International Journal of Plant & Soil Science

33(22): 251-259, 2021; Article no.IJPSS.76026
ISSN: 2320-7035

Effect of Crop Geometry and Nutrient Management Approaches on Soil Properties and Availability of Nutrients under Transplanted Finger Millet

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2021/v33i2230703
Editor(s):
(1) Dr. Hon H. Ho, State University of New York, USA.
Reviewers:
(1) María Maura Margarita Teutli León, Benemerita Universidad Autonoma de Puebla, Mexico.
(2) Chadetrik Rout, Deemed to be University, India.
(3) Mónica Guadalupe Lozano Contreras, National Institute of forest research agricultural and livestock, Mexico.
Complete Peer review History: http://www.sdiarticle4.com/review-history/76026

Original Research Article

Received 15 August 2021
Accepted 30 October 2021
Published 05 November 2021

ABSTRACT

The present investigation was conducted for two consecutive years with the objective to know various crop geometries and nutrient management approaches on soil chemical properties at Agricultural college farm, Bapatla. The experimental design was split plot with three replications. The present study comprised of three crop geometries with different age of seedlings (30x10 cm with 30 days old seedlings, 30x30 cm with 15 days old seedlings and 45x45 cm with 15 days old seedlings) and seven nutrient management practices (S_0: absolute control, S_1: FYM @ 10 tonnes ha^{-1} + application of *dravajeevamrutham*, S_2: FYM @ 10 tonnes ha^{-1} + application of *dravajeevamrutham* along with wooden log treatment, S_3: FYM @ 10 tonnes ha^{-1} + 100% RDF, S_4: FYM @ 10 tonnes ha^{-1} + 100% RDF along with wooden log treatment, S_5: FYM @ 10 tonnes ha^{-1} + 125% RDF, S_6: FYM @ 10 tonnes ha^{-1} + 125% RDF along with wooden log treatment in subplots were given to *kharif* finger millet. integrated application of FYM @ 10 tonnes ha^{-1} + 125% RDF along with wooden log treatment (S_6) resulted in higher organic carbon and nutrient status of the soil and reduced C:N ratio of the soil significantly though other soil properties were non significant due to various crop geometries and nutrient management treatments.

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Keywords: Finger millet; crop geometry; nutrient management and soil properties.

1. INTRODUCTION

Finger millet (*Eleusine coracana* L. Gaertn.), an indispensable component of dryland farming systems (Kerr [1], Pokharia *et al*. [2] and Goron *et al*. [3] is a major food crop of the semi-arid tropics of Asia and Africa. It is considered as poor man's food that has the capacity to produce consistent yield, even without special care. Finger millet with it's wonder grain quality is rich in calcium, iron and protein, (8 to 11 per cent protein) having a unique quality of slower digestibility and medicinal value is recommended as the diet for diabetic persons as well as pregnant women (Watt and Breyer Brandwijk) [4]. Among world nations, finger millet holds number one position with 50 per cent area contributing 2.8 million tonnes of production and ranked fourth globally in importance among the millets, after sorghum, pearl millet and foxtail millet (Gupta *et al*.) [5].

On global basis, finger millet occupies an area of 3.0 million ha producing 3.8 million tonnes with a productivity of 1.3 tonnes ha^{-1}. India alone contributes more than 50 per cent of the world production with an area of 1.2 million ha and a production of 1.75 million tonnes and productivity of 1.7 tonnes ha^{-1}, respectively. Being a low fertilizer input and staple food crop for tribal and lower income class, it suffers from low yields (Rurinda *et al*.) [6]. Productivity limit in finger millet is attributed to resource-poor soils of rainfed areas deficient in macro and micronutrients, besides continuous cropping, poor recycling of crop residues and low rates of organic matter application (Rao *et al*.) [7]. Delayed transplanting, coupled with faulty methods of cultivation, lower fertilizer use efficiency and higher seed rate are the other reasons for it's poor yields. Among the modern agro-management practices, suitable planting method and nutrient application are imperative for boosting the growth and production of finger millet.

