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Effects of Transplanting Dates and Organic Manure on the Growth and Yield of Onion (Allium Cepa L.) in the Rainy Season of Algezira Scheme in the Sudan

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Abstract

Onion (*Allium cepa* L.) is one of the important vegetables in Sudan. A 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 cow manure on the growth and yield of onion. The experiment was carried out based on a split plot design with the cow manure in the main plot, transplanting date 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. Application of cow manure at 20 t ha^{-1} recorded greater leaf area and early maturity compared to the control. Control cow manure produced the highest bulb yield (34.45 t ha^{-1}) in 2021 at Wad Elgatra, while application 20 t ha^{-1} recorded the lowest bulb yield (6.96 t $ha^{-1)}$ in 2020 at Abu Ajab. Late August transplanting increased plant height, number of leaves $plant^{-1}$ and leaf area $plant^{-1}$, while the early August transplanting recorded the lowest plant height, number of leaves $plant^{-1}$ and leaf area $plant^{-1}$. The highest bulb diameter 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. Based on the findings, it could be suggested that farmers in the study area, should adopt the cultivation of onion during the early and mid-August to achieve higher and marketable onion yield productivity in the Sudan Republic.

Keywords: Onion; transplanting date; Cow manure; Bulb yield

Introduction

Onion (*Allium cepa* L.) belongs to the Alliaceae family, genus Allium. The majority of the Alliums species are native to western Asia i.e. Turkmenistan, Afghanistan, and north of these countries (Farooq *et al*, 2015). Onion is a herbaceous biennial plant and one of the oldest bulb crops (Siddiquee *et al*, 2008). Onions, leek, and garlic are collectively known as alliums, as they are all species of the genus Allium, these vegetables produce organic sulfur compounds that react with the enzyme Alliinase to create the compounds, which give alliums their distinctive flavors. These organic sulfur compounds are

also anti-microbial and may help protect plants from fungi and bacteria (Brown and Leclaire-Conway, 2014). In Sudan, Onion is the first vegetable grown. Naher El-Neil, Al Gezira, Northern and Western Darfur, and Khartoum States are the main producing areas. Most of the onion produced is consumed locally and only negligible yield in Sudan is dehydrated or exported as a fresh crop to neighboring African countries and Saudi Arabia. However, onion is expected to be one of the most important exportable horticultural crops (Nourai, 2005). The crop is consumed in the green state and as matured bulbs (Siddiquee *et al*, 2008).

Fertilizer management is one of the important factors that may contribute much to the onion yield and quality. Farmers usually depend upon organic fertilizers to improve onion yield while modern agricultural practices encourage the use of inorganic fertilizers to boost crop yield. Organic materials like farmyard manure (FYM) enhance plant growth, development, and ultimately yields, because it improves the soil's physical, chemical, and biological properties along with the provision of macro and micronutrients. Nitrogen, potassium and sulfur are important nutrient elements that play important roles in bulb formation, elongation, skin colour development, and pungency of onion (Bose and Som, 1986). Balanced fertilizer application is essential for vegetative growth and thus, for producing crops with top quality and high yields, especially on soils that are cultivated continuously (Chintala *et al*., 2012). The organic manure when applied to the soil helps in plant growth which provided more nutrients to the plant roots (Edmeades, 2003). As organic manures enhance the different properties of soil i.e. physical, chemical, and biological, and increase the moisture-holding capacity of the soil, which resulted in maintaining the quality of crop production (Maheswarappa *et al*., 1999). However, organic manure holds plant nutrients, which promote enzymes and hormones, besides plant nutrients, make them necessary for the enhancement of soil fertility and production (Bhuma, 2001).

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). 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). Therefore, the objective of this investigation was to study the effect of transplanting date and cow manure on growth and yield of onion.

