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Effect of seed rates and nitrogen levels on growth and fodder yield of sweet sorghum

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Abstract
A field experiment was conducted to study the effect of seed rates and nitrogen level on green forage yield and fodder quality of sweet sorghum during *rabi* 2016 at ZARS, V. C. Farm Mandya. The soil was sandy loam in structure and medium in available N, P and K. The experiment consisted of three seed rates (50, 40 and 30 kg ha^{-1}) and three levels of nitrogen (75 RDN, 100 RDN and 125% RDN) laid out in factorial randomised complete block design with three replications. Seed rate of 40 kg ha^{-1} recorded significantly higher green fodder yield (42.82 t ha^{-1}), dry matter yield (6.18 t ha^{-1}), crude protein yield (0.54 t ha^{-1}) and crude fiber yield (1.90 t ha^{-1}). Among nitrogen levels, application of 125% RDN ha^{-1} recorded significantly higher green fodder yield (45.85 t ha^{-1}), dry matter yield (6.64 t ha^{-1}), crude protein yield (0.63 t ha^{-1}) and crude fibre yield (1.91 t ha^{-1}). Hence, application of 125% of RDN enhances green forage yield and fodder quality of sweet sorghum.

Keywords: nitrogen levels, seed rates, sweet sorghum

Introduction
Livestock has been the agriculture's most economically important sub sector. It contributes 25 per cent to the total agricultural income. With only 2.5 per cent of the world's geographical area, India supports 15 per cent of the world's livestock population. Since the beginning of 1980, milk production has shown an average compound annual growth rate of almost 4.5 per cent. Production efficiency of the Indian livestock in most of the regions is very low. This offers considerable scope for raising the productivity of Indian livestock. The low productivity is mainly due to inadequate supply of quality feeds and fodders. Balanced nutrition through feed and fodder to livestock is available in selected milk shed areas of the country where intensive fodder production systems are practiced. Rest of the farming community maintains uneconomic large herds on grazing supplemented with stall feeding.

At present, the country faces net deficit of 61.1 per cent green fodder and 21.9 per cent dry fodder. This situation indicates that the green forage supply has to be grows at 3.2 per cent to meet the deficit. To meet this challenge, concerted efforts are to be made for reducing the large gap between demand and supply of the fodder in the country. To meet the current level of livestock production and its annual growth in population, the deficit has to be met from either increasing productivity, increasing land area under fodder cultivation or through import. In animal feed supply, cereals have major role and four major cereals viz. maize, barley, sorghum and pearl millet account for about 44 per cent of the total cereals fodder production.

Sweet sorghum (*Sorghum bicolor* L.), is a special type of sorghum which has the ability to accumulate fermentable sugars (15-17%) in its stalk. Sweet sorghum belongs to family Graminae attain a height of 350 cm, bearing very wide (up to 12 cm) and long (up to 125 cm.) leaves. Sweet sorghum is being developed for the simultaneous production of grain and sweet stalk with sweet juicy stems, used for forage and silage or to produce syrup. Sweet sorghum crop produces 35-50 t ha^{-1} stalk and 1.5-2.5 t ha^{-1} grain yield (Ratnavathi *et al*., 2005) [20]. It has better digestibility than fodder sorghum (Morris and Mc Cormic, 1994) [16]. The fodder of sweet sorghum is rich source of nutrients (Singh, 2009). As a result, in general livestock suffers continuously with malnutrition round the year resulting in their production capacity at sub-optimum level. It is therefore, very essential to maximize quality and forage production per unit area and time. Cereal fodders and crop residues are major sources of forage but the nutritive value of these fodders is not adequate to achieve higher milk production. Availability of green forage to animals is the key to success of dairy enterprises and it is difficult to maintain the health and milk production of the livestock without supply of the green fodder. Green fodder not only helps for easy digestion but, also abundant quantity of Vitamin-A and important minerals like Ca and Fe in addition to energy for the animals and another

Dimension is to reduce the cost of milk production. It is established beyond doubt that raising the animals mostly on green forages reduces the cost by 40 per cent in contrast to that of 70 per cent when they are raised on a coarser dry fodder supplemented with costly grain feeds or concentrates (Relwani, 1979) [21]. Therefore, efforts to accelerate the production potential of good quality forages are of paramount importance to ascertain the adequate supply of green fodder. It will help to improve the economy of dairy farming, thereby, making the white revolution a grand success.
Considering the above facts in view, the present investigation was carried out to study "Effect of seed rate and nitrogen levels on growth and fodder yield of sweet sorghum."

