	85.474
Interaction												
T × V	0.389	0.779	0.044	0.197	0.062	0.199	0.954	0.752	0.003	0.846	0.992	0.791

Means followed by the same letter(s) in a column are not significantly different at a 5% level of probability using Tukey's Honestly Test. *=significant at 5%, **=significant at 1%, N. S= not significant

The interaction between the transplanting date and variety at 60 DAT at Wad Elgatra in 2020 on leaf area plant^{-1} is presented in (Table 1). The result indicates that the highest value was produced by the interaction between Saggai transplanting in late August (329.24 cm^2), While the shortest leaf area plant^{-1} (164.18 cm^2) was obtained when Abuferawa was transplanting in early August (Table 1). The interaction between transplanting date and variety at 60 DAT at Abu Ajab in 2020 on leaf area plant^{-1} is shown in Table 1. The result indicates that the highest value (348.91 cm^2) was produced by the interaction between Saggai transplanting in mid-August, while the shortest leaf area plant^{-1} (126.50 cm^2) was Saggai transplanting in late August. This might invariably have a positive bearing on dry matter production, accumulation, and its rapid translocation to various sink regions for smooth respiration, cell elongation, cell expansion, etc. These findings are in line with the report of (Bharti and Ram, 2014) who showed that interaction between low doses of cow manure and delayed transplanting of onion variety, were the agronomic factors that encouraged foliage growth with good display and formation of canopy for increased photosynthesis and total bulb yield.

2. Neck diameter (cm)

The different transplanting dates show variable responses of the onion neck diameter across years and both locations except at 90 DAT in 2020 at Abu Ajab (Table 2). At Wad Elgatra, a significantly higher (p > 0.000) treatment effect was observed where late August transplanting produced the widest neck diameter (1.48 cm) at 90 DAT in 2021, while the early and mid-August transplanting produced a narrower neck diameter (0.30 cm) at 30 DAT in 2020 and 2021.

At Abu Ajab, the results indicate that in 2020, at 30 DAT, late August transplanting had the widest neck diameter (1.48 cm) at 90 DAT in 2021, while mid-August transplanting recorded low values neck diameter (0.28 cm) at 30 DAT in 2020. The wider neck diameter produced resulting from late transplanting might probably be due to suitable weather and soil conditions during the growth stages of the plant, which enhanced the vegetative growth of the plant.

Table 2. Effects of Transplanting Dates and Variety on the Neck Diameter (cm) of Onion at Wad Elgatra and Abu Ajab in 2020 and 2021 Rainy Seasons.

Treatments	Wad Elgatra (DAT)						Abu Ajab (DAT)					
	30		60		90		30		60		90	
	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
Transplanting date (T)												
Early August	0.34b	0.30c	0.528b	0.79b	1.26a	1.10c	0.35a	0.31b	0.64a	0.70c	0.95	1.13c
Mid-August	0.30c	0.34b	0.60a	0.96a	1.18ab	1.34b	0.28b	0.30b	0.65a	0.96b	0.99	1.32b
Late August	0.40a	0.42a	0.57ab	0.94a	1.14b	1.48a	0.30b	0.44a	0.49b	1.07a	1.04	1.48a
Prob. level	0.000	0.000	0.013	0.000	0.049	0.000	0.002	0.000	0.000	0.000	0.869	0.000

SE ±	0.002	0.001	0.005	0.013	0.023	0.017	0.003	0.003	0.004	0.007	0.056	0.032
Variety (V)												
Baftaim	0.35ab	0.35	0.56ab	0.90	1.21	1.30	0.31	0.34	0.60	0.92	1.02	1.35
Saggai	0.36a	0.35	0.59a	0.89	1.18	1.29	0.31	0.35	0.59	0.91	0.95	1.31
Abuferawa	0.33b	0.36	0.54b	0.90	1.18	1.33	0.31	0.36	0.59	0.90	1.01	1.27
Prob. level	0.014	0.487	0.008	0.326	0.676	0.647	0.195	0.128	0.209	0.448	0.073	0.166
SE ±	0.001	0.002	0.002	0.007	0.005	0.018	0.001	0.001	0.003	0.007	0.013	0.022
Interaction												
T × V	0.056	0.715	0.065	0.769	0.656	0.882	0.045	0.482	0.008	0.789	0.152	0.404

Means followed by the same letter(s) in a column are not significantly different at a 5% level of probability using Tukey's Honestly Test. *=significant at 5%, **=significant at 1%, N. S= not significant.

