Middle East Journal of Applied Sciences
Volume: 13 | Issue: 01| Jan. – Mar. | 2023

EISSN: 2706 -7947 ISSN: 2077- 4613
DOI: 10.36632/mejas/2023.13.1.12
Journal homepage: www.curresweb.com
Pages: 143-153

Effect of Planting Methods and Seeding Rates on Yield and Yield Components of New Forage Sorghum Hybrid (Sakha 20)

EL-Gaafarey T.G., Walaa M. E. Mousa and Shereen M.A. EL- Nahrawy

Forage Crops Res. Dept., Field Crops Res. Inst., ARC, Giza, Egypt.

Received: 15 Feb. 2023 **Accepted:** 20 Mar. 2023 **Published:** 25 Mar. 2023

ABSTRACT

At the Kafer El Shiekh Governorate of the Agricultural Research Center in Egypt, a field experiment has been performed. To determine the best planting techniques and seeding rate for the growth characteristics and forage yield of a new sorghum hybrid (Sakha 20) through the summers of 2019 and 2020. Two planting methods have been followed (broadcasting on the top of the rows, hills on the top of the rows) with three rates of seeding (15, 20 and 25 kg fed^{-1}). The outcomes indicated that planting in hills on the top of rows showed the highest significant increase in plant height, tiller number m^{-2}, diameter of stem (cm), dry matter %, fresh leaf to stem ratio, dry leaf to stem ratio, and total yield of fresh and dry forage (ton fed^{-1}) as compared with the other method of planting. In two successive seasons, increasing seed rates from 15 to 25 kg fed^{-1} resulted in a significant gradual increase in plant height and tiller number m^{-2}, as well as total fresh and dry forage yield (ton fed^{-1}). Therefore, 25 kg fed^{-1} provided the greatest values of the above-mentioned characters. Diameter of stem (cm), dry matter %, and fresh and dry leaf / stem ratio percent significantly decreased in the two consecutive seasons as seed rates were increased from 15 to 25 kg fed^{-1}. The interplay between planting methods and seeding rates had a significant impact on plant height, tiller number m^{-2}, and total yield of fresh and dry forage (ton fed^{-1}). The height values were obtained by the interaction between the planting method in hills on top of rows with the rate of seeding at 25 kg fed^{-1}.

Keywords: Forage sorghum, planting methods, seeding rates, growth characters, forage yield.

1. Introduction

Sorghum (*Sorghum bicolor* L. Moench) are considered important forage crops and known as food / fodder/ feed for animals worldwide. In addition, it is a significant food crop that is highly drought-tolerant, making it a great option for semi-arid and dry regions, following wheat, rice, and maize (Khandelwal *et al.,* 2015). The shortage of livestock feed in Egypt is considered a major problem, which is aggravated during the summer season, extending from the last cut of Egyptian clover (berseem) crop to the beginning of the next winter season. In this respect great efforts have been directed towards improving fodder yields of forage sorghum. Also, the local production of forage sorghum in Egypt is not sufficient to supply the livestock, especially with the recently extensive increase in animal production. Therefore, any attempts for raising the yield of forage sorghum by improving the cultural practices is very important (Mousa *et al.,* 1991).

In addition, sorghum is the most important forage crop to tolerate water deficits, especially in semi-arid areas of tropical and sub-tropical regions, where moisture is a crop-limiting factor. These yearly summer crops can produce a large amount of forage, are palatable and of high quality, and are thus a common crop for the production of milk (Croplan Genetics, 2004 and Icrisat, 2006).

The seeding rate, which affects the production per unit of land area, is eventually what determines yield for most crops. In the meantime, method of planting significantly affect seeding rate and consequently the yield obtained (Haggag *et al.,* 1986 and Mekasha *et al.*, 2022). Also, sorghum's fresh forage yield increased as the seeding rate increased (Abdel-Gawad 1981; Ebrahim, 1982 and Hssan *et al.,* 2019). For sorghum hybrids, the effect of plant population and row spacing on forage production has been well

Corresponding Author: EL-Gaafarey T.G., Forage Crops Res. Dept., Field Crops Res. Inst., ARC, Giza, Egypt.

documented. According to Eilrich *et al.* (1964), sorghum's forage yield increased when plant populations were higher and row spacing was less. Similar findings were made by Bond *et al.* (1964) and Brown *et al.* (1964) about the effectiveness of narrow row spacing in increasing sorghum's dry matter yield. When row spacing was increased from 50 to 60 cm, the forage dry matter production in four different sorghum genotypes decreased from 10.9 to 8.1 t ha^{-1} (Caravetta *et al.*, 1990). In drilled Sudan grass, Burger and Campbell (1961) found that regardless of the variety seeded, forage production did not differ significantly when row spacing was increased from 10 to 40 cm and rates of seeding were increased from 13 to 54 kg ha^{-1}. According to Iptas *et al.* (2002), in dry land conditions, the sorghum/Sudan grass hybrid's dry matter yield was not significantly impacted by seeding rates.

This study's objective was to determine the impact of planting techniques and seedling rates on the forage yield and some growth characteristics of a new forage sorghum hybrid (Sakha 20).

2. Materials and Methods

Two field experiments have been carried out in the summers of 2019 and 2020 at Sakha Agric. Res. St., Agric. Res. Centre, Kafer El Shiekh Governorate, Egypt. This study's goal was to determine the most effective planting techniques and seeding rates for the new forage sorghum hybrid's (Sakha 20) on growth and forage yield.

The bedigree of sorghum hybrid (Sakha 20) in this study are listed in Table 1.

Table 1: Bedigree of new sorghum hybrid (Sakha 20) in this study

Parental material	Species	Source
Piper black (♂)	Sorghum sudanense	Selected through breeding program- Forage Crops Research Dept. ARC, Egypt.
Line 2002-41 (♀)	Sorghum bicolor	Male sterile strain of Sorghum, Imported from U.S.A.

