RESEARCH ARTICLE

Effect of Spacing and Fertilizer Levels on Growth, Yield and Economics of Fodder Maize Pre-Release Culture TNFM 131-9

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ABSTRACT

A field experiment was conducted for two years during 2019 - 21 at Field No.36 of Eastern block farm, Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore to identify the suitable plant spacing and nutrient levels for getting higher fodder yield and economics in fodder maize pre-release culture TNFM 131-9. The experiment was laid out in split plot design with three replications. The treatments consisted of four plant spacing viz., 30 cm × 15 cm, 30 cm × 10 cm, 20 cm × 10 cm and 40 cm × 15 cm and three nutrient levels *viz*., 75% RDF, 100% RDF and 125% RDF. The recommended dose of fertilizer (RDF) for fodder maize is 60:40:20 kg NPK ha^{-1}. The results revealed that wider spacing of 40 cm x 15cm recorded higher stem girth (2.21 cm), green fodder yield (44.80 t ha^{-1}), dry matter yield (12.10 t ha^{-1}) and crude protein yield (1.54 t/ha) which was on par with 30cm × 15cm. Application of 125% RDF (75:50:25 kg NPK/ha) resulted significantly higher stem girth (2.12 cm), green fodder yield (45.1 t ha^{-1}), dry matter yield (12.27 t ha^{-1}) and crude protein yield (1.49 t ha^{-1}) and it was on par with application of 100% RDF (60:40:20 kg NPK ha^{-1}).It can be concluded that adopting the plant spacing of 40cm × 15cm with application of 60:40:20 kg NPK ha^{-1} was found to be optimum for achieving higher green fodder and crude protein yield in the fodder maize pre-release culture TNFM 131-9.

Keywords: *Fodder maize; Pre-release culture TNFM 131-9; Green fodder yield*

INTRODUCTION

Agriculture in India is a financial symbiosis of crop and livestock production with cattle as the foundation. Livestock acts as a pivotal resource and the safety net for farmers especially to the larger extent of small and marginal farmers. It plays an essential role in the rural economy of India by offering employment and additional income in addition to the supply of balanced diet through milk, meat and egg to the millions of people. According to 20th livestock census, India possess 535.78 millions of livestock and it ranks first in cattle buffalo population with 193.46 million and 109.85 million, respectively and also have the world's second largest goat (148.88 millions) and third largest sheep (74.26 millions) population (Livestock census, 2019). Although India has made larger stride in livestock population, the productivity of milk and other livestock products are very low due to the acute shortage of feeds and forages together with its destitute quality (Sivakumar and Babu, 2019). The area under fodder crops has almost remained still for the last four decades. In order to meet the mounting demand of nutritious green fodder for livestock, it is essential to introduce high yielding fodder varieties of grasses, cereals and legumes. Among the non-leguminous fodder crops cultivated in India, fodder maize is the only fodder which holds the better nutritional quality along with good quantity of biomass (Rajesh Jolad *et al*., 2018). The fodder maize pre-release culture TNFM 131-9evolved by the Department of Forage Crops, TNAU, Coimbatore has the dry matter content of 22.4 per cent with the protein content of 12.4 per cent with easy digestibility. The harvest can be done at 60 days after sowing which is one week lesser than the existing fodder maize (var. African Tall) and it possesses the green fodder yield potential of 45t/ha. Agronomic factors such as optimum plant population and balanced fertilizer management have significant effect on crop environment, which influence crop growth and yield. Karlen *et al*. (1985) reported that optimum plant population is one of the primary factors which decide the growth and yield in crops. Optimum population should be maintained to exploit maximum natural resources, such as nutrients,

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sunlight and soil moisture, to ensure satisfactory growth and yield. Adequate supply of primary macro nutrients enhances the photosynthetic activity and also turns on the metabolic activity in seedlings which in turn leads to higher growth and yield (Brandon and Date. 1998). Among the nutrients nitrogen is the primary factor for increasing the biomass production of forage crops which largely depends on the function of leaf area development and consequential photosynthetic activity (Natr, 1992). Keeping these in view, the field experiment was conducted for two years during 2019- 2021 to optimize the plant population and nutrient levels for the fodder maize pre-release culture TNFM131-9