Material and Method
The field experiment was conducted at Zonal Agricultural Research Station, V. C. Farm, Mandya, which falls under Southern Dry Zone of Karnataka (Zone-VI). The station is situated between 12º45' N latitude, 76º 45' E longitude and at an altitude of 695 meters above Mean Sea Level (MSL). The soil was neutral in pH (7.34) and high in organic carbon content (1.08 per cent) with electrical conductivity 0.26 dSm^{-1}. The soil had medium available nitrogen (330 kg ha^{-1}), medium phosphorus (31 kg ha^{-1}) and medium available potassium (172 kg ha^{-1}). The experiment was laid out in a factorial randomized complete block design with nine treatments replicated thrice. The treatments of the experiment consisted of three levels of seed rates S_1= 50 kg ha^{-1}, S_2= 40 kg ha^{-1} and S_3= 30 kg ha^{-1} and three nitrogen levels N_1 = 75% RDN, N_2 = 100% RDN and N_3 = 125% RDN (RDN = Recommended dose of nitrogen). Details of treatment combinations T_1= S_1N_1, T_2= S_1N_2, T_3= S_1N_3, T_4= S_2N_1, T_5= S_2N_2, T_6= S_2N_3, T_7= S_3N_1, T_8= S_3N_2 and T_9=S_3N_3.
The variety used in the study was SSV 84 and it is the first sweet sorghum variety developed by AICSIP, Rahuri in 1992 and released for cultivation in the entire country. It produces average stalk yield of 37.5 t ha^{-1} with a brix of 18.6 percent, suitable for cultivation as rainfed crop. It takes 85 days for 50 per cent flowering and potential to produce biomass yield of 52.7 t ha $^{-1}$. Farm yard manure at the rate of 10 t ha^{-1} was applied to each plot two weeks prior to sowing. A uniform dose of 50 kg P_2O_5 and 40 kg K_2O ha^{-1} was applied through single super phosphate and muriate of potash, respectively to all the plots. Nitrogen was applied at 75 per cent RDN, 100 per cent RDN, and 125 per cent RDN respectively to N_1, N_2, and N_3 treatments. Nitrogen was applied in two equal splits. Half the dose of nitrogen along with full dose of phosphorus and potassium was applied as basal dose at the time of sowing. The remaining quantity of nitrogen was top dressed at 30 days after sowing. After the field preparation, furrows were opened at 30 cm interval with the help of a hand hoe. The seeds were dibbled in each hill as per treatment. Basal application of nutrients was done at the time of sowing below the seed row and covered with soil. Sowing was taken up on 15-11-2016.

Result and Discussion
Growth
Plant height
Significantly higher mean plant height was recorded with seed rate of 40 kg ha^{-1} (166.05 cm) as compared to seed rate of 30 kg ha^{-1} (154.61 cm) and it was on par with seed rate of 50 kg ha^{-1}(160.90 cm). Plant height differed significantly due to the nitrogen levels and higher plant height of 178.48 cm was obtained with 125 per cent of RDN compared to 100 per cent of RDN (160.49 cm) and 75 per cent of RDN (142.59 cm).The interaction among seed rates and nitrogen levels was found to be non-significant.
The higher plant height in seed rate of 40 kg ha^{-1} was mainly due to reduced competition within the intra row spacing as compared to higher seed rate. The findings of Singh and Sumeriya (2005) [5, 27] confirmed these results. Increase in plant height with increasing seed rates may be due to competition for light. Further, auxins have besipetal movement and spelling effect because the auxins to move from illuminated side to shade side and thus, the imbalance of auxins cause more elongation of plants in shade with curvature compared to being in light. Since auxin is sensitive to light, shading prevents its destruction and thus, higher accumulation of auxin in shady plants triggers its growth to height. Earlier Mahdi *et al.* (2011) [13] and Osman *et al.* (2010) [18] agreed with the same results. The higher plant height on higher levels of nitrogen is mainly attributed to more availability and uptake of nitrogen by crop which resulted in more vegetative growth and increase in protoplasmic constituent and acceleration in the process of cell division, expansion and differentiation and there by resulting in luxuriant growth. The findings of Jigyasa *et al.* (2010) [9], Manjunatha (2011) [14], Tiwana and Puri (2003) [28], Naveen Kumar and Naleeni Ramawat (2006) [17] have also confirmed the results.