A split-plot design with four replications was used to lay out the experimental treatments. The main plots have been assigned to planting methods, the 1st method (broadcasting on the top of the rows) and the 2nd method (hills on the top of the rows), the sub-plots were devoted to three seeding rates (15, 20 and 25 kg fed^{-1}), the experimental plot measured 6 m^2 (2 x 3 m, including 5 rows of long 2m). Wheat was the preceding crop, and the first and second seasons' sowing dates were May 20 and 22, respectively. The first cut was applied after 60 days from seeding followed by 45 and 30 days for the second and the third cuttings, respectively. The normal cultural practices for forage sorghum cultivation were applied: phosphorus was given to the soil as calcium superphosphate (15 % P_2O_5) prior to planting at a rate of 100 kg fed^{-1}, and nitrogen fertilizer (urea) was added at a rate of 45 kg N fed^{-1} at the second watering. At intervals of 10 to 15 days, irrigation water has been applied. Hand weeding maintained the weed population at a minimal level.

Mechanical and chemical properties were analyzed of the experimental site of Sakha station, according to Piper (1950) and Page *et al.* (1982) presented in Table (2) as follows:

The following characters were studied:

A. Plant growth characters:

- Plant height (cm).
- Number of tillers m^{-2}.
- Stem diameter (cm).
- Dry matter (%).
- Fresh leaf/stem ratio (%): Was estimated from one square meter in each plot as: (Weight of fresh leaves/ Weight of fresh stems) X100.
- Dry leaf/stem ratio (%): Was estimated from one square meter in each plot as: (Weight of dry leaves/ Weight of dry stems) X100.

B. Fresh and dry forage yield (ton fed^{-1}).

Statistical analysis

Utilizing the MSTAT-C computer program, version 4 (1986), data were analyzed statistically following the methods outlined by Steel *et al*. (1997). The homogeneity of error variances was examined

using Bartlett's test. Because the test had not been significant for all traits, a combined analysis has been performed for all traits evaluated in both seasons.

Table 2: Some of the experimental site's soil's mechanical and chemical properties.

Soil properties	Season 2019	Season 2020
Clay %	50.00	52.00
Sand %	18.70	13.78
Silt %	31.30	34.22
Soil texture (%)	Clayey	Clayey
pH (1: 2.5 water suspension)	7.90	7.95
EC (dSm^{-1})	3.16	3.59
Organic matter	1.24	1.17
Available P mg Kg^{-1}	9.33	8.77
Available NH_4 mg Kg^{-1}	12.60	10.60
Available K mg Kg^{-1}	350	322
Cations (meq L^{-1})		
Ca^{++}	6.00	5.65
Mg^{++}	1.50	1.41
Na^{+}	13.00	14.00
K^{+}	0.50	0.44
Anions (meq L^{-1})		
HCO_3^{-}	5.00	4.20
Cl^{-}	14.00	15.30
SO_4^{--}	2.00	2.00
CO_3^{-}	0.00	0.00

3. Results and Discussion

3.1. Growth characters:

3.1.1. Effect of planting methods:

Results presented in Tables (3 to 8) indicated clearly that the 2nd method showed a significant increase in plant height, tiller number m^{-2}, diameter of stem (cm), dry matter %, fresh leaf /stem ratio, and dry leaf / stem ratio in the summer seasons of 2019 and 2020 and in combined analysis as compared with the other method of planting, except for dry matter % in the second season, which gave the highest value when broadcasting on the top of the rows. Means of three cuts of combined analysis recorded 199.49 cm, 66.48, 1.54 cm, 13.43%, 55.51 and 63.36, respectively. This increase in growth characteristics could be attributed to the fact that planting in hills on the top of the rows was more favorable to plant growth, which was affected by competition between plants for nutrients, moisture, sunlight and other growth sources. These findings correspond with those published by Burger and Campbell (1961), Haggag *et al.* (1986) and Hssan *et al.* (2019).

3.1.2. Effect of seeding rates:

Tables (3 & 4) demonstrated that increasing seed rates from 15 to 25 kg fed^{-1} resulted in a significant gradually increasing in plant height and number of tillers m^{-2} in summer seasons 2019 and 2020 and combined analysis. Therefore, 25 kg fed^{-1} gave the highest values of above mention characters which recorded 203.46 cm and 73.06 in the first season, 221.59 cm and 79.72 in the second season and 212.52 cm and 76.39 in the combined analysis for the mean of the three cuts.

On another hand, results in Tables (5,6,7 and 8) exhibited that increasing seed rates from 15 to 25 kg fed^{-1} resulted in a significantly decrease in stem diameter (cm), dry matter %, fresh leaf /stem ratio and dry leaf / stem ratio in both seasons. Therefore, among the mentioned characters, 15 kg fed^{-1} provided the greatest values. The intra-plant competition for nutrients and radiation may be responsible for these outcomes. Many researchers discovered comparable findings Bishnoi (1980); Haggag *et al.* (1986); Kazlauskas *et al.* (2021) and Mekasha *et al.* (2022) found that leaf / stem ratio was significantly reduced with increasing seeding rates. The reduction in leaf / stem ratio as a result of increasing seeding rates is probably a result of the intense competition among plants for nutrients, water, and light. Also,

Salem (2015) reported that sorghum plants' height noticeably increased when their plant density was increased from 17,500 to 35,000.

3.1.3. Effect of interaction between planting methods and seeding rates:

The interaction between planting methods and seeding rate treatments (Tables 3 & 4) significantly affected growth parameters, including plant height and tiller number m^{-2} in the summer seasons of 2019 and 2020, as well as the combined analysis. The second planting method with a rate of seeding at 25 kg fed^{-1} significantly increased plant height and number of tillers m^{-2} plants, which recorded 206.25 cm and 76.11 in the first season, 226.08 cm and 82.50 in the second season, and 216.17 cm and 79.31 in the combined analysis for the mean of three cuts. Followed by the interaction between 1st method and seeding rate at 25 kg fed^{-1}. Whereas, the lowest values have been observed by the interaction between 1st method and seeding rate at 15 kg fed^{-1}.