MATERIAL AND METHODS

The field experiment was conducted for two years during 2019 - 21 at Field No.36 of Eastern block farm, Department of Agronomy, TNAU, Coimbatore to identify the suitable spacing and nutrient levels for higher yield and economics in fodder maize pre-release culture TNFM 131-9. The experiment was laid out in split plot design with three replications. The treatments consisted of plant spacing as main plot factor with four levels viz., 30 cm × 15 cm (S_1), 30 cm × 10 cm (S_2), 20 cm × 10 cm (S_3) and 40 cm × x 15 cm (S_4) and nutrient management as sub-plot factor with three levels viz., 75% RDF (N_1), 100% RDF (N_2) and 125% RDF (N_3). The recommended dose of fertilizer for existing fodder maize is 60:40:20 kg NPK/ha. The soil of the experimental field was low in available nitrogen (206 kg ha^{-1}), medium in available phosphorus (10.2 kg ha^{-1}) and high in available potassium (402 kg ha^{-1}). The growth and yield parameters of fodder maize pre-release culture TNFM 131-9 were recorded. The laboratory analysis for estimating the crude protein percentage was done and data were documented. Total nitrogen content was estimated by micro kjeldahl's method suggested by Humphries, (1956) and was multiplied with the factor (6.25) to obtain the crude protein content. Crude protein content was multiplied with dry matter yield to obtain crude protein yield. Economic indicators *viz*., cultivation cost, gross returns, net returns and benefit cost ratio were worked for all the treatments out on the basis of prevailing input cost and market price of fodder crops at the time of experimentation. Data on various biometric observations studied during the course of investigation were statistically analyzed as suggested by Gomez and Gomez, (1984).

RESULTS AND DISCUSSION

Mean of three trial results showed that spacing and fertilizer levels resulted significant impact on growth and yield of fodder maize culture TNFM131-9.

Plant height

Plant height of fodder maize pre-release culture TNFM 131-9 was not significantly influenced by different spacing. However, fertilizer levels exerted a substantial impact on plant height (Table 1 & Figure 1). Application of 125 per cent RDF (75:50:25 kg NPK/ha) registered the maximum plant height of 321.6 cm and it was on par with 100 % of RDF (60:40:20 kg NPK/ha) which recorded the plant height of 317.5 cm. Enhancement of plant height under higher fertilizer level might be attributed to the higher photosynthetic activity with greater nitrogen supply. Soni *et al*. (1991) also stated that enhanced cell division and multiplication with higher availability of macronutrients might be the reason for higher plant height. Application of 75 % RDF (45:30:15 kg NPK/ha) recorded significantly the lesser plant height of 290.1 cm. This might probably be due to the reduced supply of nutrients when compared to higher levels. This is in conformity with the findings of Sivakumar and Babu, (2019). There was no interaction effect observed between spacing and nutrient levels on plant height.

Table 1. Effect of spacing and fertilizer levels on plant height of fodder maize pre-release culture TNFM 131-9 (Mean of three trials)

	S_1	S_2	S_3	S_4	Mean
N_1	284.4	291.2	297.8	286.9	**290.1**
N_2	313.1	316.1	324.4	315.3	**317.5**
N_3	318.2	323.2	329.5	316.4	**321.6**
Mean	**305.4**	**310.2**	**316.7**	**306.6**	**309.7**
		S	**N**	**S x N**	
	SED	**9.8**	**8.9**	**9.7**	
	CD (5%)	**NS**	**18.1**	**NS**	

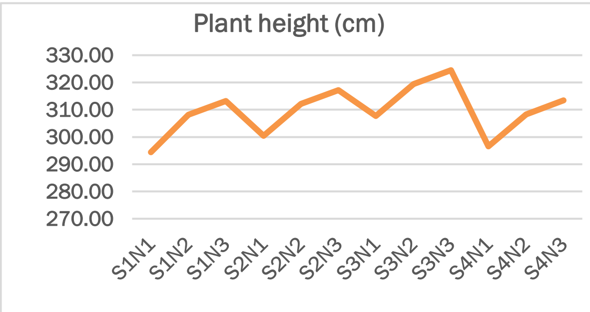

Figure 1. Plant height (cm)