Crop geometry of any crop depends on several factors *viz*., plant type, season, soil fertility and age of seedlings. An ideal crop geometry is essential for obtaining optimum plant stand in the field as the yield of a crop depends on the final plant density with effective utilization of growth resources. Conjunctive use of chemical fertilizers and organic manures is important to maintain and sustain soil fertility and crop productivity (Hebbal) [8]. Organic manures enrich soil organic matter, improve soil physical and biological environment and act as store house of nutrients. Since integrated nutrient management system is gaining importance among the farmers, it is advisable to optimize the use of inorganic fertilizers along with organic manures such as FYM, for getting high yields of better quality besides sustaining soil fertility.

2. MATERIALS AND METHODS

The experiment was conducted at Agricultural college farm, Bapatla during the *kharif* seasons of 2018 and 2019. The soil of experimental site was sandy clay loam in texture with slightly alkaline reaction, low organic carbon content, low available nitrogen and medium in available phosphorous and potassium. The experiment was laid in split plot design with 21 treatments, replicated thrice. The treatments comprised of two factors, *viz*., crop geometries with different age of seedlings (M_1: 30x10 cm with 30 days old seedlings, M_2: 30x30 cm with 15 days old seedlings and M_3: 45x45 cm with 15 days old seedlings) and seven nutrient management practices (S_0: absolute control, S_1: FYM @ 10 tonnes ha^{-1}+ application of *dravajeevamrutham*, S_2: FYM (Farm yard manure) @ 10 tonnes ha^{-1} + application of *dravajeevamrutham* along with wooden log treatment, S_3: FYM @ 10 tonnes ha^{-1} + 100% RDF, S_4: FYM @ 10 tonnes ha^{-1} + 100% RDF along with wooden log treatment, S_5: FYM @ 10 tonnes ha^{-1} + 125% RDF, S_6: FYM @ 10 tonnes ha^{-1} + 125% RDF along with wooden log treatment. The RDF (Recommended dose of fertilizers) of 60 kg N ha^{-1} through urea, 40 kg P_2O_5 ha^{-1} through single super phosphate and 30 kg K_2O ha^{-1} through muriate of potash as per treatments.

2.1 Soil pH

Soil pH was determined with the help of glass electrode pH meter in 1:2.5 soil water suspensions as described by Jackson [9].

2.2 Electrical Conductivity (dSm^{-1})

Electrical conductivity was determined with the help of electrical conductivity meter in 1:2.5 soil water suspensions as described by Jackson [9].

2.3 Organic Carbon (%)

Organic carbon was determined with the help of Walkley and Black's rapid titration method as advocated by Walkley and Black [10].

2.4 C:N Ratio

Organic carbon (C) concentration evaluated by the Walkley-Black method and total nitrogen (N) concentration determined by Kjeldahl method, were compared with corresponding results of C and N concentrations obtained through the dry combustion method.

2.5 Available Nutrients (N, P & K) in soil (kg ha^{-1})

The available nitrogen (N) content in soil samples was determined by alkaline permanganate method as described by Subbiah and Asija [11]. The available phosphorus (P) in soil determined by Olsen's method as per procedure described by Olsen *et al*. [12]. The available potassium (K) in soil was determined by neutral normal ammonium acetate extractant using a flame photometer (Jackson) [9].

3. RESULTS AND DISCUSION

3.1 Soil pH

Though the crop geometries failed to exert significant influence on pH of the soil, the values ranged between 7.35 and 7.51. The similar results were also observed by Harikesh *et al*. [13] who found that the soil pH was not differed significantly due to different crop geometries tried in rice (Table. 1.).

With regard to the various nutrient management practices tried in the experiment, the soil pH was not significantly influenced by the treatments. The soil pH ranged from 7.22 to 7.55 in different treatments during 2018-19, 7.35 to 7.53 during 2019-20 and in pooled data soil pH ranged from 7.31 to 7.51 in different treatments. The current results are in conformity with the earlier findings by Sridevi *et al*. [14] and Andleeb *et al*. [15] who found that neither residue nor fertilizer treatments had a significant influence on soil pH values.

3.2 Electrical Conductivity (dsm^{-1})

A glance at the data indicated a non-significant influence of crop geometries, nutrient management and their interaction. The similar results were also observed by Harikesh *et al*. [13] who found that the soil EC was not differed significantly due to different crop geometries tried in rice. The current results are in conformity with the earlier findings by Tolanur and Badanur [16] who found that neither residue nor fertilizer treatments had a significant influence on soil EC values.