Data showing the influence of the interaction between planting methods and rate of seeding on stem diameter (cm), dry matter %, and fresh and dry leaf /stem ratio are presented in Tables (5, 6, 7, and 8). Results showed significant differences in both seasons; the interaction between the 2nd method and the rate of seeding at 15 kg fed^{-1} gave the highest values, followed by the interaction between the 1st method and 15 kg fed^{-1}. Whereas the lowest values have been attained by the 1st method with 25 kg fed^{-1}. Similar results were attained by Haggag *et al.* (1986); Anders *et al.* (2020); Mehring *et al.* (2020) and Mekasha *et al.* (2022).

Table 3: Effect of planting methods and seeding rates on plant height (cm) of the new forage Sorghum hybrid (Sakha 20) in the summer seasons 2019, 2020 and combined analysis.

Treat.	Plant height (cm)											
	2019			Mean	2020			Mean	Combined			Mean
	1st cut	2nd cut	3rd cut		1st cut	2nd cut	3rd cut		1st cut	2nd cut	3rd cut	
Planting methods												
1st Method	215.50	197.17	135.58	182.75	193.58	209.33	201.50	201.47	204.54	203.25	168.42	192.07
2nd Method	221.67	202.67	143.67	189.34	203.25	217.25	208.42	209.64	212.46	209.96	176.04	199.49
F-test	**	**	**	**	**	**	**	**	**	**	**	**
Seeding rates (kg fed^{-1})												
15 kg fed^{-1}	197.75	183.88	122.75	168.13	180.50	198.75	188.13	189.13	189.13	191.31	155.44	178.63
20 kg fed^{-1}	.21975	200.88	139.00	186.54	198.50	212.50	206.50	205.83	209.13	206.69	172.75	196.19
25 kg fed^{-1}	238.25	215.00	157.13	203.46	216.25	228.63	219.88	221.59	227.25	221.81	188.50	212.52
L.S.D $_{0.05}$	1.276	0.979	1.275	1.327	2.912	2.590	1.811	2.684	3.864	5.324	3.521	4.612
Interaction												
1st Method X (15 kg fed^{-1})	193.00	182.00	118.00	164.33	177.00	196.25	183.50	185.58	185.00	189.13	150.75	174.96
1st Method X (20 kg fed^{-1})	216.50	197.00	136.25	183.25	192.00	208.75	203.75	201.50	204.25	202.88	170.00	192.38
1st Method X (25 kg fed^{-1})	237.00	212.50	152.50	200.67	211.75	223.00	216.50	217.08	224.38	217.75	184.50	208.88
2nd Method X (15 kg fed^{-1})	202.50	185.75	127.50	171.92	184.00	201.25	192.75	192.67	193.25	193.50	160.13	182.29
2nd Method X (20 kg fed^{-1})	223.00	204.75	141.75	189.83	205.00	216.25	209.25	210.17	214.00	210.50	175.50	200.00
2nd Method X (25 kg fed^{-1})	239.50	217.50	161.75	206.25	220.75	234.25	223.25	226.08	230.13	225.88	192.50	216.17
L.S.D $_{0.05}$	1.804	1.385	1.803	1.659	4.118	2.663	2.562	2.843	5.422	4.512	6.374	4.318

1st Method : Broadcasting on the top of the rows - 2nd Method: Hills on the top of the rows

Table 4: Effect of planting methods and seeding rates on number of tillers/m2 of the new forage Sorghum hybrid (Sakha 20) in the summer seasons 2019, 2020 and combined analysis.

Treat.	Number of tillers/m²											
	2019			Mean	2020			Mean	Combined			Mean
	1st cut	2nd cut	3rd cut		1st cut	2nd cut	3rd cut		1st cut	2nd cut	3rd cut	
Planting methods												
1st Method	63.06	58.06	52.22	57.78	79.44	57.78	52.22	63.15	71.25	57.92	52.23	60.46
2nd Method	72.78	63.89	55.00	63.89	86.38	62.50	58.33	69.07	79.58	63.20	56.67	66.48
F-test	**	*	*	*	**	*	**	*	**	*	*	**
Seeding rates (kg fed^{-1})												
15 kg fed^{-1}	53.75	48.75	40.83	47.78	72.50	49.17	40.42	54.03	63.13	48.96	40.63	50.90
20 kg fed^{-1}	67.08	61.25	56.67	61.67	79.17	58.75	55.83	64.58	73.13	60.00	56.25	63.13
25 kg fed^{-1}	82.92	72.92	63.34	73.06	97.08	72.50	69.58	79.72	90.00	72.71	66.46	76.39
L.S.D $_{0.05}$	2.719	1.937	4.352	2.562	4.597	2.691	2.425	3.116	5.426	3.522	3.664	6.384
Interaction												
1st Method X (15 kg fed^{-1})	50.00	45.00	36.67	43.89	68.33	47.50	37.50	51.11	59.17	46.25	37.09	47.50
1st Method X (20 kg fed^{-1})	62.50	59.17	56.67	59.45	75.83	56.67	51.67	61.39	69.17	57.92	54.17	60.42
1st Method X (25 kg fed^{-1})	76.67	70.00	63.34	70.00	94.17	69.17	67.50	76.95	85.42	69.59	65.42	73.48
2nd Method X (15 kg fed^{-1})	57.50	52.50	45.00	51.67	76.67	50.84	43.33	56.95	67.09	51.67	44.17	54.31
2nd Method X (20 kg fed^{-1})	71.67	63.33	56.67	63.89	82.50	60.84	60.00	67.78	77.09	62.09	58.34	65.84
2nd Method X (25 kg fed^{-1})	89.17	75.83	63.34	76.11	99.99	75.84	71.67	82.50	94.58	75.84	67.51	79.31
L.S.D $_{0.05}$	3.845	2.740	6.155	4.225	6.501	3.810	3.430	2.437	4.517	2.974	4.012	3.510

1st Method : Broadcasting on the top of the rows - 2nd Method: Hills on the top of the rows

Table 5: Effect of planting methods and seeding rates on stem diameter (cm) of the new forage Sorghum hybrid (Sakha 20) in the summer seasons 2019, 2020 and combined analysis.

