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Production potential and economics of finger millet (*Eleusine coracana* L. Gaertn.) as affected by integrated nutrient management

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Abstract
A field experiment was conducted during *Kharif* 2016 on sandy loam textured soil of Agronomical Research Farm, Western Section, Birsa Agricultural University, Ranchi under rainfed upland condition in RBD with 10 treatments replicated thrice. It was observed that of the 10 treatments higher yield attributing characters *viz*., effective tillers/m^2 (111.7), weight of ear (8.57 g), finger length (7.40 cm) and no. of grains/ear (1203) was recorded with the application of FYM (10 t/ha) + Biofertilizers (*Azospirillum brasilense* + *Bacillus* spp. + *Pseudomonas fluorescens* @ 20 g/kg seed each) + $ZnSO_4$ (12.5 kg/ha) + Borax (5kg/ha) + 75% RDF. Maximum grain yield (3774 kg/ha) was recorded with application of FYM (10 t/ha) + Biofertilizer + $ZnSO_4$ (12.5 kg/ha) + Borax (5kg/ha) + 75% RDF while straw yield (7695 kg/ha) was recorded maximum with application of FYM (10 t/ha) + Biofertilizer + $ZnSO_4$ (12.5 kg/ha) + Borax (5kg/ha) + 100% RDF. Minimum grain yield (1197.7 kg/ha) and straw yield (2770 kg/ha) was observed with control. The highest gross returns (Rs.72740/ha), net returns (Rs.52272/ha) and B: C (2.55) ratio was observed with the application of FYM (10 t/ha) + Biofertilizer + $ZnSO_4$ (12.5 kg/ha) + Borax (5kg/ha) + 75% RDF.

Keywords: finger millet, INM, FYM, biofertilizers, yield attributes, yield and economics

Introduction
Finger millet is a major food crop of the semi-arid tropics of Asia and Africa and has been an indispensable component of farming systems (Goron *et al*., 2015) [5]. Its name is derived from the seed head, which has the shape of human fingers. Locally, the crop is called *ragi* or *marua* (India); *koddo* (Nepal); *dagussa*, (Ehiopia); *wimbi*, *mugimbi* (Kenya); *bulo* (Uganda) and *kurakkan* (Sri Lanka) (National Research Council, 1996) [9]. Finger millet ranked fourth globally in importance among the millets, after sorghum, pearl millet, and foxtail millet (Gupta *et al.,* 2012). In India it is cultivated over an area of 1.61 million hectares with total production of about 2.1 million tonnes and productivity 1661 kg per hectare (AICSMIP, 2013-14). In Jharkhand, it is cultivated over an area of 0.490 mha with total production of about 27412 ton and productivity 684 kg per hectare (SAMETI GOJ, 2012-13) [13]
Wide adaptations, easy cultivation, free from major pests and diseases and drought tolerance have made this crop an indispensable component of farming system (AICSMIP, 2002) [2]. Modern management practices rely on chemical fertilizers and pesticides that have led to decline in soil organic matter, increased soil erosion and pollution of surface and ground water (Relyea, 2005) [12]. Continuous use of chemical fertilizers alone has some deleterious effects on physical, chemical and biological properties of soil which in turn reflects on yield levels and soil health. On the other hand, many farmers apply only available organic manures and do minimum management which though maintains soil health but reduces crop yield. High production cost and reliance on loans to purchase inputs are the major risks especially in rainfed areas where yields are uncertain (Eyhorn *et al*., 2007) [3]. In order to achieve better yield potential on sustainable basis without degradation of land resources, there is need to supply balanced nutrition. Hence Integrated Nutrient Management system is gaining importance now-a-days among farmers which is a concept of continuous improvement of soil health and productivity on long term basis through balanced use of fertilizers, organic manures along with biofertilizers for better growth, yield and economic returns of different crops and cropping systems in specific agro-ecological situations (Thumar *et al*., 2016) [14].
Under poor soil conditions and uneven rainfall distribution pattern of Jharkhand, Integrated Nutrient Management can be adopted which would save resources from further depletion as well as provide direct and indirect benefits and assured livelihood security to the farming community. Information on effect of INM on finger millet is limited in agro-ecosystem of Jharkhand, therefore, present experiment was carried out to study the effect of integration of

organic manures and biofertilizers in combination with graded levels fertilizers on productivity and economics of finger millet.