This supported the findings of (Kumbhkar *et al.*, 2017) who reported that the neck diameter of onion was significantly higher with the transplanting of seedlings in early September. In most studies conducted onion neck diameter increased significantly with a delayed transplanting date from July to September. Also, (Dhar *et al*., 2019) reported similar results showing that neck diameter varied significantly among the different transplanting dates. Generally, the lowest neck diameter was found under an early August transplanting.

In addition to these, the onion variety shows variable treatment effects on their neck diameter. The results indicate significant (p=0.014) and highly significant (p=0.008) treatment effects, observed at 30 DAT and 60 DAT both in 2020 at Wad Elgatra, respectively (Table 2). Saggai in 2020 at 30 DAT, produced the highest neck diameter of (0.36 cm) closely followed by Baftaim (0.35 cm) compared to Abuferawa which had a value of (0.33 cm). The result shows a similar trend at 60 DAT in the same study year, where Baftaim (0.56 cm) closely followed Saggai (0.59 cm) while Abuferawa performed comparatively low having a value of (0.54 cm) only. The interaction between the transplanting date and variety at 30 DAT at Abu Ajab in 2020 is shown in Table 2. Baftaim and Saggai had higher neck diameters representing similar values (0.35 cm) transplanted early in August followed by when Abuferawa was transplanted in the period (0.33 cm). Table 2 shows the interaction between the transplanting date and variety at 60 DAT at Abu Ajab in 2020. The result indicates that except for the late August transplanting stage, all onion varieties interacted statistically similarly to produce higher neck diameters although the highest value among similar interactions was produced by Saggai versus mid-August (0.69 cm). This might indicate that both location and year had random effects on the varietal impact on measured characters. These varietal response differences to the same year and location are particularly important in the study of the environmental effects on the growth mechanisms of onions in the study area. This supports the findings of Mohammed (2008) who found

that the introduced genotypes had vigorous vegetative growth, large bulb size, and high yields but low dry matter content compared with local genotypes.

3. Fresh weight (g) plant^{-1}

Transplanting date shows variable significant treatment effect on fresh weight (g) plant^{-1} where differences were observed at all levels of transplanting date across the two study locations except at 60 DAT in 2020 at Wad Elgatra (Table 3). The late August transplanting had a higher fresh weight (362.59g) plant^{-1} at 90 DAT in 2021, while the mid-August transplanting recorded a lower fresh weight (6.15g) plant^{-1} at 30 DAT in 2020. At Abu Ajab, the results show that in 2021 at 90 DAT late August transplanting had higher fresh weight (436.67 g) plant^{-1}, while the mid-August transplanting produced lower fresh weight (8.67g) plant^{-1}at 30 DAT in 2021. The outstanding performance of the fresh weight produced might be related to the contributory function of all the growth and the yield characters at various stages of the plant growth, which could have led to more assimilated production and accumulation in the storage organ. Similar findings by Mohamed *et al*., (2018) have shown that transplanting in both mid and early September produced the heaviest fresh-weight plant^{-1}, whereas onion transplanting in mid-August produced the thinnest and lighter fresh plant weight. In addition, a similar result was observed by Mashayekhi *et al*., (2022) who found that transplanting in October produced higher fresh and dry weight than transplanting in March.