Treat.	Stem diameter (cm)											
	2019			Mean	2020			Mean	Combined			Mean
	1st cut	2nd cut	3rd cut		1st cut	2nd cut	3rd cut		1st cut	2nd cut	3rd cut	
Planting methods												
1st Method	1.38	1.67	1.77	1.61	1.15	1.22	1.41	1.26	1.27	1.44	1.59	1.43
2nd Method	1.41	1.79	1.86	1.69	1.27	1.34	1.53	1.38	1.34	1.57	1.70	1.54
F-test	*	*	*	*	*	*	*	*	*	*	*	*
Seeding rates (kg fed^{-1})												
15 kg fed^{-1}	1.50	2.09	1.96	1.85	1.44	1.52	1.72	1.56	1.47	1.80	1.84	1.70
20 kg fed^{-1}	1.36	1.76	1.81	1.64	1.17	1.28	1.45	1.30	1.27	1.52	1.63	1.47
25 kg fed^{-1}	1.33	1.34	1.66	1.44	1.03	1.05	1.25	1.11	1.18	1.20	1.46	1.28
L.S.D $_{0.05}$	0.058	0.083	0.172	0.066	0.067	0.048	0.034	0.057	0.033	0.061	0.080	0.054
Interaction												
1stMethod X (15 kg fed^{-1})	1.50	2.00	1.90	1.80	1.35	1.45	1.63	1.48	1.43	1.73	1.77	1.64
1st Method X (20 kg fed^{-1})	1.35	1.70	1.80	1.62	1.10	1.20	1.40	1.23	1.23	1.45	1.60	1.43
1st Method X (25 kg fed^{-1})	1.30	1.30	1.60	1.40	1.00	1.00	1.20	1.07	1.15	1.15	1.40	1.23
2nd Method X (15 kg fed^{-1})	1.50	2.18	2.03	1.90	1.53	1.58	1.80	1.64	1.52	1.88	1.92	1.77
2nd Method X (20 kg fed^{-1})	1.38	1.83	1.83	1.68	1.23	1.35	1.50	1.36	1.31	1.59	1.67	1.52
2nd Method X (25 kg fed^{-1})	1.35	1.38	1.73	1.49	1.05	1.10	1.30	1.15	1.20	1.24	1.52	1.32
L.S.D $_{0.05}$	0.083	0.117	0.243	0.079	0.095	0.067	0.048	0.060	0.071	0.064	0.091	0.044

1st Method : Broadcasting on the top of the rows - 2nd Method: Hills on the top of the rows

Table 6: Effect of planting methods and seeding rates on dry matter % of the new forage Sorghum hybrid (Sakha 20) in the summer seasons 2019, 2020 and combined analysis.

Treat.	Dry matter %											
	2019			Mean	2020			Mean	Combined			Mean
	1st cut	2nd cut	3rd cut		1st cut	2nd cut	3rd cut		1st cut	2nd cut	3rd cut	
Planting methods												
1st Method	12.01	12.17	15.44	13.21	12.78	12.24	15.59	13.54	12.39	12.21	15.52	13.37
2nd Method	12.07	12.44	15.86	13.46	12.53	12.44	15.20	13.39	12.30	12.45	15.53	13.43
F-test	*	**	*	**	*	*	*	**	*	**	*	**
Seeding rates (kg fed^{-1})												
15 kg fed^{-1}	12.29	12.54	15.85	13.56	12.91	12.34	15.61	13.62	12.60	12.44	15.74	13.59
20 kg fed^{-1}	12.00	12.30	15.65	13.32	12.51	12.58	15.40	13.50	12.26	12.44	15.53	13.41
25 kg fed^{-1}	11.83	12.08	15.45	13.12	12.52	12.11	15.18	13.27	12.18	12.10	15.32	13.20
L.S.D $_{0.05}$	0.083	0.095	0.112	0.147	0.314	0.467	0.621	0.051	0.071	0.012	0.125	0.015
Interaction												
1st Method X (15 kg fed^{-1})	12.20	12.40	15.68	13.43	13.18	12.15	15.73	13.69	12.69	12.28	15.71	13.56
1st Method X (20 kg fed^{-1})	12.00	12.18	15.43	13.20	12.70	12.53	15.68	13.64	12.35	12.36	15.56	13.42
1st Method X (25 kg fed^{-1})	11.83	11.93	15.23	13.00	12.45	12.05	15.38	13.29	12.14	11.99	15.31	13.15
2nd Method X (15 kg fed^{-1})	12.38	12.68	16.03	13.70	12.65	12.53	15.50	13.56	12.52	12.61	15.77	13.63
2nd Method X (20 kg fed^{-1})	12.00	12.43	15.88	13.44	12.33	12.63	15.13	13.36	12.17	12.53	15.51	13.40
2nd Method X (25 kg fed^{-1})	11.83	12.23	15.68	13.25	12.60	12.18	14.98	13.25	12.22	12.21	15.33	13.25
L.S.D $_{0.05}$	0.117	0.135	0.158	0.116	0.445	0.660	0.879	0.079	0.127	0.276	0.041	0.061

1st Method : Broadcasting on the top of the rows - 2nd Method: Hills on the top of the rows

Table 7: Effect of planting methods and seeding rates on fresh leaf/stem ratio of the new forage Sorghum hybrid (Sakha 20) in the summer seasons 2019, 2020 and combined analysis.