MATERIALS AND METHODS

The experiment was conducted during rainy seasons of 2020 and 2021, at experimental farm of Wad Elgatra, and Abu Ajab in the Algezira scheme. The experimental site at longitude and the latitude of 14° 32´N, 32° 27´E and 14° 47´ N, 32° 75´ E, respectively. Before transplanting, the soil was sampled for analysis to establish the soil fertility status of the experimental plots from a depth of 0 – 20 cm and analysis of cow manure. The treatments consisted of three transplanting dates (early August, mid-August and late August) and three rate of cow manure (control (0), 10 t ha^{-1} and 20 t ha^{-1}). The treatments were laid out in a spilt plot design with three replications. In both experiments seedling 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 was applied. The onion seed 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 the watered lightly. The mulch was removed as soon as the seed germinated in order 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; ploughed, harrowed and raised beds of size 2 x 2 m (4 m^2) were constructed. Transplanting of the healthy seedling into the raised beds was done on 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, 80:50:50 kg/ha were applied to the 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. Cow manure was applied two weeks before transplanting. 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 Appling insecticide. Data was recorded on the plant height, number of leaf $plant^{-1}$, leaf area $plant^{-1}$, bulb diameter, maturity days and onion bulb yield. Collected data was analyzed using Mstatc statistical package. Tukey's Honestly Significant Difference Test was used to separate the means at 5% probability level.

Results and Discussions

1. Physical and Chemical characteristics of Soil and Cow Manure

The results indicated that at Wad Elgatra in 2020 and 2021 were having a clay texture with a pH that ranged from 8.37 to 8.33 in water. The soil nutrients status was 0.07 and 0.06 g kg^{-1} total nitrogen, 0.0005 and 0.0002g kg^{-1} of available phosphorus, and potassium was 9.68 to 7.09 cmol kg^{-1}. Exchangeable bases were 150.39, 181.73 cmol kg^{-1} Ca, 442.00-448.10 cmol kg^{-1} Mg, 0.53-0.63 cmol kg^{-1} Cu, 30.30-27.64 cmol kg^{-1} Fe, 2.14-1.74 cmol kg^{-1} Mn, 1.29-1.54 cmol kg^{-1} Zn, while cation exchange capacity (CEC) was 1.72–1.20 cmol kg^{-1} of soil.

The results also showed that at Abu Ajab in the 2020 and 2021 rainy seasons, the soil was characterized as alkaline and clay in texture, with a pH in water ranging between 8.35 to 8.29 in water. The total nitrogen of the soil varies between 0.06 and 0.08 g kg^{-1}, the available phosphorus between 0.003 and 0.0003 g $kg^{-1,}$ and the potassium ranged from 7.74-to 8.39cmol kg^{-1}. The soil exchangeable bases content ranged from 68.46-180.68cmol kg^{-1} Ca, 439.10 to 418.95cmol kg^{-1} Mg. The respective values of the micronutrients varied between 0.68-0.46cmol kg^{-1} Cu, 21.60- 27.86cmol kg^{-1} Fe, 2.36-2.05 cmol kg^{-1} Mn, 1.12–1.10 cmol kg^{-1} Zn. The cation exchange capacity (CEC) fluctuated between 1.26–1.20 cmol kg^{-1} of soil.

The cow manure in 2020 and 2021 had a pH ranging between 7.22 to 7.66 in water. The manure nutrient status varied from 1.96 to 1.40 g kg^{-1} total nitrogen, 6.60 to 4.40 kg^{-1} available phosphorus, and 123.87 to 87.01 cmol kg^{-1} potassium. The Ca was 152.85 to 168.76 cmol kg^{-1}, 3.28 to 2.78 cmol kg^{-1} Cu, 158.10 and 87.45 cmol kg^{-1} Fe, 2079.00-to 2062.75 cmol kg^{-1} Mg, 6.20 and 3.63 cmol kg^{-1} Mn and 4.70-to 4.40 cmol kg^{-1} Zn.

Table 1. Physical and Chemical characteristics of the Experimental Soil before treatment application and characteristics of Cow Manure.

	Wad Elgatra		Abu Ajab		Cow manure	
	2020	2021	2020	2021	2020	2021
Physical properties						
sand	15	8	14	15	-	-
slit	30	25	28	25	-	-
clay	55	67	58	60	-	-
Chemical properties						
pH in H_2O	8.37	8.33	8.35	8.29	7.22	7.66
Total available of N (g kg^{-1})	0.067	0.064	0.064	0.081	1.96	1.40
Total available of P (mg kg^{-1})	0.0005	0.0002	0.0034	0.0003	8.60	4.40
Exchangeable bases (cmol kg^{-1})						
K+	9.68	7.09	7.74	8.39	123.87	87.09
Ca++	150.385	181.730	68.460	180.675	152.850	168.775
Cu++	0.530	0.625	0.680	0.460	3.275	2.775
Fe+++	30.300	27.635	21.595	27.860	158.100	87.450
Mg++	442.00	448.10	439.10	418.95	2079.00	2062.75
Mn++	2.135	1.740	2.355	2.045	6.200	3.625
Zn++	1.285	1.540	1.120	1.095	4.700	4.400
CEC	1.715	1.201	1.262	1.343	1.406	1.553

