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Effect of integrated nutrient management on yield attributes, yield and quality of pearl millet [*Pennisetum glaucum* (L.) R. br.emend. stuntz]

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Abstract
A field experiment was conducted during *kharif*, 2017 on sandy loam soils of Dryland Farm of S. V. Agricultural College, Tirupati campus of Acharya N. G. Ranga Agricultural University. The experiment was laid out in Randomized Block design with ten treatments and replicated thrice. Among the integrated nutrient management practices, application of 75 % RDF + Poultry Manure (PM) @ 2 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + PSB @ 5 kg ha^{-1} produced higher yield attributes (number of earheads m^{-2}, length of earhead, weight of grains $earhead^{-1}$, 1000 grain weight), yield (Grain yield, stover yield and harvest index) and quality parameters (protein, carbohydrate) in pearlmillet. However, it was comparable with application of 75 % RDF + FYM @ 5 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + PSB @ 5 kg ha^{-1} (T_5). Application of 50 % RDF + FYM @ 7.5 t ha^{-1} (T_7), registered the lowest values of yield attributes, yield and quality parameters.

Keywords: Poultry manure, biofertilizers, yield and quality parameters

Introduction
Pearlmillet is a multipurpose cereal crop providing food, fodder and fuel and is being cultivated on more than 27 M ha worldwide. India is the largest producer of pearlmillet covering about 7.32 M ha of marginal and sub-marginal lands. It is the fifth important cereal crop after rice, wheat, maize and sorghum. Pearlmillet has evolved under varied pressures of infertile soils, heat and drought, thus giving it a natural ability to thrive in low moisture, nutrient deprived soils and at temperatures more than $40^{O}C$. Pearlmillet is naturally more nutritious when compared to rice and wheat with high levels of metabolizable energy, proteins and more balanced amino acid profile.

The use of organic manures dates back to the beginning of settled agriculture but after the introduction of wide spread use of mineral fertilizers, organic manures were thought of as a secondary source of nutrients. However, with increasing awareness on soil health and sustainability in agriculture, organic manures and many diverse organic materials have gained importance as components of integrated plant nutrient management.

Biofertilizers are products of beneficial microorganisms which increase agricultural production by way of nutrient supply especially N and P. Biofertilizers can either fix atmospheric nitrogen for plant or can mobilize unavailable phosphorus pool which can be used by plants. These biofertilizers are inexpensive and simple to use and have no problem of environmental pollution. Thus, judicious use of biofertilizers along with chemical and other organic sources of plant nutrients will help to sustain productivity and soil health apart from meeting a part of fertilizer requirement for different crops. Hence, it is very much essential to develop a workable and compatible nutrient management package through organic and biofertilizers including the recommended dose of chemical fertilizers, based on scientific facts, local conditions and economic viability.

Material and Methods
A field experiment was conducted at S. V. Agricultural College dryland Farm, Tirupati campus of Acharya N. G. Ranga Agricultural University in *kharif*, 2017. Total rainfall received during the crop growth period was 784 mm in 37 rainy days. The soil of the experimental field was sandy loam in texture with a pH of 6.8, low in organic carbon (0.32 %) and available N (163 kg ha^{-1}) and medium in available phosphorus (41 kg ha^{-1}) and available

potassium (215 kg ha^{-1}).

The treatments consisted of ten integrated nutrient management practices *viz.*, Recommended Dose of Fertilizer (RDF): 60-30-20 kg N, P_2O_5 and K_2O ha^{-1} (T_1), RDF + *Azospirillum* @ 5 kg ha^{-1} + PSB @ 5 kg ha^{-1} (T_2), 75 % RDF + FYM @ 5 t ha^{-1} (T_3), 75 % RDF + Poultry Manure (PM) @ 2 t ha^{-1} (T_4), 75 % RDF + FYM @ 5 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + PSB @ 5 kg ha^{-1} (T_5), 75 % RDF + PM @ 2 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + PSB @ 5 kg ha^{-1} (T_6), 50 % RDF + FYM @ 7.5 t ha^{-1} (T_7), 50 % RDF + PM @ 3 t ha^{-1} ($T_{8,}$) 50 % RDF + FYM @ 7.5 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + PSB @ 5 kg ha^{-1} (T_9) and 50 % RDF + PM @ 3 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + PSB @ 5 kg ha^{-1} (T_{10}).