Treat.	Fresh leaf/stem ratio											
	2019			Mean	2020			Mean	Combined			Mean
	1st cut	2nd cut	3rd cut		1st cut	2nd cut	3rd cut		1st cut	2nd cut	3rd cut	
Planting methods												
1st Method	46.75	38.50	73.67	52.97	46.92	39.33	76.08	54.11	46.83	38.92	74.88	53.54
2nd Method	46.75	40.42	77.67	54.95	47.33	41.08	79.83	56.08	47.04	40.75	78.75	55.51
F-test	*	*	**	*	*	*	**	*	*	*	**	*
Seeding rates (kg fed^{-1})												
15 kg fed^{-1}	50.50	41.75	79.00	57.08	50.88	41.38	81.50	57.92	50.69	41.56	80.25	57.50
20 kg fed^{-1}	47.00	39.25	75.25	53.83	47.63	40.50	78.00	55.38	47.31	39.88	76.63	54.60
25 kg fed^{-1}	42.75	37.38	72.75	50.96	42.88	38.75	74.38	52.00	42.81	38.06	73.56	51.48
L.S.D $_{0.05}$	2.383	0.808	1.376	1.548	2.204	2.406	1.275	1.351	1.574	1.358	2.241	1.641
Interaction												
1st Method X (15 kg fed^{-1})	51.00	40.50	77.25	56.25	51.00	40.25	79.75	57.00	51.00	40.38	78.50	56.63
1st Method X (20 kg fed^{-1})	46.75	38.50	73.25	52.83	46.75	39.75	76.00	54.17	46.75	39.13	74.63	53.50
1st Method X (25 kg fed^{-1})	42.50	36.50	70.50	49.83	43.00	38.00	72.50	51.17	42.75	37.25	71.50	50.50
2nd Method X (15 kg fed^{-1})	50.00	43.00	80.75	57.92	50.75	42.50	83.25	58.83	50.38	42.75	82.00	58.38
2nd Method X (20 kg fed^{-1})	47.25	40.00	77.25	54.83	48.50	41.25	80.00	56.58	47.88	40.63	78.63	55.71
2nd Method X (25 kg fed^{-1})	43.00	38.25	75.00	52.08	42.75	39.50	76.25	52.83	42.88	38.88	75.63	52.46
L.S.D $_{0.05}$	3.370	1.143	1.946	1.120	3.116	3.403	1.803	1.216	2.314	3.215	2.147	1.851

1st Method : Broadcasting on the top of the rows - 2nd Method: Hills on the top of the rows

Table 8: Effect of planting methods and seeding rates on dry leaf/stem ratio of the new forage Sorghum hybrid (Sakha 20) in the summer seasons 2019, 2020 and combined analysis.

Treat.	Dry leaf/stem ratio											
	2019			Mean	2020			Mean	Combined			Mean
	1st cut	2nd cut	3rd cut		1st cut	2nd cut	3rd cut		1st cut	2nd cut	3rd cut	
Planting methods												
1st Method	59.08	43.83	79.75	60.89	59.83	45.42	81.42	62.22	59.46	44.63	80.58	61.56
2nd Method	59.58	46.75	82.67	63.00	60.58	47.92	82.67	63.72	60.08	47.33	82.67	63.36
F-test	*	**	**	*	*	**	*	*	*	**	**	*
Seeding rates (kg fed^{-1})												
15 kg fed^{-1}	61.75	47.50	84.88	64.71	63.75	48.88	85.38	66.00	62.75	48.19	85.13	65.35
20 kg fed^{-1}	60.13	45.13	81.25	62.17	60.25	46.50	81.75	62.83	60.19	45.81	81.50	62.50
25 kg fed^{-1}	56.13	43.25	77.50	58.96	56.63	44.63	79.00	60.09	56.38	43.94	78.25	59.52
L.S.D $_{0.05}$	1.193	1.028	1.623	1.574	2.243	1.06	1.875	1.361	1.384	1.524	1.621	1.648
Interaction												
1st Method X (15 kg fed^{-1})	61.00	45.75	84.00	63.58	63.25	47.50	85.50	65.42	62.13	46.63	84.75	64.50
1st Method X (20 kg fed^{-1})	60.00	44.00	80.25	61.42	59.50	45.50	82.00	62.33	59.75	44.75	81.13	61.88
1st Method X (25 kg fed^{-1})	56.25	41.75	75.00	57.67	56.75	43.25	76.75	58.92	56.50	42.50	75.88	58.29
2nd Method X (15 kg fed^{-1})	62.50	49.25	85.75	65.83	64.25	50.25	85.25	66.58	63.38	49.75	85.50	66.21
2nd Method X (20 kg fed^{-1})	60.25	46.25	82.25	62.92	61.00	47.50	81.50	63.33	60.63	46.88	81.88	63.13
2nd Method X (25 kg fed^{-1})	56.00	44.75	80.00	60.25	56.50	46.00	81.25	61.25	56.25	45.38	80.63	60.75
L.S.D $_{0.05}$	3.101	1.454	2.295	1.032	3.173	1.499	2.652	1.216	2.412	2.135	3.120	1.028

1st Method : Broadcasting on the top of the rows - 2nd Method: Hills on the top of the rows

3.2. Fresh and dry forage yield:

3.2.1. Effect of planting methods:

Findings shown in Tables (9 and 10) indicated that, when compared to the other method of planting, the 2nd method of planting significantly increased the yield of fresh and dry forage at each cut as well as the total yield of fresh and dry forage (ton fed^{-1}) in the first and second summer seasons. This increment in the yield of fresh and dry forage might be owing to the fact that using planting in the 2nd method was more favorable to plant growth and yield. These findings concur with those provided by Burger and Campbell (1961); Mekhail (1970); Abdel-Gawad (1981) and Haggag *et al.* (1986), they reported that planting methods showed significant differences in fresh forage yield of sorghum. Hills method gave the highest fresh forage yield, while broadcasting method gave the lowest values.