2. Plant height

The effect of cow manure on plant height had no significant effect on the plant height in both years and locations except at 90 DAT in 2020 at Wad Elgatra, with no statistical differences among the treatment means. At Wad Elgatra in 2020, the control treatment recorded the shortest plants (14.78 cm) at 30 DAT, while the tallest plants (46.42 cm) were recorded from the control cow manure treatment at 90 DAT. However, at Abu Ajab in 2021, the results indicate that application 10 t ha^{-1} cow manure recorded the highest plant height (41.71 cm) at 90 DAT, while the shorter plant height (17.80 cm) was recorded with the application 10 t ha^{-1} manure at 30 DAT. This might be attributed to the role of organic manure in improving the soil physical conditions such as soil structure, porosity and reduce bulk density, aeration thus might have increased the microbial functions as well as colloidal exchange capacity of soil in the environment. This corresponds with the findings of (Salami and Omotoso, 2018) who observed insignificant differences in plant height of onion measured at 4WAT between control, 5 t ha^{-1}, 10 t ha^{-1} and 20 t ha^{-1} for cow manure application. Also reported similar findings by Khan *et al*. (2002) who recorded that the interactive effects of cow manure did not significantly influence onion growth characters. Transplanting date had significant effects on the plant height of onion in both seasons and locations and for all sampling periods, except 30 DAT in 2020 at both locations. Significant increases in plant heights were observed with the transplanting date of late August compared to the other transplanting date in all the sampling periods at both locations. At Wad Elgatra in 2020, the early August

transplanting recorded the short plant height (14.54 cm) at 30 DAT, whilst the highest plant height (54.22 cm) was observed from the plants transplanted on late August and recorded at 90 DAT. At Abu Ajab, the mid-August transplanted onions recorded the shortest plant height (15.77 cm) at 30 DAT in 2021, but the highest plants (47.08 cm) from the plants transplanted in late August at 90 DAT in 2020. The interaction between cow manure and transplanting date on the plant height was significant at 30 DAT at Abu Ajab in 2021 as shown in Table 3. The interaction between the applications of 20 t ha^{-1} transplanted in late August produced the tallest (22.37 cm) plants, while the shortest (15.44 cm) plants were recorded with the interaction of the application 10 t ha^{-1} when transplanted in mid-August. The observed progressive increase in the growth characters with late transplanting might be due to the congenial environment for better and early establishment of seedlings in the field by exhibiting minor transplanting shock as compared to other transplanting dates. This corresponds with the finding of (Bhatt *et al.* 2007) who obtained the highest plant height and several onion leaves in mid-and late August at 45 days after transplanting and at 60 DAT over a later transplanting date. Another related study by Dhar *et al.* (2019) reported that the highest plant height was observed on the mid-September transplanting date which was significantly superior to other transplanting dates.

Table 2. Effects of Cow Manure, Transplanting Date and Variety on Plant Height (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
Cow Manure (M t ha^{-1})												
0	14.78	17.27	30.70	34.69	46.42a	42.79	19.60	17.93	28.04	32.39	39.56	39.90
10	14.88	16.67	28.88	32.46	43.82a	42.70	20.60	17.80	28.41	33.27	40.05	41.71
20	15.12	16.12	30.26	32.63	45.97a	42.04	20.16	17.96	27.75	33.70	38.70	41.15
Prob. Level	0.570	0.154	0.252	0.254	0.045	0.521	0.967	0.317	0.428	0.214	0.262	0.276
SE±	1.464	2.851	12.302	21.064	7.080	8.749	7.144	5.862	2.784	19.911	18.399	16.117
Transplanting Date (T)												
Early August	14.54	14.87c	26.54b	28.34b	38.03c	35.63c	20.72	16.19b	28.45ab	27.90c	34.65b	36.64c
Mid-August	14.79	16.56b	28.98b	34.69a	43.96b	42.64b	19.48	15.77b	29.88a	34.31b	36.58b	40.07b
Late August	15.45	18.63a	34.32a	36.74a	54.22a	49.25a	20.17	21.72a	25.86b	37.14a	47.08a	46.05a
Prob. Level	0.185	0.0001	0.000	0.000	0.000	0.000	0.817	0.000	0.019	0.000	0.000	0.000
SE ±	3.050	3.808	11.858	13.093	12.045	17.758	12.774	1.333	20.039	10.491	19.693	15.288
Interaction												
M × T	0.378	0.201	0.137	0.815	0.596	0.410	0.303	0.010	0.158	0.358	0.418	0.426