Poultry manure and Farm yard manure were incorporated 15 days before sowing in marked plots as per treatments and its composition on dry basis was 0.51 % N, 0.25 % P_2O_5, 0.52 % K_2O for FYM and 2.20 % N, 1.70 % P_2O_5, 1.40 % K_2O for poultry manure. The Recommended dose of 60-30-20 kg N, P_2O_5 and K_2O ha^{-1} were applied in the form of urea, single super phosphate (SSP) and muriate of potash (MOP) respectively. Entire quantity of phosphorus, potassium and half of the dose of nitrogen were applied as basal at the time of sowing and the remaining half of the nitrogen was top dressed at 30 DAS. The biofertilizers *i.e*. *Azospirillium brasillience* and Phosphorous Solubilising Bacteria (PSB) were broadcasted in main field each @ 5 kg ha^{-1} by mixing it with 200 kg of dried and powdered FYM.

Yield Attributes

Among the ten integrated nutrient management practices tried, application of 75 % RDF + PM @ 2 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + PSB @ 5 kg ha^{-1} (T_6) registered higher stature of yield attributes *viz*., number of earheads m^{-2}, length of earhead, weight of grains $earhead^{-1}$, 1000 grain weight (Table 1.) compared with that due to 75 % RDF + FYM @ 5 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + PSB @ 5 kg ha^{-1} (T_5). The yield attributes were at their lowest with 50 % RDF + FYM @ 7.5 t ha^{-1} (T_7) which was however, on par with that of 50 % RDF + PM @ 3 t ha^{-1} (T_8).

The difference in treatments could be attributed to the increased supply of essential nutrients by fertilizers, poultry manure or FYM and biofertilizers might have resulted in higher photosynthates and its subsequent partitioning towards sink. Integrated nutrient supply had continuous favourable effect on yield attributes. Increased grain weight $earhead^{-1}$ was due to higher concentration of macro and micro nutrients, enhanced and steady nutrient release with the application of 75 % RDF + biofertilizers (*Azospirillum* + PSB) either in combination with poultry manure or FYM. The results are in accordance with Meena and Gautam (2005) [5], Neelam *et al*. (2009) [8] and Divya *et al*. (2017) [2].

The probable reason for increase in yield attributes was mainly due to balanced supply of nutrients from poultry manure in combination with inorganic fertilizers and biofertilizers throughout the grain filling and development period which resulted in bold grain, and consequently highest 1000 grain weight. The results are in conformity with that of Thumar *et al*. (2016) [12], Khan *et al*. (2000) [4] and Apoorva *et al*. (2010) [1].

Grain Yield

The highest grain yield (Table 2. and Fig. 1.) of pearlmillet was produced with 75 % RDF + PM @ 2 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + PSB @ 5 kg ha^{-1} (T_6) which was however, comparable with that of 75 % RDF + FYM @ 5 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + PSB @ 5 kg ha^{-1} (T_5). The lowest grain and stover yield was recorded with 50 % RDF + FYM @ 7.5 t ha^{-1} (T_7). The increase in grain yield of pearlmillet with 75 % RDF + FYM or poultry manure + Biofertilizer might be due to the fact that application of fertilizers make the nutrients readily available to the plant, while organic manures improves the soil physic-chemical and biological properties (in terms of hydraulic conductivity of soil, availability of nutrients and microbial load) that promotes plant growth and development resulting in increased yield attributes and yield. Use of biofertilizers (*Azospirillum* + PSB) can fix atmospheric nitrogen for plant use and can mobilize unavailable phosphorus pool which can be used by plants. The present results corroborates with the findings of Meena and Gautam (2005) [5], Kanzaria *et al*. (2010) [3] and Priyadarshini *et al*. (2012) [9].

Stover Yield

The highest stover yield (Table 2 and Fig. 1.) of pearlmillet was recorded with 75 % RDF + PM @ 2 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + PSB @ 5 kg ha^{-1} (T_6) which was however, on par with that of 75 % RDF + FYM @ 5 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + PSB @ 5 kg ha^{-1} (T_5). Application of 75 % RDF + poultry manure or FYM + Biofertilizers enhanced the stover yield. This might be due to synergistic effect of integration of organic and inorganic sources along with biofertilizers that resulted in better nutrient uptake, which accelerated the photosynthetic rate, adequate biomass production that reflected on stover yield. The results are in accordance with Reddy *et al*. (2016) [10] and Sakarvadia *et al*. (2012) [11]. The lowest stover yield was recorded with 50 % RDF + FYM @ 7.5 t ha^{-1} (T_7) which was statistically on par with that due to 50 % RDF + PM @ 3 t ha^{-1} (T_8).