3.2.2. Effect of seeding rates:

The results in Tables 9 and 10 demonstrated that increasing seed rates from 15 to 25 kg fed^{-1} resulted in a significant gradual increase in the yield of fresh and dry forage at each cut and the total yield of fresh and dry forage (ton fed^{-1}) in the summer seasons 2019 and 2020 and combined analysis. The highest values of the aforementioned features were therefore found at 25 kg fed^{-1}. The intra-plant competition for nutrients and radiation could be responsible for these results. Numerous researchers discovered comparable outcomes. Abdel-Gawad (1981); Ebrahim (1982); Haggag *et al.* (1986); Koller and Scholl (1986); Mousa (1986); Silva *et al.* (2017) and Hssan *et al.* (2019) exhibited that fresh and dry forage yields of sorghum have been increased with increasing seeding rates. Also, these improvements may be attributable to the high density, which would allow more efficient use of available sunlight, moisture, and nutrients. In addition, it would save the most harvested plants/unit area. According to studies by Andrade *et al.* (2002); Thelen (2006), and Salem (2015), the yield response to narrow rows is influenced by a variety of environmental, spatial, and temporal field interactions. These findings are consistent with those of Javadi *et al.* (2005); Lak *et al.* (2006); Soleymani *et al.* (2011); Fernandez *et al.* (2012); Mousavi *et al.* (2012); Zand *et al.* (2014) and Salama (2019).

Table 9: Effect of planting methods and seeding rates on fresh forage yield (ton fed^{-1}) of the new forage Sorghum hybrid (Sakha 20) in summer seasons 2019, 2020 and combined analysis.

Treat.	Fresh forage yield (ton fed^{-1})											
	2019			Total fresh forage yield (ton fed^{-1})	2020			Total fresh forage yield (ton fed^{-1})	Combined			Total fresh forage yield (ton fed^{-1})
	1st Cut	2nd Cut	3rd cut		1st cut	2nd Cut	3rd Cut		1st cut	2nd cut	3rd Cut	
Planting methods												
1st Method	34.20	26.73	16.45	77.38	34.66	21.27	20.03	75.96	34.43	24.00	18.24	76.68
2nd Method	35.96	28.40	18.27	82.62	35.62	22.84	21.32	79.78	35.79	25.62	19.80	81.21
F-test	*	*	*	**	*	*	*	**	*	*	*	**
Seeding rates (kg fed^{-1})												
15 kg fed^{-1}	31.25	24.07	13.66	68.98	32.87	19.35	18.15	70.37	32.06	21.71	15.90	69.68
20 kg fed^{-1}	35.37	27.50	16.99	79.86	34.77	21.53	20.69	76.98	35.07	24.52	18.84	78.44
25 kg fed^{-1}	38.61	31.11	21.43	91.16	37.78	25.28	23.19	86.25	38.20	28.20	22.32	88.72
L.S.D $_{0.05}$	1.057	1.228	0.378	1.658	0.935	0.667	0.372	0.542	0.724	0.451	0.660	0.814
Interaction												
1st Method X (15 kg fed^{-1})	29.63	23.33	12.68	65.65	32.59	18.61	17.69	68.89	31.11	20.97	15.19	67.27
1st Method X (20 kg fed^{-1})	34.44	26.49	16.12	77.04	34.17	21.02	19.91	75.09	34.31	23.76	18.02	76.09
1st Method X (25 kg fed^{-1})	38.52	30.37	20.56	89.45	37.23	24.17	22.50	83.89	37.88	27.27	21.53	86.68
2nd Method X (15 kg fed^{-1})	32.87	24.82	14.63	72.31	33.15	20.09	18.61	71.85	33.01	22.46	16.62	72.09
2nd Method X (20 kg fed^{-1})	36.30	28.52	17.87	82.68	35.37	22.04	21.46	78.87	35.84	25.28	19.67	80.79
2nd Method X (25 kg fed^{-1})	38.71	31.85	22.31	92.87	38.34	26.39	23.89	88.61	38.53	29.12	23.10	90.75
L.S.D $_{0.05}$	1.494	1.736	0.535	2.427	1.323	0.944	0.526	1.930	0.671	1.063	0.941	1.231

1st Method : Broadcasting on the top of the rows - 2nd Method: Hills on the top of the rows

Table 10: Effect of planting methods and seeding rates on dry forage yield (ton fed-1) of the new forage Sorghum hybrid (Sakha 20) in summer seasons 2019, 2020 and combined analysis.