3.3 Soil Organic Carbon

Soil organic carbon did not differ significantly due to different crop geometries in finger millet during both years and in pooled data. Joginaidu *et al*. [17], Singh [18] observed a non significant influence of crop geometry on organic carbon content and numerically higher values with narrow spacing compared to wider spacing. Further, Hebbal [8] stated that regular addition of organic matter is a food for microbes, insects, worms and other organisms. Building organic matter is a slow process where the amount of residue and active organic matter will increase first and then the species and diversity of organisms in the soil will change and amounts of stabilized organic matter will rise. It may take a decade or more for total organic matter levels to significantly increase after a management change.

The data on organic carbon content also indicates that the influence of nutrient management treatments was consistent. Significantly the highest organic carbon content (0.53, 0.55 and 0.54 during 2018-19, 2019-20 and in pooled data, respectively) was registered in S_6 (125% RDF + FYM 10 tonnes ha^{-1} along with wooden log treatment). Significantly the lowest organic carbon content (0.43, 0.44 and 0.43 during 2018-19, 2019-20 and in pooled data, respectively) was recorded in absolute control (Table.1.). Sharma and Subehia [19] reported greater levels of soil organic carbon under integrated treatments of organic and inorganic combinations in Alfisols. Direct addition of organic matter in the form of FYM in an integrated plant nutrient supply system might be attributed to increased soil organic carbon content (Acharya, *et al*.) [20]. The beneficial effect of balanced nutrition through IPNS over the control treatment on the soil organic carbon content was attributed to better crop growth with concomitant greater root biomass generation and greater return of leftover surface plant residues (Christensen) [21]. Arbad [22] and Saha *et al*. [23] also reported a significant improvement in organic carbon with integrated nutrient management practices over control.

Table 1. pH, EC, OC and C:N ratio of soil as influenced by crop geometry and nutrient management practices after harvest of finger millet during *kharif,* 2018-19 & 2019-20 and in pooled data

Treatments	pH			Electrical Conductivity(dsm^{-1})			Organic Carbon			C:N ratio		
	2018-19	**2019-20**	**Pooled data**	**2018-19**	**2019-20**	**Pooled data**	**2018-19**	**2019-20**	**Pooled data**	**2018-19**	**2019-20**	**Pooled data**
Crop geometry												
M_1- 30×10 cm with 30 days old seedlings	7.39	7.40	7.40	0.39	0.48	0.43	0.51	0.51	0.51	12.78	12.18	12.48
M_2- 30×30 cm with 15 days old seedlings	7.35	7.51	7.43	0.45	0.45	0.45	0.49	0.50	0.50	11.88	11.32	11.60
M_3- 45×45 cm with 15 days old seedlings	7.36	7.43	7.40	0.46	0.50	0.48	0.50	0.51	0.50	12.86	12.39	12.63
S.Em±	0.08	0.17	0.11	0.02	0.02	0.01	0.01	0.01	0.01	0.27	0.28	0.28
CD (p = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	5.02	10.50	6.56	18.45	14.77	12.09	10.39	6.55	6.28	10.00	10.89	10.58
Nutrient management												
S_0-Absolute control	7.29	7.46	7.37	0.41	0.43	0.42	0.43	0.44	0.43	15.41	14.72	15.06
S_1- FYM @ 10 tonnes ha^{-1} + *dravajeevamrutham*	7.22	7.42	7.32	0.42	0.50	0.46	0.49	0.48	0.48	13.29	12.65	12.97
S_2- S_1+ passing wooden log	7.27	7.35	7.31	0.44	0.49	0.46	0.49	0.48	0.48	12.92	12.46	12.69
S_3- FYM @ 10 tonnes ha^{-1} + 100% RDF	7.41	7.52	7.46	0.41	0.49	0.45	0.51	0.51	0.51	12.02	11.29	11.65
S_4- S_3+ passing wooden log	7.50	7.53	7.51	0.46	0.49	0.47	0.52	0.53	0.53	11.70	11.04	11.37
S_5- FYM @ 10 tonnes ha^{-1} + 125% RDF	7.36	7.38	7.37	0.46	0.48	0.47	0.53	0.55	0.54	11.25	10.87	11.06
S_6- S_5+ passing wooden log	7.55	7.46	7.51	0.44	0.46	0.45	0.53	0.55	0.54	10.97	10.73	10.85
S.Em±	0.14	0.13	0.13	0.03	0.03	0.02	0.02	0.01	0.01	0.38	0.44	0.32
CD (p = 0.05)	NS	NS	NS	NS	NS	NS	0.05	0.03	0.03	1.08	1.25	0.92
CV (%)	5.72	5.18	5.35	19.28	15.81	13.11	10.36	6.41	7.25	9.06	10.91	7.82
Interaction												
M x S	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
S x M	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Available nutrients in soil (kg ha^{-1})