A significantly higher (p=0.000) varietal effect was observed on fresh weight (g) plant^{-1} at Wad Elgatra in 2020 only at 60 DAT where Saggai had produced the highest fresh weight (54.37g) followed by Baftaim (43.11g) and Abuferawa (40.82g) showing a statistically similar effect. At Abu Ajab, the result indicates significant effects at 30 DAT (p=0.021) and 60 DAT (p=0.026) in 2020. At both 30 DAT and 60 DAT, Saggai produced higher fresh weight (14.30g) (73.41g) closely followed by Abuferawa (12.30g), (63.85g) while Baftaim recorded the lowest values, respectively (Table 3).

Table 3. Effects of Transplanting Dates and Variety on the Fresh Weight (g) Plant^{-1} of Onion at Wad Elgatra and Abu Ajab in 2020-2021 Rainy Seasons.

Treatments	Wad Elgatra (DAT)						Abu Ajab (DAT)					
	30		60		90		30		60		90	
	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
Transplanting date (T)												
Early August	9.04a	7.11b	42.52	48.70b	176.07 b	187.41c	15.00a	8.85b	77.44a	43.89c	220.52b	218.15b
Mid-August	6.15b	8.67b	49.33	88.70a	240.82a	287.59b	12.82ab	8.67b	96.11a	90.37b	293.33a	383.70a
Late August	9.00a	14.26a	46.44	93.89a	243.26a	362.59a	10.93b	14.44a	26.30b	124.07a	189.48b	436.67a

Prob. Level	0.000	0.000	0.796	0.000	0.002	0.000	0.008	0.000	0.000	0.000	0.000	0.000
SE ±	4.877	8.500	30.685	67.284	33.957	66.469	15.148	17.636	39.654	42.093	118.173	80.321
Variety (V)												
Baftaim	7.82	9.48	43.11 b	74.82	215.70	265.37	12.15b	9.93	62.59b	85.16	249.04	364.07
Saggai	8.63	10.37	54.37a	78.15	237.70	283.52	14.30a	10.82	73.41a	86.11	221.85	343.33
Abuferawa	7.74	11.198	40.82b	78.33	206.74	288.70	12.30ab	11.22	63.85ab	87.04	232.44	331.11
Prob. Level	0.138	0.530	0.000	0.358	0.105	0.356	0.021	0.103	0.026	0.636	0.115	0.361
SE ±	3.142	11.198	22.833	40.691	77.333	76.309	8.963	4.895	28.586	29.290	45.093	33.451
Interaction												
T × V	0.487	0.182	0.173	0.052	0.245	0.855	0.022	0.406	0.000	0.685	0.119	0.916

Means followed by the same letter(s) in a column are not significantly different at a 5% level of probability using Tukey's Honestly Test. *=significant at 5%, **=significant at 1%, N. S= not significant.

The interaction between the transplanting date and variety on fresh weight (g) plant^{-1} at 30 DAT at Abu Ajab in the 2020 rainy season is presented in Table 3. The result indicates Baftaim and Saggai when transplanted in early and mid-August produced the highest fresh weight (g) plant^{-1} (16.11g), respectively while Baftaim recorded the lowest value (9.78g) in late August. Table 3 shows the interaction between the transplanting date and varieties on fresh weight (g) plant^{-1} at 60 DAT at Abu Ajab in 2020. The result shows that the highest fresh weight (124.22g) plant^{-1} was observed between Saggai and transplanted in mid-August, while the lowest value was recorded between the same variety and delayed transplanting (19.56g). The observations suggest that different onion varieties could perform differently under the same environmental conditions as well and the same variety could respond differently to different environmental conditions tested with similar treatment. A related study (Mohamedali, 2009) reported Baftaim to have produced better vegetative growth, large bulb size, and high yields when compared with some onion genotypes; Saggai, Kamleen, and Abuferawa tested in different environments.