Treat.	Dry forage yield (ton fed^{-1})											
	2019			Total dry forage yield (ton fed^{-1})	2020			Total dry forage yield (ton fed^{-1})	Combined			Total dry forage yield (ton fed^{-1})
	1st Cut	2nd cut	3rd cut		1st cut	2nd Cut	3rd Cut		1st cut	2nd Cut	3rd Cut	
Planting methods												
1st Method	4.10	3.25	2.54	9.88	4.42	2.60	3.12	10.14	4.27	2.93	2.83	10.03
2nd Method	4.25	3.53	2.90	10.68	4.46	2.84	3.24	10.54	4.36	3.19	3.07	10.62
F-test	*	*	*	**	*	*	*	**	*	*	*	**
Seeding rates (kg fed^{-1})												
15 kg fed^{-1}	3.72	3.02	2.17	8.91	4.24	2.39	2.83	9.46	3.98	2.71	2.50	9.19
20 kg fed^{-1}	4.25	3.38	2.66	10.29	4.35	2.71	3.18	10.24	4.30	3.05	2.93	10.28
25 kg fed^{-1}	4.57	3.76	3.32	11.65	4.73	3.06	3.52	11.31	4.65	3.41	3.42	11.48
L.S.D $_{0.05}$	0.208	0.147	0.058	0.237	0.151	0.147	0.158	0.163	0.142	0.135	0.320	0.421
Interaction												
1st Method X (15 kg fed^{-1})	3.62	2.89	1.99	8.50	4.29	2.26	2.78	9.33	3.96	2.58	2.39	8.93
1st Method X (20 kg fed^{-1})	4.13	3.22	2.49	9.84	4.34	2.64	3.12	10.10	4.24	2.93	2.81	9.98
1st Method X (25 kg fed^{-1})	4.56	3.62	3.13	11.31	4.64	2.91	3.46	11.01	4.60	3.27	3.30	11.17
2nd Method X (15 kg fed^{-1})	3.82	3.15	2.35	9.32	4.19	2.52	2.89	9.60	4.01	2.84	2.62	9.47
2nd Method X (20 kg fed^{-1})	4.36	3.54	2.84	10.74	4.36	2.79	3.25	10.40	4.36	3.17	3.05	10.58
2nd Method X (25 kg fed^{-1})	4.58	3.90	3.50	11.98	4.83	3.22	3.58	11.63	4.71	3.56	3.54	11.81
L.S.D $_{0.05}$	0.294	0.208	0.083	0.327	0.213	0.208	0.224	0.298	0.132	0.311	0.298	0.211

1st Method : Broadcasting on the top of the rows - 2nd Method: Hills on the top of the rows

3.2.3. Effect of the interaction between planting methods and seeding rates:

Fresh and dry forage yield at each cut and total fresh and dry forage yield (ton fed^{-1}) in summer seasons 2019 and 2020 and combined analysis were significantly affected by the interaction between planting methods and seeding rates treatments Tables (9 and 10). The interaction between 2nd method of planting and seeding rate at 25 kg fed^{-1} increased significant fresh and dry forage yield at each cut and total fresh and dry forage yield (ton fed^{-1}). Followed by the interaction between the 1st planting method with seeding rate at 25 kg fed^{-1}. While, the lowest values were observed by the interaction between 1st planting method with seeding rate at 15 kg fed^{-1}. In this connection, it should be mentioned that Mousa *et al.* (1991); Salama (2019) and Sarauskis *et al.* (2022) reported that the superiority in fresh and dry forage yield in dense sowing over thin one might be attributed to the high amount of energy intercepted by leaves. In addition, dense sowing resulted in well utilization of water and nutrient per unit area and this might contribute much to the superiority of weight of plants per feddan in dense sowing. Moreover, the plants in low density did not grow sufficiently larger to compensate for the total loss in yield from reduction in stand. The loss in yield per plant in dense planting was compensated by the greater number of stems per unit area.

4. Conclusion

It could be concluded that planting in hills on the top of the rows with 25 kg fed^{-1} was more favor to planting new sorghum hybrid (Sakha 20) at Sakha Agric. Res. St., which gave the highest plant growth, fresh and dry forage yield.

References

Abdel-Gawad, K. L., 1981. Studies on some factors influencing the productivity of summer fodder crops (*Sorghum bicolor* L. Moench.) Ph.D. Thesis, Fac. of Agric. Cairo Univ.

Andrade, F.H., P. Calvino, A. Cirilo and P. Barbieri, 2002. Yield responses to narrow rows depend on increased radiation interception. Agronomy Journal, 94 (5): 975-980.

Anders A., P. Markowski, S. Konopka, Z. Kaliniewicz, A. J. Lipinski and D. J. Choszcz, 2020. Effect of seeding rate on selected physical parameters and biomass yield of maize. Chil. j. agric. res., 80 (2): 111-118.

Bishnoi, U. R., 1980. Effect of seeding rates and row spacing on forage and grain population of triticale, wheat, rye and sorghum. Crop Sci., 20 (1): 107-109.

Bond, J.J., T.J., Army, and O.R. Lehman, 1964. Row spacing, plant populations and moisture supply as factors in dryland grain sorghum production. Agr. J., 56, 3-7.

Brown, A.R., C. Cobb and E.H. Wood, 1964. Effect of irrigation and row spacing on grain sorghum in Piedmont. Agr. J., 56, 506-509.

Burger, A.W. and W.F. Campbell, 1961. Effect of rates and methods of seeding on the original stand, tillering, stem diameter, leaf-stem ratio, and yield of Sudan grass. Agr. J. ,53, 289-291.

Caravetta, G.J., J.H. Cherney and K.D. Johnson, 1990. Within row spacing influences on diverse sorghum genotypes: II. Dry matter yield and forage quality. Agr. J., 82, 210-215.

Croplan Genetics (2004). Sorghum forage. [Visited on 3 July 2006] Available online at: http://www.croplangenetics.com/sorghum_forage.asp , topic=1&sm=h_b.

Ebrahim, M.E. (1982). Studies on some summer forage crops. M. Sc. Thesis, Fac. Agric., Menoufia Univ.

Eilrich, G. L., R. C. Long, F.C. Stickler and A.W. Pauli, 1964. Stage of maturity, plant population, and row width as factors affecting yield and chemical composition of Atlas forage sorghum. Kansas Agric. Exp. Stn. Tech. Bull., 138.

Fernandez, C.J., D.D. Fromme and W.J. Grichar, 2012. Grain sorghum response to row spacing and plant populations in the Texas Coastal Bend Region. International J. of Agron., 1-6.

Haggag, M. E., M. S. Osman, A. M. Rammah and M. E. Mousa (1986). Planting methods and seeding rates of two sorghum varieties in Egypt. Al-Azhar J. Agric. Res., 6 (12), 429-440.

Hssan, M.U., chatta,M.B. ,A.Mahmood and S.T.Sahi, 2019.Chemical composition and methane yield of sorghum as influence by planting methods and cultivars. Journal of animal & plant Sciences251-259.