Stem girth

Significant variation in stem girth of the fodder maize pre-release culture TNFM 131-9 was observed due to different spacing and fertilizer levels (Table 2 & Figure 2). Among the different spacing studied, wider spacing of 40cm × 15cm recorded maximum stem girth of 2.17 cm, however it was on par with the plant spacing of 30cm × 15cm and 30cm × 10cm. Whereas, closer spacing of 20cm × 10 cm registered significantly the lower stem girth of 1.81cm. Huge competition between plants for resources like nutrients, solar energy and water under closer spacing might have suppressed the performance of individual plants and resulted in lesser stem girth. The result is in complete agreement with the findings of Imran *et al*., (2015).Application of 125 per cent RDF (75:50:25 kg NPK/ha) recorded significantly higher stem girth of 2.12 cm and it was on par with application of 100 percent RDF(60:40:20 kg NPK/ha). It might be due to increased supply of macro nutrients in general and nitrogen in particular for higher synthesis and accumulation of photosynthates in the stem. These results are in line with the findings of Natr, (1992). However, application of 75% RDF (45:30:15 kg NPK/ha) resulted the lower stem girth of 1.93 cm. It might be attributed by reduced photosynthetic activity in plants due to lack of sufficient nutrients. Among the interaction, adopting the spacing of 40cm × 15cm with application of 125 percent RDF (75:50:25 kg NPK/ha) (S_4N_3 treatment) registered the maximum stem girth of 2.24 cm and it was on par with S_1N_3 and S_4N_2 treatments which recorded stem girth of 219 cm and 2.18 cm, respectively. It might be due to higher availability of nutrients under optimum plant population that enhanced the growth and vigour of the crop and in turn resulted in higher stem girth.

Table 2. Effect of spacing and fertilizer levels on stem girth (cm) of fodder maize pre-release culture TNFM 131-9 (Mean of three trials)

	S_1	S_2	S_3	S_4	Mean
N_1	2.03	2.01	1.72	2.08	**1.93**
N_2	2.13	2.11	1.82	2.18	**2.06**
N_3	2.19	2.16	1.88	2.24	**2.12**
Mean	**2.12**	**2.09**	**1.81**	**2.17**	**2.05**
		S	N	S x N	
	SED	0.09	0.05	0.04	
	CD (5%)	0.20	0.12	0.08	