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

3. Number of leaves plant^{-1}

The cow manure had no significant effect on the number of leaves plant^{-1} in both seasons at both locations except at 90 DAT in 2020 and 60 DAT in 2021 at Wad Elgatra. The lowest number of leaves plant^{-1} (3.4) was recorded from the application 20 t ha^{-1} at 30 DAT in 2020, whilst the control treatment obtained the highest number of leaves (9.44) at 90 DAT in 2021 at Wad Elgatra. However, at Abu Ajab in 2021, the highest and lowest number of leaves plant^{-1} were produced by the control at 90 and 30 DAT, respectively. Transplanting date had significant effects on the number of leaves plant^{-1} in both seasons and locations. The lowest number of leaves (3.06) was obtained from the mid-August transplanting at 30 DAT in 2020 and those transplanted in late August recorded the highest number of leaves plant^{-1}(10.50) at 90 DAT in 2021 at Wad Elgatra. However, at Abu Ajab in 2021, the highest number of leaves plant^{-1} (11.22) was recorded in late August at 90 DAT, while the least number of leaves per plant (3.47) from mid-August at 30 DAT. A significant interaction was observed between cow manure and transplanting date on the number of leaves plant^{-1} at 30 DAT at Abu Ajab in 2020 (Table 7). The highest number of leaves plant^{-1} (4.60) was observed by the control treatment and transplanting in early August, as well as by the application of 20 t manure ha^{-1}, transplanted in early August, respectively. The least number of leaves plant^{-1} (4.06) was recorded by the interaction between 20 t manure ha^{-1} and the mid-August transplanting. This suggested that the significant effect of the manure at the late stage of growth could be explained by the fact that manure requires substantial time to completely decay through amortization, ammonification, and the nitrification processes to release nutrients such as sulfate, nitrate, borate, chlorate, phosphate, etc. for immediate plant use. It might be due to the inherent genetic characteristics of the onion that responded well to late August conditions and the varietal interaction between them. This corresponds with the findings of (Salami and Omotoso, 2018) who observed insignificant differences in plant height of onion measured at 4WAT between control, 5 t ha^{-1}, 10 t ha^{-1} and 20 t ha^{-1} for cow manure application.

Table 3. Effects of Cow Manure, Transplanting Dates and Variety on the Number of Leaves Plant^{-1} 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
Cow Manure (M t ha-1)												
0	3.45	3.82	5.60	6.75a	8.52a	9.44	4.38	3.90	5.63	6.78	7.81	9.92
10	3.46	3.78	5.67	6.38b	8.11b	9.39	4.38	4.02	5.70	6.68	7.92	9.77
20	3.40	3.76	5.79	6.50ab	8.51a	9.07	4.42	3.92	5.59	6.84	7.96	9.59
Prob. level	0.080	0.109	0.602	0.045	0.020	0.340	0.116	0.452	0.311	0.656	0.091	0.377
SE±	0.300	0.286	0.440	0.130	0.122	0.759	0.094	0.218	0.245	0.254	1.755	0.572
Transplanting Date (T)												
Early August	3.74a	3.51b	5.3b	5.91c	7.66b	7.98c	4.54a	3.69b	5.71a	5.91b	7.04b	8.29c
Mid-August	3.06b	3.76ab	5.97a	6.54b	8.66a	9.42b	4.21b	3.47b	6.08a	6.97a	8.47a	9.77b
Late August	3.50a	4.08a	5.79ab	7.17a	8.81a	10.50a	4.43a	4.68a	5.14b	7.42a	8.16a	11.22a

Prob. level	0.002	0.005	0.013	0.000	0.000	0.000	0.001	0.000	0.001	0.000	0.000	0.000
SE ±	0.288	0.259	0.518	0.299	0.371	0.497	0.064	0.190	0.507	0.602	0.967	1.395
Interaction												
M × T	0.722	0.264	0.929	0.355	0.172	0.229	0.032	0.729	0.249	0.321	0.851	0.184

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.