Harvest Index

Harvest index was not significantly influenced by integrated nutrient management practices. However, the higher value of harvest index was with 75 % RDF + PM @ 2 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + PSB @ 5 kg ha^{-1} (T_6) which could be attributed to proportionately higher grain yield as presented in Table 2.

Quality Parameters

Protein content in grain

Integrated nutrient management exerted significant influence on protein and carbohydrate content of pearlmillet (Table 2.).

Application of 75 % RDF + PM @ 2 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + PSB @ 5 kg ha^{-1} (T_6) resulted in significantly higher protein content than that with 75 % RDF + FYM @ 5 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + PSB @ 5 kg ha^{-1} (T_5). Increased availability of nitrogen in the soil to the plant (through inorganic and organic sources and biofertilizers) might have resulted in increased nitrogen content in seed. It is a well-known fact that nitrogen in seed is directly responsible for higher protein because it is a primary component of amino acid which constitutes the basis of protein. The present investigations were in agreement with those of Mundra *et al*. (2002) [7] and Meena and Gautam (2005) [5]. The lowest grain protein content of pearlmillet was recorded with 50 % RDF + FYM @ 7.5 t ha^{-1} (T_7) which was comparable with that of 50 % RDF + PM @ 3 t ha^{-1} (T_8).

Carbohydrate content in grain

The highest carbohydrate content of pearlmillet grain (Table 2.) was recorded with 75 % RDF + PM @ 2 t ha^{-1} +

Azospirillum @ 5 kg ha^{-1} + PSB @ 5 kg ha^{-1} (T_6), which maintained parity with that due to 75 % RDF + FYM @ 5 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + PSB @ 5 kg ha^{-1} (T_5). The microbial load in the soil secrete many growth promoting substances which accelerates the physiological processes like synthesis of carbohydrate and protein. The findings of present investigation are in agreement with that of Mekki *et al*. (1999) [6]. The lowest carbohydrate content of pearlmillet grain was recorded with 50 % RDF + FYM @ 7.5 t ha^{-1} (T_7) followed by 50 % RDF + PM @ 3 t ha^{-1} (T_8).

Table 1: Yield attributes of pearl millet as influenced by integrated nutrient management practices

Treatments	Number of earheads m^{-2}	Weight of grains earhead^{-1} (g)	1000-grain weight (g)	Length of earhead (cm)
T_1: Recommended Dose of Fertilizer (RDF): 60-30-20 kg N, P_2O_5 and K_2O ha^{-1}	14.5	14.9	10.9	24.0
T_2: RDF + *Azospirillum* @ 5 kg ha^{-1} + PSB @ 5 kg ha^{-1}	14.6	15.0	11.3	24.2
T_3: 75 % RDF + FYM (Farm Yard Manure) @ 5 t ha^{-1}	13.0	13.7	9.6	22.6
T_4: 75 % RDF + Poultry Manure (PM) @ 2 t ha^{-1}	13.2	13.8	10.2	23.0
T_5: 75 % RDF + FYM @ 5 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + PSB @ 5 kg ha^{-1}	15.5	15.1	11.7	24.5
T_6: 75 % RDF + PM @ 2 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + PSB @ 5 kg ha^{-1}	16.4	15.3	12.3	25.1
T_7: 50 % RDF + FYM @ 7.5 t ha^{-1}	10.3	11.2	8.2	20.4
T_8: 50 % RDF + PM @ 3 t ha^{-1}	10.4	11.4	8.6	20.7
T_9: 50 % RDF + FYM @ 7.5 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + PSB @ 5 kg ha^{-1}	11.5	12.4	9.2	21.6
T_{10}: 50 % RDF + PM @ 3 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + PSB @ 5 kg ha^{-1}	11.6	12.4	9.4	21.7
SEm±	0.36	0.29	0.28	0.25
CD (P=0.05)	1.1	0.9	0.8	0.8