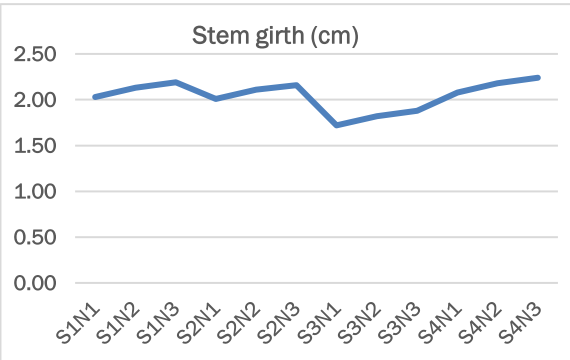

Figure 2. Stem girth

Green fodder yield

Green fodder yield of fodder maize pre-release culture TNFM 131-9 was significantly influenced by different spacing and fertilizer levels (Table 3 & Figure 3).The data of different spacing showed that plant spacing of 40cm × 15cm recorded significantly higher green fodder yield of 44.8 t/ha and it was on par with 30cm × 15cm and 30cm × 10 cm. Imran *et al*., (2015) also reported that optimum plant stand has allowed the fodder crop to intercept and use solar radiation more efficiently for higher photosynthates assimilation and in turn paves the way for achieving potential yield. However, lower green fodder yield of 42.2 t/ha was registered with closer spacing of 20 cm x 10 cm. Among the different fertilizer levels, application of 125 per cent RDF (75:50:25 kg NPK/ha) recorded significantly higher green fodder yield of 45.1 t/ha and it was on par with application of 100 per cent RDF (60:40:20 kg NPK/ha). This might be due to proportional supply of primary macro nutrients which in turn allowed the leaves continue to function photosynthetically and also triggered the metabolic activity in plants that led to higher growth and finally yield. The higher green fodder yield with application of sufficient quantity of nutrients was also reported by Rajesh Jolad *et al*., (2018). The green fodder yield (41.8 t/ha) was lower with application of 75% RDF (45:30:15 kg NPK/ha). Reduced accumulation of photosynthates due to the shortage of nutrients might be the reason for lower green fodder yield in lower fertilizer levels. Among the interaction, adopting the spacing of 40cm × 15cm with application of 125 per cent recommended dose of fertilizers (75:50:25 kg NPK/ha) recorded significantly higher green fodder yield of 46.2 t/ha and it was on par with adopting the spacing of 40 cm × 15cm with application of 100 per cent RDF (60:40:20 kg NPK/ha) and adopting the spacing of 30cm × 15cm with application of 125 per cent RDF (75:40:25 kg NPK/ha). Higher supply of nutrients in these treatments might have accumulated relatively high synthates and led to increased green fodder yield. The results of the experiment also support the earlier observations of Bewley, (1997). Adopting the narrow spacing of 20 cm × 10 cm with application of 75 per cent RDF (45:30:15 kg NPK/ha) registered with significantly lower green fodder yield of 40.3 t/ha.

Table 3. Effect of spacing and fertilizer levels on green fodder yield (t/ha) of fodder maize pre-release culture TNFM 131-9 (Mean of three trials)

	S_1	S_2	S_3	S_4	Mean
N_1	42.5	41.5	40.3	42.9	**41.8**
N_2	45.0	44.0	42.8	45.4	**44.3**
N_3	45.2	44.8	43.6	46.2	**45.1**
Mean	**44.4**	**43.4**	**42.2**	**44.8**	**43.7**
		S	N	S x N	
	SED	1.14	1.17	0.84	
	CD (5%)	2.34	2.37	1.74	

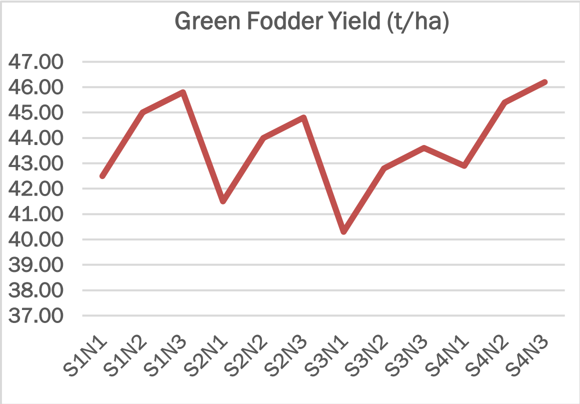

Figure 3. Green fodder yield

Dry matter yield

There was an appreciable difference in dry matter yield of fodder maize pre-release culture TNFM 131-9 due to different spacing and fertilizer levels (Table 4 & Figure 4). Significantly higher dry matter yield of 12.20 t/ha was recorded under wider spacing of 40cm × 15cm and it was on par with 30cm × 15cm and 30cm × 10 cm. Whereas, lower dry matter yield of 11.50 t/ha was registered in narrow spacing of 20 cm × 10 cm. This could be attributed by reduced root and stem growth of seedlings due to relatively less supply of nutrients and moisture resulted by excess population. Reduction of dry matter accumulation under narrow spacing was also reported by Imran *et al*., (2015). Regarding different nutrient levels, application of 125 per cent RDF (75:50:25 kg NPK/ha) recorded significantly higher dry matter yield of 12.27 t/ha and it was on par with application of 100 percent RDF(60:40:20 kg NPK/ha) which recorded the dry matter yield of 12.05 t/ha. Adequate availability of nutrients and the presence of larger photosynthesizing surface, production and accumulation of photosynthates proceeded at a rapid rate leading to greater dry matter accumulation. It might be the reason for significantly higher dry matter yield in these treatments. The results of the present study are also in accordance with findings of Banasode and Math, (2018). While, application of 75% RDF (45:30:15 kg NPK/ha) recorded significantly the lower dry matter yield of 11.38 t/ha. It might be due to reduced growth and vigour of plants due to the lack of sufficient nutrients. Among the interaction, the spacing of 40cm × 15cm with application of 125 per cent RDF (75:50:25 kg NPK/ha) recorded significantly higher dry matter yield of 12.57 t/ha and it was on par with $S_1N_3$and S_4N_2 treatments. This was probably due to higher production and accumulation of assimilates under optimum population of plants with adequate supply of nutrients. The results are in line with the findings of Sivakumar and Vasuki, (2019).