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

The cow manure had no significant effects on the leaf area plant^{-1} in both seasons and at both locations. At Wad Elgatra in 2020, the highest leaf area plant^{-1} (905.17 cm^2) was obtained from the 20 t ha^{-1} at 90 DAT, whilst the lowest leaf area plant^{-1} (24.39 cm^2) was noted from the 10 t ha^{-1} at 30 DAT. However, at Abu Ajab in 2021, the highest leaf area (772.10 cm^2) was observed from the application 10 t ha^{-1} at 90 DAT, while application 20 t ha^{-1} recorded the lowest leaf area plant^{-1} (39.43 cm^2) at 30 DAT. Transplanting date had significant effects on the leaf area plant^{-1} in both seasons at locations. 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. The interaction between cow manure and transplanting date on the leaf area plant^{-1} had no significant effect across the years and both locations. The lack of significant effect of cow manure on the leaf area plant^{-1} indicates that the soil was not responsive to all levels of the applied treatment across the years and both locations of the experiment. Similar findings by Salami and Omotoso (2018) reported that the number of leaves plant^{-1} was highest with the application of 20 t ha^{-1} cow manure. 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}.

Table 4. Effects of Cow Manure, 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
Cow Manure (M t ha^{-1})												
0	28.16	39.38	237.50	346.03	894.36	796.84	60.76	42.41	236.99	298.54	622.88	726.49
10	24.39	34.81	220.76	298.37	773.71	818.88	60.17	40.20	233.16	309.41	620.55	772.01
20	25.37	33.46	240.95	300.69	905.17	733.60	61.96	39.43	225.79	320.54	591.27	741.25
Prob. level	0.420	0.852	0.334	0.125	0.200	0.423	0.125	0.226	0.416	0.420	0.129	0.541
SE±	9.825	6.382	19.834	16.992	193.142	109.747	13.00	13.720	57.569	128.420	106.647	41.250
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 ± Interaction	6.73	3.741	28.048	15.647	149.718	140.828	12.228	18.273	30.253	187.862	182.539	141.551
M × T	0.503	0.364	0.926	0.606	0.103	0.386	0.259	0.716	0.345	0.066	0.343	0.203

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

4. Days to Flowering and Maturity

The results indicate that across years and at both locations, treatment with cow manure did not produce any significant effect on days to maturity in the experimental sites. The transplanting date was significant and show effects and variability among the treatment means. At Wad Elgatra in 2020, late August recorded comparatively shorter days (129.07 days) to reach the physiological maturity stage and closely followed by mid-August while early August transplanting took longer days (131.33 days) for the onion to mature. In 2021, the mid-August transplanting had shorter days (131.41 days) to reach maturity, closely followed by transplanting in late August (132.11 days) and early August had longer days (139.52 days). The transplanting date did not produce any significant effect across the years at Abu Ajab. Similarly, neither effect nor significant interactions were observed. This could be attributed mainly to the genetic makeup of the varieties used in the study, as each might have received different weather elements such as light, relative humidity, temperature, etc. For instance, the day and night temperatures across the years had shown very slight variation but there were differences in terms of the relative humidity received. This finding is in contrast to Salari *et al.*(2022) who reported that early September and mid-September transplanting of onion took longer time to mature while transplanting in mid-August had the shortest.

Table 5. Effects of Cow Manure, Transplanting Dates and Variety on the Days to Maturity of Onion at Wad Elgatra and Abu Ajab in 2020 and 2021 Rainy Seasons.