Table 2: Yield and quality parameters of pearl millet as influenced by integrated nutrient management practices

Treatments	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)	Protein Content (%)	Carbohydrate content (%)
T_1 : Recommended Dose of Fertilizer (RDF): 60-30-20 kg N, P_2O_5 and K_2O ha^{-1}	1955	5371	26.7	11.1	65.2
T_2 : RDF + *Azospirillum* @ 5 kg ha^{-1} + PSB @ 5 kg ha^{-1}	2019	5548	26.7	11.3	65.7
T_3 : 75 % RDF + FYM @ 5 t ha^{-1}	1768	4984	26.2	10.4	62.6
T_4 : 75 % RDF + Poultry Manure (PM) @ 2 t ha^{-1}	1803	5003	26.5	10.7	64.7
T_5 : 75 % RDF + FYM @ 5 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + PSB @ 5 kg ha^{-1}	2086	5692	26.8	11.4	67.7
T_6 : 75 % RDF + PM @ 2 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + PSB @ 5 kg ha^{-1}	2160	5886	26.9	12.2	69.3
T_7 : 50 % RDF + FYM @ 7.5 t ha^{-1}	1446	4259	25.3	9.4	59.6
T_8: 50 % RDF + PM @ 3 t ha^{-1}	1454	4273	25.4	9.7	60.9
T_9: 50 % RDF + FYM @ 7.5 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + PSB @ 5 kg ha^{-1}	1602	4598	25.9	10.0	61.3
T_{10}: 50 % RDF + PM @ 3 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + PSB @ 5 kg ha^{-1}	1620	4614	26	10.3	61.1
SEm±	48.6	104	0.005	0.22	0.71
CD (P=0.05)	145	313	NS	0.7	2.1

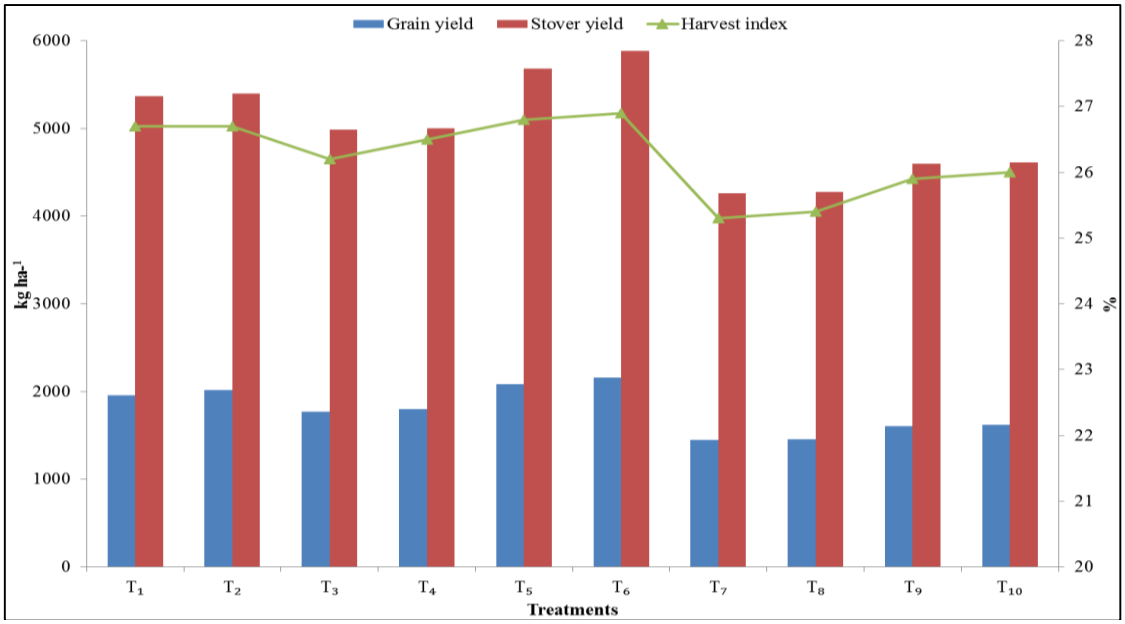

Fig 1: Grain and stover yield (kg ha^{-1}) and harvest index (%) of pearl millet as influenced by integrated nutrient management practices.

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