Leaf area
Leaf area differed significantly and higher mean leaf area was recorded with seed rate of 40 kg ha^{-1} (13592.66 cm^2) as compared to seed rate of 30 kg ha^{-1} (8987.00 cm^2) and it was on par with seed rate of 50 kg ha^{-1} (12949.43 cm^2). The leaf area increased significantly with increase in levels of nitrogen. Application of 125 per cent of RDN recorded significantly higher leaf area (13257.77 cm^2) compared to 100 per cent of RDN (12034.32 cm^2) and 75 per cent of RDN (10237.00 cm^2). The interaction between seed rates and nitrogen levels was found to be non-significant. This was due to the higher leaf area due to higher accumulation of dry matter in leaves and to obtain higher leaf area there must be more number of leaves or the size of the leaves should be large. To hold more number of leaves in the plant the plant height must be higher. Similar results were reported by Alagarsamy (1993) [2] and Ayub *et al*. (2002) [4]. Similarly, significantly higher mean leaf area index was recorded with the application of 125 per cent of RDN. Higher leaf area was due to higher accumulation of dry matter in leaves and to obtain higher leaf area there must be more number of leaves or the size of the leaves should be large. To hold more number of leaves in the plant the plant height must be higher. Similar results were reported by Alagarsamy (2002) and Ayub *et al*. (2002) [4].

Leaf: stem ratio
Significantly higher mean leaf: stem ratio was recorded with seed rate of 40 kg ha^{-1} (0.30) as compared to seed rate of 30 kg ha^{-1} (0.26) and it was on par with seed rate of 50 kg ha^{-1} (0.29). Among the nitrogen levels 125 per cent of RDN recorded significantly higher leaf: stem ratio (0.31) compared to 100 per cent of RDN (0.28) and 75 per cent of RDN (0.26). The interaction between seed rates and nitrogen levels was found to be non-significant. The higher leaf stem ratio with the seed rate of 40 kg ha^{-1} was due to increased leaf size and decreased stem girth. In higher seed rate because of more population per unit area lead to grassy shoot appearance. At

lower seed rate, more space is available for crop growth resulted in higher stem girth which leads to lower leaf stem ratio in both higher and lower seed rate respectively. Similar results were reported by Verma *et al*. (2005) [29] and Bishanoi *et al*. (2005) [5]. The increase in leaf stem ratio with increasing levels of nitrogen was mainly due to rapid expansion of dark green foliage which could intercept and utilize the incident solar radiation in the production of photosynthates and eventually resulting in higher meristematic activity and increased leaf stem ratio of fodder sorghum. This might be also due to favourable influence of nitrogen on cell division and cell elongation, which could have produced more functional leaves for a longer period of time. These results are in conformity with the findings of Agarwal *et al*. (2005), Singh and Gill (1976) [26], Gardner Franklin *et al.* (1988) [7], Shekara and Lohithaswa (2009) [23] and Ayub *et al*. (2002) [4].

Nitrogen uptake
Among the seed rates significantly higher mean nitrogen uptake was recorded at harvest stage with seed rate of 40 kg ha^{-1} (87.22 kg ha^{-1}) as compared to seed rate of 30 kg ha^{-1} (72.59 kg ha^{-1}) and it was on par with seed rate of 50 kg ha^{-1} (81.57 kg ha^{-1}). The nitrogen uptake increased significantly with increase in levels of nitrogen. Significantly higher nitrogen uptake was obtained with application of 125 per cent of RDN (101.45 kg ha^{-1}) compared to 100 per cent of RDN (77.80 kg ha^{-1}) and 75 per cent of RDN (62.13 kg ha^{-1}). The interaction among seed rates and nitrogen levels was found to be non-significant. The higher nitrogen uptake at seed rate of 40 kg ha^{-1} was mainly due to reduced competition within the intra row spacing as compared to higher seed rate. The findings of Singh and Sumeriya (2005) [5, 27] confirmed these results. Increased nitrogen application increases nitrogen uptake in plant more availability of nitrogen. These results are in conformity with the findings of Siddique (1989) [25], Purohit (1960) [19].

Table 1: Green fodder yield (t ha^{-1}) and dry matter yield (t ha^{-1}) of fodder sweet sorghum as influenced by seed rates and nitrogen levels

Treatments	Green fodder yield (t ha^{-1})				Dry matter yield (t ha^{-1})			
	N_1	N_2	N_3	Mean	N_1	N_2	N3	Mean
S_1	38.90	40.23	46.66	41.93	5.25	5.59	6.72	5.85
S_2	39.78	41.68	47.00	42.82	5.49	6.02	7.03	6.18
S_3	34.34	38.83	43.91	39.02	4.43	5.28	6.19	5.3
Mean	37.67	40.24	45.85		5.05	5.63	6.64	
	Seed rates	**Nitrogen levels**	**Interactions (SxN)**		**Seed rates**	**Nitrogen levels**	**Interactions (SxN)**	
S. Em.±	0.870	0.870	1.507		0.118	0.118	0.205	
C.D. (P=0.05)	2.601	2.601	NS		0.354	0.354	NS	