Treatments	Wad Elgatra		Abu Ajab	
	2020	2021	2020	2021
Cow manure (M t ha^{-1})				
0	130.11	129.89	129.26	124.41
10	130.52	132.19	129.78	128.96
20	129.59	140.96	129.93	119.96
Prob. level	0.562	0.287	0.082	0.063
SE±	10.352	76.401	40.494	91.444
Transplanting date (T)				
Early August	131.33a	139.52a	131.93	127.52
Mid-August	129.82ab	131.41b	127.96	124.41
Late August	129.07b	132.11ab	129.07	121.41
Prob. level	0.033	0.023	0.211	0.222
SE ±	7.747	26.975	63.525	14.556
Interaction				
M × T	0.741	0.586	0.187	0.224

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

6. Bulb Diameter (cm)

The effect of cow manure, transplanting date and variety on bulb diameter (cm) shows in Table 30. The results indicate that in both years, at both locations, treatment with cow manure did not produce any significant effect on bulb diameter in the study. For the transplanting date, significant treatment effects show variability among the treatment means and were observed at Wad Elgatra in 2020 and at Abu Ajab in both years. At Wad Elgatra in 2020 early August recorded the highest bulb diameter (6.30 cm) compared to the other transplanting date, which was statistically at par. While Abu Ajab in 2020, the results indicate that early August transplanting produced the highest bulb diameter (5.87 cm) followed by mid-August (5.51 cm), while late transplanting recorded the lowest value (4.84 cm). In 2021, late August had the highest bulb diameter (6.06 cm) and was closely followed by mid-August while early transplanting recorded the lowest bulb diameter (5.75 cm). The Interaction shows no significant variations. This was because the first and second weeks of the August transplanting date provided low temperatures condition (31.6°C and 32.4°C) in 2020 and 2021, respectively, which might have encouraged rapid vegetative growth. This corresponds with the findings of (George *et al*., 2009) who reported that early transplanting of onion produced higher bulb diameter.

Table 6. Effects of Cow Manure, Transplanting Dates and Variety on the Bulb Diameter (cm) of Onion at Wad Elgatra and Abu Ajab in 2020 and 2021 Rainy Seasons.

Treatments	Wad Elgatra		Abu Ajab	
	2020	2021	2020	2021
Cow manure (M t ha^{-1})				
0	6.36	6.78	5.35	5.89
10	5.78	6.67	5.58	5.81
20	6.07	6.69	5.30	6.07
Prob. level	0.223	0.380	0.533	0.166
SE±	1.014	0.074	1.130	0.175
Transplanting date (T)				
Early August	6.30 a	6.76	5.87a	5.75b
Mid-August	6.04b	6.77	5.51a	5.96ab
Late August	5.87b	6.61	4.84b	6.06a
Prob. level	0.003	0.168	0.001	0.013
SE ±	0.124	0.105	0.537	0.107
Interaction				
M × T	0.357	0.855	0.978	0.390

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

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

The result indicates that cow manure did not produce any significant treatment effect on bulb yield t ha-^{1} irrespective of the levels, years and locations. Significant effects of transplanting were observed across the locations and years of study except for Abu Ajab, which showed 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 show 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 produce a lower yield (5.26 t ha-^{1}). No significant treatment effect was observed in 2021. The interaction observed that on significant effect in study area. The lack of significant effect of cow manure on bulb yield results could be due to the harmful effect of increased electric conductivity resulting from organic acid concentration because of manure application. In addition, (Gambo *et al.*, 2008) reported that increasing rates of farmyard manure did not have significant effects on onion bulb yield. Transplanting date recorded high significant difference thus indicating that the random effect of year was main factor that significantly affected onion bulb yield. However, this finding was similar with that of Nourai (1992) who recommended early August while this

differed with Ali *et al*. (2016) and Patil *et al*. (2012) who suggested transplanting in mid-September and mid-November, respectively.

Table 3. Effects of Cow Manure, 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
Cow manure (M t ha-1)				
0	15.09	34.45	8.01	16.58
10	11.43	34.14	8.44	14.27
20	13.28	32.47	6.96	17.03
Prob. level	0.151	0.448	0.950	0.105
SE±	6.732	17.757	2.027	4.205
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
Interaction				
M × T	0.961	0.911	0.829	0.581

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

Conclusion

We concluded that the excessive application of cow manure did not affect onion yield and accumulated soil fertility. To achieve heavier bulb yield at both study locations, onions should be transplanted in early and mid-August.

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