3.4 C: N Ratio

The data indicates that the C:N ratio was significantly influenced by nutrient management practices only but not due to various crop geometries and their interaction. With regard to nutrient management practices, S_6 treatment reduced the C:N ratio of the soil significantly (10.97, 10.73 and 10.85 during 2018-19, 2019-20 and in pooled data, respectively) and was on a par with all the integrated nutrient management practices. Farmers practices (S_1 and S_2) were comparable with S_3 treatment during both years of study. The highest value of C:N ratio (15.41, 14.72 and 15.06 during 2018-19, 2019-20 and in pooled data, respectively) was observed in the absolute control.

Combined use of fertilizers and well decomposed FYM helped to reduce the C:N ratio of soil significantly which finally leads to improvement in the available nutrient status of soil. The current findings are supported by the earlier researchers Ravankar *et al*. [24] and Kharate [25].

The data indicates that the available nitrogen, phosphorus and potassium were significantly influenced by nutrient management practices only and not by various crop geometries and their interaction (Table.2.). Anitha [26] also reported a non significant influence of crop geometries and age of seedlings on the post harvest soil nutrient status.

Nitrogen (kg ha^{-1}): With regard to the nutrient management practices, the available nitrogen was significantly the highest (173.7, 178.4 and 176.0 kg ha^{-1} during 2018-19, 2019-20 and in pooled data, respectively) with the application of 125% RDF + FYM @ 10 tonnes ha^{-1} along with wooden log treatment (S_6), which was on a par with 125% RDF + FYM @ 10 tonnes ha^{-1} (S_5). The lowest available nitrogen (123.0, 127.0 and 125.0 kg ha^{-1} during 2018-19, 2019-20 and in pooled data, respectively) was observed with absolute control.

Applying higher levels of NPK fertilizers along with 10 tonnes FYM ha^{-1}, could be the reason for higher residual available nitrogen in soil after the harvest of the preceding finger millet crop. The current findings are supported by Kumar [27].

Phosphorus (kg ha^{-1}): Among the nutrient management practices, the post-harvest soil available phosphorous was higher (33.9, 35.8 and 34.9 kg ha^{-1} during 2018-19, 2019-20 and in pooled data, respectively) with 125% RDF+FYM @ 10 tonnes ha^{-1} along with wooden log treatment (S_6) which was significantly superior to the rest of the treatments except S_5 alone during 2019-20 and in pooled data and S_4 and S_5 both during 2018-19. S_4 treatment was on a par with S_3. The lowest residual available phosphorous in soil (24.3, 27.4 and 25.8 kg ha^{-1} during 2018-19, 2019-20 and in pooled data, respectively) was observed in absolute control.

Applying fertilizers, combined with manures in the nutrient management practices might have added more phosphorus to benefit the crop growth and this more phosphorus added in 100% and 125% RDF to finger millet crop could be reason for high residual soil phosphorus. Further addition of 10 tonnes FYM ha^{-1} to finger millet might have resulted in better soil physical and chemical conditions. The better soil conditions could be the reason for high conversion of unavailable phosphorus reserves to available forms in the soil leading to high residual available phosphorus. The current results are in line with the earlier findings of Parmer and Sharma [28], Verma *et al*. [29] and Tolanur and Badanur [16].

Potassium (kg ha^{-1}): With respect to nutrient management practices, the post-harvest soil available potassium was higher with 125% RDF+FYM @ 10 tonnes ha^{-1} along with wooden log treatment (S_6) (313.5, 313.8 and 313.7 kg ha^{-1} during 2018-19, 2019-20 and in pooled data, respectively) which was significantly superior to rest of the treatments except S_4 and S_5. While, the lowest residual available potassium in soil (235.3, 244.2 and 239.8 kg ha^{-1} during 2018-19, 2019-20 and in pooled data, respectively) was observed with absolute control.