4. Bulb Marketable Weight (g)

The transplanting date and the treatment effects show variability among the treatment means. High significant means differences were observed at all levels of transplanting date across the two study locations. At Wad Elgatra, in 2020 at 135 DAT, the late August transplanting had the highest bulb marketable weight (99.82g), while early August recorded a lower value (28.33g) at 30 DAT in 2021. At the Abu Ajab site, the result shows that in 2021 at 135 DAT in late August transplanting produced a higher bulb marketable weight (96.85g), the early August transplanting noted the lowest bulb marketable weight (41.09g) in 2021 at 105. This could probably be due to the delayed transplanting and the

Table 4. Effects of Transplanting Dates and Variety on the Bulb Marketable Weight (g) of Onion at Wad Elgatra and Abu Ajab in 2020 and 2021 Rainy Season. Means followed by the same letter(s) in a column are not

Treatments	Wad Elgatra (DAT)						Abu Ajab (DAT)					
	105		120		135		105		120		135	
	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
Transplanting date (T)												
Early August	31.16b	28.33c	45.79c	45.89c	69.63b	66.00b	48.70ab	41.09b	61.63b	52.94c	86.85a	63.74b
Mid-August	38.76a	43.87b	59.82b	62.44b	98.67a	88.22a	55.44a	56.56a	84.59a	73.41b	88.22a	92.48a
Late August	39.30a	51.82a	76.93a	72.70a	99.82a	90.07a	45.42b	60.07a	49.67b	87.44a	73.00a	96.85a
Prob. Level	0.039	0.000	0.000	0.000	0.000	0.000	0.053	0.000	0.000	0.000	0.049	0.000
SE ±	9.868	10.419	31.159	26.028	45.143	44.098	38.098	28.678	35.775	28.378	57.117	36.284
Variety (V)												
Baftaim	36.62ab	40.43	63.99	59.99	94.33	81.04	50.40	52.18	66.94	71.87	85.60	82.82
Saggai	39.90a	42.04	57.74	60.59	85.27	85.67	49.82	54.02	61.83	72.69	81.16	85.59
Abuferawa	32.70b	41.56	60.81	60.45	88.51	77.59	49.35	51.52	67.12	69.24	81.31	84.67
Prob. Level	0.011	0.337	0.106	0.587	0.063	0.063	0.100	0.582	0.242	0.351	0.863	0.661
SE ±	6.832	9.844	29.355	9.844	46.782	38.478	17.808	24.524	25.139	20.765	21.611	27.025
Interaction												
T × V	0.930	0.337	0.363	0.378	0.947	0.384	0.161	0.201	0.096	0.010	0.240	0.289

significantly different at a 5% level of probability using Tukey's Honestly Test. *=significant at 5%, **=significant at 1%, N. S= not significant

impacts of weather conditions during the bulb enlargement stage especially higher temperatures coupled with ideal sunshine hours received in the agroecology. This might have induced more nutrients and water uptake by the plants. This condition might have stimulated a rapid production of larger bulbs, during the delayed transplanting time (late August) which enabled good seedling establishment with reduced transplanting shocks. This supported the report of (Misu *et al.*, 2018) who observed that transplanting onion in mid-September produced maximum bulb marketable weight than in mid-November. Also, (Salari *et al*., 2022) observed that the highest fresh bulb weight at the initial stage was recorded for the first transplanting date which gradually decreased, and the lowest fresh bulb weight at the initial stage was recorded for the third planting date.

The variety effect on bulb marketable weight (g). The result indicates that there is no significant variation across years and locations except for 2020 at 105 DAT at Wad Elgatra. The results indicate that significant (p=0.011) treatment effect, where Saggai produces the highest bulb marketable weight (39.70g) closely followed by Baftaim (36.62g) compared to Abuferawa lower value (32.70g). The interaction between the transplanting date and variety at 120 DAT at Abu Ajab in 2021 is presented in Table 4. A study across the onion variety indicates that Saggai, Baftaim, and Abuferawa transplanted in late August produced a higher bulb marketable weight (90.11g), (87.67g) and (84.56g) respectively, while the rest produced statistically different bulb marketable weights. This might indicate that both location and year had random effects on the varietal impact on measured characters. These varietal response differences to the year and location differences are particularly important in the study of the environmental effects on the growth mechanisms of onions in the study area. This supports the findings of Mohammed (2008) who found that the introduced genotypes had vigorous vegetative growth, large bulb size, and high yields but low dry matter content compared with local genotypes.