Table 4. Effect of spacing and fertilizer levels on dry matter yield (t/ha) of fodder maize pre- release culture TNFM 131-9 (Mean of three trials)

	S_1	S_2	S_3	S_4	Mean
N_1	11.56	11.30	10.98	11.68	**11.38**
N_2	12.24	11.98	11.65	12.35	**12.05**
N_3	12.45	12.19	11.87	12.57	**12.27**
Mean	**12.09**	**11.82**	**11.50**	**12.20**	**11.90**
		S	N	S x N	
	SED	0.31	0.29	0.27	
	CD (5%)	0.64	0.60	0.56	

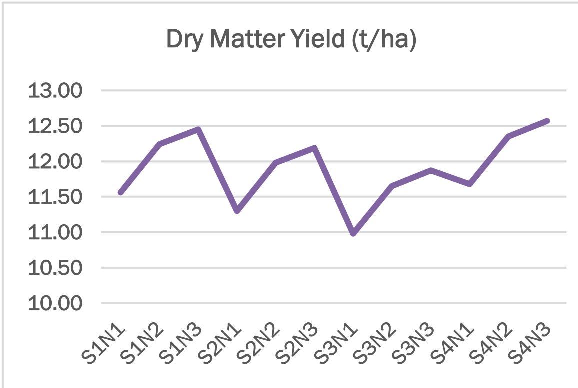

Figure 4 Dry matter yield

Crude protein yield

Crude protein yield of fodder maize pre-release culture TNFM 131-9 was appreciably influenced by different spacing and fertilizer levels (Table 5 & Figure 5). Among the different plant spacing adopted, wider spacing of 40cm × 15cm recorded significantly higher crude protein yield of 1.48 t/ha. However, it was statistically on par with plant spacing of 30cm × 15cm and 30cm × 10 cm. Dry matter fractions form the basis for crude protein yield and therefore higher absorption and accumulation of dry matter due to well established root and shoot system under optimum plant stand might have resulted in higher crude protein yield. This is in conformity with the findings of Natr, (1992). The crude protein yield was lower (1.40 t/ha) in closer plant spacing of 20 cm × 10 cm. It was because of lower dry matter yield resulted due to overcrowding of plants under closed spacing. Among the different fertilizer levels, application of 125 per cent RDF (75:50:25 kg NPK/ha) recorded significantly higher crude protein yield of 1.49 t/ha and it was on par with application of 100 percent RDF (60:40:20 kg NPK/ha). This might be due to accelerated accumulation of dry matter with adequate supply of primary nutrients. The current observations are in line with the finding of Rajesh Jolad *et al*., (2018). However, application of 75% RDF (45:30:15 kg NPK/ha) recorded the lower crude protein yield of 1.39 t/ha. The interaction effect of plant spacing and fertilizer levels revealed that the plant spacing of

40cm × 15cm with application of 125 per cent RDF (75:50:25 kg NPK/ha) recorded significantly higher crude protein yield of 1.52 t/ha. The treatment was on par with the spacing of 40 cm × 15cm with 100 per cent RDF (60:40:20 kg NPK/ha) and spacing of 30cm × 15cm with 125 per cent RDF (75:40:25 kg NPK/ha). This might be due to higher dry matter yield with the supply sufficient nutrients and other resources under optimum plant stand. Similar results were also reported by Sivakumar and Babu, (2019).