S_1= 50 kg ha^{-1}, S_2= 40 kg ha^{-1} and S_3= 30 kg ha^{-1}
N_1 = 75% RDN, N_2 = 100% RDN and N_3 = 125% RDN

Table 2: Growth parameters of fodder sweet sorghum as influenced by seed rates and nitrogen levels

	Plant height (cm)				Leaf area (cm^2 0.3 m row length)				Leaf stem ratio				Nitrogen uptake (kg ha^{-1})			
	N_1	N_2	N_3	Mean	N_1	N_2	N3	Mean	N_1	N_2	N3	Mean	N_1	N_2	N3	Mean
S_1	143.1	160.8	178.7	160.9	10816.3	13081.6	14950.3	12949.4	0.26	0.29	0.32	0.29	64.97	77.36	102.40	81.57
S_2	146.1	165.6	186.4	166.0	11453.6	13893.0	15431.3	13592.6	0.28	0.30	0.34	0.30	68.39	85.07	108.21	87.22
S_3	138.5	155.0	170.3	154.6	8441.0	9128.3	9391.6	8987.0	0.25	0.26	0.28	0.26	53.04	70.99	93.75	72.59
Mean	142.5	160.4	178.4		10237	12034.3	13257.7		0.26	0.28	0.31		62.13	77.80	101.45	
	Seed rates	Nitrogen levels	Interactions (SxN)		Seed rates	Nitrogen levels	Interactions (SxN)		Seed rates	Nitrogen levels	Interactions (SxN)		Seed rates	Nitrogen levels	Interactions (SxN)	
S. Em.±	2.765	2.765	4.790		370.20	370.20	641.21		0.007	0.0072	0.012		2.72	2.72	4.72	
C.D. (P=0.05)	8.266	8.266	NS		1106.62	1106.62	NS		0.021	0.021	NS		8.15	8.15	NS	

S_1= 50 kg ha^{-1}, S_2= 40 kg ha^{-1} and S_3= 30 kg ha^{-1}
N_1 = 75% RDN, N_2 = 100% RDN and N_3 = 125% RDN

Green fodder yield and mean dry matter yield
Green fodder yield and mean dry matter yield of sweet sorghum as influenced by seed rates and nitrogen levels are presented in table 1. Significantly higher mean green fodder yield and mean dry matter yield were recorded with seed rate of 40 kg ha^{-1} (42.82 t ha^{-1} and 6.18 t ha^{-1}, respectively) as compared to seed rate of 30 kg ha^{-1} (39.02 t ha^{-1} and 5.30 t ha^{-1}, respectively) and it was on par with seed rate of 50 kg ha^{-1} (41.93 t ha^{-1} and 5.85 t ha^{-1}, respectively). Among the nitrogen levels significantly higher green fodder yield and dry matter yield were recorded with application of 125 per cent of RDN (45.85 t ha^{-1} and 6.64 t ha^{-1}, respectively) compared to 100 per cent of RDN (40.24 t ha^{-1} and 5.63 t ha^{-1}, respectively) and 75 per cent of RDN (37.67 t ha^{-1} and 5.05 t ha^{-1}, respectively). The interaction between seed rates and nitrogen levels was found to be non-significant.

The higher green fodder yield in seed rate of 40 kg ha^{-1} was mainly due to higher plant height, leaf stem ratio and leaf area. Apart from this the over burden of the plant population which might compete for light and nutrients which leads to lanky growth and grassy shoot appearance resulted in lower green fodder yield in seed rate of 50 kg ha^{-1}. These results are in conformity with the findings of Kaushuk *et al.* (2005) [11], Mishra *et al.* (1994) [15], Gaurkar and Bharad (1998) [8], Sajjankumar *et al.* (2004) Avatar Singh *et al.* (2008) [3]. The green fodder and dry matter yield were significantly higher at 125 per cent of RDN. This may be mainly attributed to improved growth and yield parameters, *viz.*, plant height, leaf area, leaf stem ratio and the beneficial effects of nitrogen on cell division and elongation, formation of nucleotides and Co-enzymes which resulted in increased meristematic activity and photosynthetic area and hence more production and accumulation of photosynthates, yielding higher green fodder and dry matter. These results are in conformity with the findings of Ayub *et al*. (2002) [4], Sheoran and Rana (2006)

[24], Chotiya and Singh (2005) [6] and Joshi and Kuldeep Kumar (2007) [10].

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