5. Bulbs Fresh Weight (g)

The effect of transplanting date on bulb fresh weight (g) of onion shows variability among the treatment means. The results indicate that highly significant differences were observed at Wad Elgatra in 2020 and at Abu Ajab in 2021. At Wad Elgatra in 2020, early August had the highest bulb fresh weight (129.70g) closely followed by mid-August while late August transplanting recorded a lower value (109.30g). At Abu Ajab in 2021, it showed that both the late and mid-August transplanting had produced the highest bulb fresh weight (106.07g), (101.07g) compared to early August transplanting which recorded lower bulb fresh weight (90.37g). This indicated that the response of onion to produce higher bulb fresh weight was affected by variations in growing location and random effect of year in the study area. The differential effect observed in this study might be due to the effect of low average temperature in the transplanting date treatments during the growing season, reflected increases in better plant growth that might have enhanced the photosynthetic rate, thereby increasing the dry matter accumulation

and increased total bulbs yield t ha^{-1}. This contrasts with the findings of (Misu *et al.*, 2018) who reported that fresh bulb weight varied with differences in onion transplanting date. Heavier fresh bulbs were produced with mid-September transplanting and the minimum bulb weight was obtained from transplanting in mid-November. Also, the result observed by Deepak *et al.* (2014) indicated that transplanting in late November exhibited the highest single bulb weight, whereas the lowest was recorded with transplanting in early January.

Regarding the effect of variety on bulb fresh weight (g) the result indicates that no significant effect across years at both locations except at Abu Ajab in 2020, the results indicate that were record a significant effect (p=0.048). Abu Ajab in 2020, Baftaim produced the highest bulb fresh weight (111.11g) followed by Saggai (100.78g) while Abuferawa recorded lower bulb fresh weight (98.19) and statistically no difference for mean values in the experimental site. However, no effect was observed they interacted. The observations suggest that different onion variety could perform differently under the same environmental conditions as well and the same variety could respond differently to different environmental conditions tested with similar treatment. This supports the findings of (Ali *et al*., 2011) observed significant differences between the two tested

Table 5. Effects of Transplanting Dates and Variety on the Bulb Fresh Weight (g) of Onion at Wad Elgatra and Abu Ajab in 2020 and 2021 Rainy Seasons.

Treatments	Wad Elgatra		Abu Ajab	
	2020	2021	2020	2021
Transplanting date (T)				
Early August	129.70a	145.56	108.52	90.37b
Mid-August	116.07ab	146.48	105.96	101.07a
Late August	109.30b	138.85	95.59	106.07a
Prob. level	0.006	0.173	0.273	0.003
SE ±	57.469	50.840	49.840	16.222
Variety (V)				
Baftaim	121.67	138.70	111.111a	97.85
Saggai	117.22	146.52	100.78a	102.59
Abuferawa	116.19	145.67	98.19a	97.07
Prob. level	0.686	0.067	0.048	0.124
SE ±	52.420	47.593	26.864	18.802
Interaction				
T × V	0.570	0.108	0.189	0.308

Means followed by the same letter(s) in a column are not significantly different at a 5% level of probability using Tukey's Honestly Test. *=significant at 5%, **=significant at 1%, N. S= not significant.

cultivars; where Baftaim had a higher bulb diameter, bulb weight, and dry matter content, while Abuferawa produced a lower bulb diameter, bulb weight, and dry matter content.