The post harvest soil fertility was superior with integrated nutrient management practices tried in the experiment. The findings are similar to the earlier findings of Kumar [27] who reported higher available nutrients in soil with the application of 100% N +7.5 t FYM which might be attributed to the direct addition of readily available inorganic nutrients and slow release of nutrients from organic manure added to soil. The beneficial and favorable effect of organic manures on nutrient availability to crops was due to their solubility effect of different forms of mineral nutrients present in soil and their own contribution.

Table 2. Available NPK status (kg ha^{-1}) of the soil as influenced by crop geometry and nutrient management practices after harvest of finger millet during *kharif,* 2018-19 & 2019-20 and in pooled data

Treatments	Nitrogen (N)			Phosphorus (P_2O_5)			Potassium (K_2O)		
	2018-19	2019-20	Pooled data	2018-19	2019-20	Pooled data	2018-19	2019-20	Pooled data
Crop geometry									
M_1- 30×10 cm with 30 days old seedlings	148.2	148.5	148.3	28.9	31.7	30.3	270.4	281.4	275.9
M_2- 30×30 cm with 15 days old seedlings	151.1	155.5	153.3	30.2	32.4	31.3	280.1	284.6	282.4
M_3- 45×45 cm with 15 days old seedlings	152.9	160.7	156.8	30.0	32.2	31.1	286.9	288.3	287.6
S.Em±	2.37	3.29	3.06	0.86	0.50	0.44	4.54	4.66	4.69
CD (p = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	7.20	9.74	9.18	13.28	7.10	6.56	7.45	7.50	7.61
Nutrient management									
S_0-Absolute control	123.0	127.0	125.0	24.3	27.4	25.8	235.3	244.2	239.8
S_1- FYM @ 10 tonnes ha^{-1} + *dravajeevamrutham*	136.0	140.1	138.0	26.7	29.7	28.2	257.9	265.2	261.6
S_2- S_1+ passing wooden log	140.0	145.2	142.6	27.8	30.7	29.2	263.7	273.3	268.5
S_3- FYM @ 10 tonnes ha^{-1} + 100% RDF	153.6	158.5	156.1	30.4	32.8	31.6	286.1	291.2	288.6
S_4- S_3+ passing wooden log	160.8	164.0	162.4	31.9	33.4	32.6	291.8	297.8	294.8
S_5- FYM @ 10 tonnes ha^{-1} + 125% RDF	167.8	171.2	169.5	33.2	35.0	34.1	305.8	308.1	306.9
S_6- S_5+ passing wooden log	173.7	178.4	176.0	33.9	35.8	34.9	313.5	313.8	313.7
S.Em±	3.47	4.33	4.08	0.75	0.65	0.49	7.71	6.07	6.61
CD (p = 0.05)	10.0	12.4	11.7	2.2	1.9	1.4	22.1	17.4	18.9
CV (%)	6.91	8.38	8.01	7.57	6.09	4.76	8.28	6.39	7.03
Interaction									
M x S	NS	NS	NS	NS	NS	NS	NS	NS	NS
S x M	NS	NS	NS	NS	NS	NS	NS	NS	NS

Govindappa *et al*. [30] also observed higher residual potassium due to application of 100% RDF + FYM which substantiate the effect of conjunctive use of organic manures with inorganic fertilizer in building active pools of nutrients and also maintains consistent supply of nutrient for proper growth of the crop. The combined use of both organics and inorganic in right proportion was necessary for sustaining and enhancing the productivity. The non supply of nutrients through either organic or inorganic sources coupled with exhaustion of native soil nutrients by the crop in the absolute control might have resulted in lower soil available NPK (Mahapatra) [31].

4. CONCLUSION

Concludingly, it is indicated from the study that pH and electrical conductivity of soil was not significantly influenced due to either crop geometry or nutrient management practices and their interaction. The organic carbon and nutrient status of the soil differed significantly due to nutrient management treatments but not by crop geometries and their interaction. Integrated application of FYM @ 10 tonnes ha^{-1} + 125% RDF along with wooden log treatment (S_6) resulted in higher organic carbon and nutrient status of the soil and reduced C:N ratio of the soil significantly.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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