Materials and Methods

A field experiment was conducted on sandy loam soil at Western section of Birsa Agricultural University Farm, Kanke, Ranchi ($23^0 17'$ North latitude, $85^0 19'$ East longitudes and at an altitude of 625 meter above mean sea level) during *Kharif* 2016. The soil of the experimental site was sandy loam (sand 55.4%, silt 28.3% and clay 16.3%), having bulk density 1.37 Mg/m^3, organic carbon 4.23 g/kg, acidic in reaction (pH 5.3), low in available nitrogen (232.47 kg/ha), medium in available phosphorus (14.30 kg/ha) and potassium (131.84 kg/ha). The *Ragi* cultivar A-404 was of medium duration with seed rate 10 kg/ha and spacing of 30 cm ×10 cm was grown. The experiment was laid out in a Randomized Block Design (RBD) and replicated thrice with ten treatments. The treatments consisted of: T_1. Absolute control, T_2. FYM (10 t/ha), T_3. Recommended dose of fertilizers (NPK @ 50:30:25 kg/ha, respectively), T_4. FYM (10t/ha) + Biofertilizers (*Azospirillum brasilense* + *Bacillus* spp. + *Pseudomonas fluorescens* @ 20 g/kg seed each), T_5. T_4 + $ZnSO_4$ (12.5 kg/ha), T_6. T_4 + Borax (5 kg /ha), T_7. T_4 + $ZnSO_4$ (12.5 kg/ha) + Borax (5 kg/ha), T_8. T_4 + $ZnSO_4$ (12.5 kg/ha) + Borax (5kg/ha) + 50% RDF, T_9. T_4 + $ZnSO_4$ (12.5 kg/ha) + Borax (5kg/ha) + 75% RDF, T_{10}. T_4 + $ZnSO_4$ (12.5 kg/ha) + Borax (5kg/ha) + 100% RDF.

Organic source of nutrients used in the experiment was farm yard manure (FYM). Inorganic sources were N, P and K containing fertilizers such as Urea, Single super phosphate, Murate of potash. Zinc and Boron was applied in the form of Zinc sulphate and Borax respectively. The biofertilizers used for seed inoculation were *Azospirillum brasilense*, *Bacillus* spp. and *Pseudomonas fluorescens*. In case of organic nutrient management, the requisite quantity of FYM was applied as per the treatments and incorporated well in advance i.e. two weeks before sowing of the crop. One third of urea, full dose of SSP, Murate of Potash along with Zinc sulphate and Borax were applied at the time of sowing as basal dose and remaining urea was applied in two split doses *viz.,* 1/3 at tillering stage (30 DAS) and 1/3 before ear head initiation (55 DAS) as per various treatments. The grain and straw yield of finger millet were recorded treatment wise from net plot area at harvest and converted into Kg.per hectare basis. Yield attributing characters such as effective tillers/m^2, finger length (cm), ear weight (g), no. of grains/ear, grain weight/ear (g) and 1000 grain weight (g) were measured and recorded at maturity. Cost of cultivation was calculated by taking into account the prevailing price of inputs like fertilizers, seed, herbicides, tillage operations, etc. Returns of the treatments were computed based on prevalent market prices of finger millet grain and straw. Gross returns were calculated based on current market price of the produce. The net returns were obtained after deducting the cost of cultivation from gross returns. The benefit-cost ratio was worked out by using the formula.

$$\text{B: C ratio} = \frac{\text{Gross returns}}{\text{Cost of cultivation}}$$

The collected data for various parameters were statistically analysed using the method of analysis of variance (ANOVA) as described by Gomez and Gomez (1984) [4]. The significance of comparison was tested. The significant difference values were computed for 5 percent probability of error. Wherever the variance ratio (F value) was found significant, critical difference (CD) values were computed for the comparison among the treatment means.