Table 5. Effect of spacing and fertilizer levels on crude protein yield (t/ha) of fodder maize pre-release culture TNFM 131-9 (Mean of three trials)

	S_1	S_2	S_3	S_4	Mean
N_1	1.40	1.38	1.34	1.42	**1.39**
N_2	1.48	1.46	1.41	1.50	**1.46**
N_3	1.51	1.48	1.43	1.52	**1.49**
Mean	**1.47**	**1.44**	**1.40**	**1.48**	**1.45**
		S	N	S x N	
	SED	0.03	0.04	0.03	
	CD (5%)	0.06	0.08	0.05	

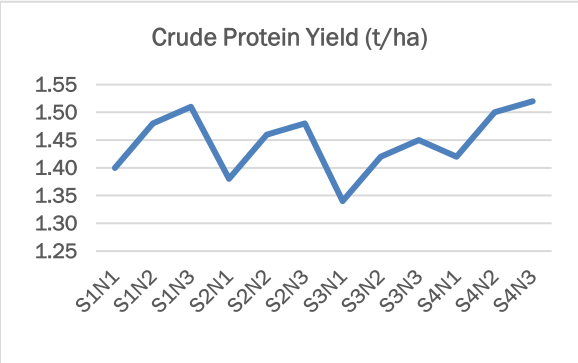

Figure 5 Crude protein yield

Economics

The data on economic indices as influenced by different plant spacing and fertilizer levels (Table 6) revealed that wider spacing of 40cm × 15cm with application of 125 per cent RDF (75:50:25 kg NPK/ha) recorded significantly higher gross return (Rs.92,400/- per hectare), net return (Rs.47,520/- per hectare) with benefit cost ratio of 2.06. It was closely followed by adopting the wider spacing of 40cm × 15cm with application of 100 per cent RDF (60:40:20 kg NPK/ha) which recorded the gross return of Rs.90,800/- per hectare and net return of Rs.46,536/- per hectare with benefit cost ratio of 2.04. Higher green fodder yield obtained with optimum plant population and sufficient supply of nutrients might be the reason for getting higher net return and BCR. However, lower gross return of Rs.80,600/- per hectare, net return of Rs.34,776/- per hectare and benefit cost ratio of 1.76 were recorded in narrow spacing of 20 cm × 10 cm with application of 75 per cent RDF (45:30:15 kg NPK/ha)

Table 6. Effect of spacing and fertilizer levels on economics of fodder maize pre- release culture TNFM 131-9 (Mean of three trials)

Treatments	Cost of Cultivation (Rs. /ha)	Gross returns (Rs. /ha)	Net returns (Rs/ha)	BCR
S_1N_1	44305	85000	40696	1.92
S_1N_2	44721	90000	45280	2.01
S_1N_3	45137	91600	46464	2.03
S_2N_1	44981	83000	38019	1.85
S_2N_2	45397	88000	42603	1.94
S_2N_3	45813	89600	43787	1.96
S_3N_1	45824	80600	34776	1.76
S_3N_2	46240	85600	39360	1.85
S_3N_3	46656	87200	40544	1.87
S_4N_1	44048	85800	41752	1.95
S_4N_2	44464	90800	46536	2.04
S_4N_3	44880	92400	47520	2.06

CONCLUSION

It could be concluded that adopting the plant spacing of 40cm × 15cm with application of 60:40:20 kg NPK/ha was found to be optimum for achieving higher productivity (green fodder and crude protein yield) and profitability in cultivation of the fodder maize pre-release culture TNFM 131-9.

Ethics statement

No specific permits were required for the described field studies because no human or animal subjects were involved in this research.

Originality and plagiarism

We ensure that we have written and submit only entirely original works with no plagiarism

Consent for publication

All the authors agreed to publish the content.

Competing interests

There were no conflict of interest in the publication of this content

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