6. Bulb Yield (t ha^{-1})

Significant effects of transplanting were observed across the locations and years of study except for Abu Ajab in 2021, which shows no significant treatment effect. At Wad Elgatra in 2020, early August onion transplanting resulted in the production of (16.40 t ha-^{1}) yield (p= 0.000) followed by mid-August (13.05 t ha-^{1}) while late August transplanting produced a lower value (10.24 t ha-^{1}). The result also shows that in 2021, mid-August produced higher bulb yields (37.18 t ha-^{1}) followed by early August (35.07 t ha-^{1}), while late August resulted in a low yield (28.82 t ha^{-1}). At Abu Ajab, in 2020, the result shows that a higher yield was observed in early August transplanting (11.70 t ha^{-1}) yield (p= 0.000) followed by mid-August (6.45 t ha^{-1}) while late August produced a lower yield (5.26 t ha-^{1}). This indicated that the random effect of year was a significant factor that significantly affected onion bulb yield. However, this is similar to Nourai (1992) who recommended early August while this differed with Ali *et al*. (2016) and Patil *et al*. (2012) suggested transplanting in mid-September and mid-November, respectively.

Considering the effect of variety on the bulb yield t ha^{-1}, the results were significant for 2020 at Wad Elgatra and in 2021 at Abu Ajab. At Wad Elgatra in 2020, Baftaim produced the highest bulb yield t ha^{-1} (14.23 t ha^{-1}) followed by Saggai (13.45 t ha^{-1}) while Abuferawa had the lowest yield. A significant varietal effect was also noted at Abu Ajab in 2021 where Abuferawa closely followed by Saggai produced the highest yield (17.46 t ha^{-1}) and (15.78 t ha^{-1}), respectively. This indicated that Saggai was a superior local variety that perhaps adapted to the local environmental conditions. Scientific evidence revealed that prolonged exposure to certain plant species in a given biophysical environment could lead to the development of some important genetic traits that provide better adaptive mechanisms and appreciable field performances over the other varieties. Although the introduced Baftaim was not as superior as the local variety Saggai, its continued cultivation in the study environment could exploit its inherent

Table 1. Effects of Transplanting Dates and Variety on the Bulb Yield t ha^{-1} of Onion at Wad Elgatra and Abu Ajab in 2020 and 2021 Rainy Seasons.

Treatments	Wad Elgatra		Abu Ajab	
	2020	2021	2020	2021
Transplanting date (T)				
Early August	16.40a	35.07a	11.70a	16.24
Mid-August	13.05b	37.18a	6.45b	16.63
Late August	10.24c	28.82b	5.26b	15.02

Prob. level	0.000	0.003	0.000	0.506
SE ±	5.461	14.197	2.728	7.267
Variety (V)				
Baftaim	14.23a	35.40	8.58	14.64b
Saggai	13.45ab	32.87	7.31	15.78ab
Abuferawa	12.01b	32.80	7.52	17.46a
Prob. level	0.020	0.246	0.171	0.005
SE ±	5.349	15.066	3.751	8.797
Interaction				
T × V	0.020	0.813	0.531	0.936

Means followed by the same letter(s) in a column are not significantly different at a 5% level of probability using Tukey's Honestly Test. *=significant at 5%, **=significant at 1%, N. S= not significant.

genetic potential and may perform better with time. This finding was in agreement with that of (Mofadal *et al.*, 2000) who reported that the introduced cultivars such as Baftaim

showed higher values of bulb weight compared to the local cultivar such as Abuferawa. A similar result by Ali *et al*. (2011) reported significant differences between the two tested genotypes whereby Baftaim produced a higher total bulb yield than Abuferawa. The first order of interaction (early August vs. Baftaim) produced the highest bulb yield in 2020 at Wad Elgatra, which could be attributed to variations in genetic factors, environmental influence, and the interaction between them. This finding was in line with the work of (Elkashif *et al.*, 2018) who reported an increase in total yield from the interaction of Baftaim with early transplanting, while lower onion yield was recorded by Abuferawa vs. transplanted late.

Conclusion

The transplanting in mid and late August was the best for character growth at both locations. Transplanting onion in early August and mid-August produced heavier bulb yield at both study locations. Both Baftaim and Saggai had demonstrated outstanding field performances for the character at Wad Elgatra, while Abuferawa and Saggai outwitted Baftaim at Abu Ajab. The best interaction between mid-August and Baftaim at Wad Elgatra recorded the highest bulb yield (19.53 t ha^{-1}) in 2020.

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