Icrisat, 2006. Crops Gallery: *Sorghum bicolor* (L.) Moench [Visited on 3 July 2006] Available on rows at: http://www.icrisat.org/Text/coolstuff/crops/gcrops2.html.

Iptas, S., A.R. Brohi and H. Aslan (2002). Effect of seeding rate and nitrogen fertilizers on forage yield and quality of sorghum (*Sorghum bicolor*) Sudan grass (*Sorghum sudanense*) hybrid. Indian J. Agr., 47, 298- 303.

Javadi, H., M.H. Rashed Mohasel, G. Zamani, A. Azari Nasrabad and G. Mousavi, 2005. Study on effect of plant density on yield, yield components and protein percentage of four grain sorghum cultivars. Iranian J. of Agricultural Researches, 3(2): 233-243.

Kazlauskas, M., E. Sarauskis, K. Romaneckas, D. Steponavicius, A. Jasinskas, V. Naujokiene, I. Bruciene, T. Ziogas, D.Vaicekauskas and J. Anusauskas, 2021. Effect of variable rate seeding on winter wheat seedbed and germination parameters using soil apparent electrical conductivity. In Proceedings of the Engineering for Rural Development: 20th International Scientific Conference, Engineering for Rural Development, Jelgava, Latvia, 26–28 May; Volume 20, pp. 1108–1113.

Khandelwal, V, M.shakha, B. S. Jod, S. Nathawat and S.K. Dashora, 2015. Genetic parameters and charater Association in sorghum *(Sorghum bicolor* (L.) *Moench)*. Indian Journal of science and technology, Vol. 8 (22): 1-5.

Koller, H. R. and J. M. Scholl, 1986. Effect of row spacing and seeding rates population and chemical composition of two sorghum varieties harvested at two cutting frequencies. Agron. J., 60 (5): 456-460.

Lak, S., A. Naderi, S.A.A. Siadat, A. Aynehband, G. Noormohammadi and S.H. Mousavi, 2006. Effect of different irrigation and plant densities levels on yield, yield components and assimilate remobilization of grain maize under climatic conditions of Khuzestan. Iran. J. of Agric. and Natural Resources Sciences, 10 (43): 92-101.

Mehring, G.H., J.J. Wiersma, J.D. Stanley and J.K. Ransom, 2020 Genetic and environmental predictors for determining optimal seeding rates of diverse wheat cultivars. Agronomy, (10) 332.

Mekasha, A., D. Min, N. Bascom and J. Vipham, 2022. Seeding rate effects on forage productivity and nutritive value of sorghum. Agronomy Journal.114:201-215.

Mekhail, G. M., 1970. Effect of some cultural treatments on yield and chemical composition of some summer forage crops. M.Sc. Theses, Fac. Agric. Alex. Univ.

Mousa, M. E., 1986. Study of the effect of some cultural treatments on yield and chemical components of some summer forage crops. Ph. D. Thesis, Fac. Agric. Azhar Univ., Egypt.

Mousa, M. E., M. K. Ahmed, M. A. Harfoush and A. Barakat, 1991. Productivity of four local sorghum-sudan grass hybrids under different seeding rates. Egypt. J. Agric. Res., 70 (2): 575-586.

Mousavi, S.G.R., M.J. Seghatoleslami and R. Arefi, 2012. Effect of N fertilization and plant density on yield and yield components of grain sorghum under climatic conditions of Sistan, Iran. Plant Ecophysiology, 4: 141-149.

MSTAT-C, Ver. 4, 1986. A micro computer program for the Design and Analysis of Agronomic Research Experiments. Michigan State Univ., USA.

Page, A. L., R.H. Miller and D. R. Keeney, 1982. Methods of soil analysis. II Chemical and microbiological properties 2nd Ed. Madison, Wisconsim. U.S.A.

Piper, C. S., 1950. Soil and plant analysis. Inter. science pubi. Inc. New York. Plant and soil. 91(3): 429-432.

Salama, H. S. A., 2019. Yield and nutritive value of maize (*Zea mays* L.) forage as affected by plant density, sowing date and age at harvest. Italian Journal of Agronomy, 14, 1383. https://doi.org/10.4081/ija.2019.1383

Salem, E.M.M. (2015). Response of grain sorghum (*Sorghum bicolor*, L. Monech) to irrigation, nitrogen and plant density under new valley conditions, Egypt. Egyptian J. Desert Res., 65, 11-30.

Sarauskis, E., M. Kazlauskas, V. Naujokiene, I. Bruciene, D. Steponavicius, K. Romaneckas and A. Jasinskas (2022). Variable rate seeding in precision agriculture: Recent advances and future perspectives. Agriculture 12, 305. https://doi.org/10.3390/ agriculture12020305

Silva, J.M.F. D.a, Dutra, A. S., Camara, F. T. D.a, Pinto, A. A., and Silva, F. E. D. (2017). Row spacing, plant density, sowing and harvest times for sweet sorghum. Pesquisa Agropecuária Tropical, 47, 408–415. https://doi.org/10.1590/1983-40632017v4748585

Soleymani, A., M.H. Shahrajabian and Lila Naranjani, 2011. The effect of plant density and nitrogen fertilization on yield, yield components and grain protein of grain sorghum. Journal of Food, Agriculture & Environment, 9 (3&4): 244-246.

Steel, R.G.D., T.H. Torrie and D.A. Dickey, 1997. Principles and Procedures of Statistics: A Biometrical Approach, 3rd Edition, pp: 204-232. MeGraw Hill Book International Co. Inc., Singapore.

Thelen, K.D., 2006. Interaction between row spacing and yield: why it works. Crop Management.5(1) doi: 10.1094/CM-2006-0227-03-RV.

Zand, N., M.R. Shakiba, M.M. Vahed and A.D.M. Nasab, 2014. Response of sorghum to nitrogen fertilizer at different plant densities. International. J. of Farming and Allied Sci., 3 (1):71-74.