Results and Discussion

Yield attributes and Yield

Yield attributes *viz*., Effective tillers/m^2 (111.7), finger length (7.4 cm), ear weight (8.57 g), no. of grains/ear (1203) and grain weight/ear (4.19 g) were highest with application of FYM (10 t/ha) + Biofertilizer + $ZnSO_4$ (12.5 kg/ha) + Borax (5kg/ha) + 75% RDF, which was at par with application of FYM (10 t/ha) + Biofertilizer + $ZnSO_4$ (12.5 kg/ha) + Borax (5kg/ha) + 100% RDF (Table 1). The maximum grain yield (3773.7 kg/ha) was recorded with application of FYM (10 t/ha) + Biofertilizer + $ZnSO_4$ (12.5 kg/ha) + Borax (5kg/ha) + 75% RDF while straw yield (7695 kg/ha) was recorded with application of FYM (10 t/ha) + Biofertilizer + $ZnSO_4$ (12.5 kg/ha) + Borax (5kg/ha) + 100% RDF (Table 1 & Fig. 1). The increase in grain yield with increased nutrient supply could be explained on the basis of their beneficial effects on yield attributing characters like effective tillers/m^2, finger length, ear weight, number of grains/ear, grain weight/ear which has direct influence on grain yield. Combined application of manure and inorganics along with biofertilizer lead to increase availability of nutrients and improved the soil properties hence resulting better root growth. This in turn, increased absorption and translocation of nutrient by crop leading to increased production of photosynthates by the crop resulting in increased biomass accumulation. Further, biofertilizers applied in the treatments which are nitrogen fixing, plant growth promoting and phosphate solubilizing bacteria has synergistic effect on plant growth as they increase the fertilizer efficiency as well as soil fertility. These results are in line with the findings of Khan *et al.* (2012) [8].

Maximum straw yield (7695 kg/ha) was recorded with application of FYM (10 t/ha) + Biofertilizers + $ZnSO_4$ (12.5 kg/ha) + Borax (5kg/ha) + 100 % RDF followed by application of FYM (10 t/ha) + Biofertilizers + $ZnSO_4$ (12.5 kg/ha) + Borax (5kg/ha) + 75% RDF (6983 kg/ha) and was significantly superior to rest of the treatments. Higher straw yield was recorded under combined use of biofertilizers, organics and 100% RDF due to higher vegetative growth as a result of greater nitrogen dose in T_{10} than rest of treatments. The increased availability of the nutrients especially nitrogen, causing enhancement of the photosynthetic rate resulting in more vegetative growth and dry matter production. These results are in conformity with the results of Pratap *et al.* (2008) [11].

Economics

The data indicated that cost of cultivation, gross returns, net returns and benefit cost ratio were greatly influenced by the different treatments under investigation (Table. 2 & Fig.2). Gross return and net return increased with increase in levels of nutrients applied in combination with FYM and biofertilizers. Highest gross return (Rs.72740/ha) and net return (Rs.52272/ha) were recorded by application of FYM (10 t/ha) + Biofertilizers + $ZnSO_4$ (12.5 kg/ha) + Borax (5kg/ha) + 75% RDF followed by application of FYM (10 t/ha) + Biofertilizers + $ZnSO_4$ (12.5 kg/ha) + Borax (5kg/ha) + 100% RDF. Highest benefit : cost ratio (2.55) was obtained with application of FYM (10 t/ha) + Biofertilizers + $ZnSO_4$ (12.5 kg/ha) + Borax (5kg/ha) + 75% RDF followed by application of FYM (10 t/ha) + Biofertilizers +$ZnSO_4$ (12.5

kg/ha) + Borax (5kg/ha) + 100% RDF (2.33) and application of FYM (10 t/ha) + Biofertilizers + $ZnSO_4$ (12.5 kg/ha) + Borax (5kg/ha) + 50% RDF (2.16). Higher level of biomass accumulation and efficient translocation to the reproductive parts due to supply of adequate nutrients might be responsible for greater yield. Which resulted in higher monetary returns and B: C ratio. These results are in accordance with Jakhar (2006) [7] and Patil *et al.* (2006) [10].

Conclusion

On the basis of one year experimentation, it may be concluded that application of FYM (10 t/ha) + Biofertilizers + $ZnSO_4$ (12.5 kg/ha) + Borax (5kg/ha) + 75% RDF is the better Integrated nutrient management practice for finger millet cultivation in achieving higher productivity and profitability under rainfed conditions of Jharkhand.

Table 1: Yield attributes and yield of finger millet as affected by integrated nutrient management practices

Treatment	Effective tillers/m^2	Finger length (cm)	Ear Weight (g)	No. of grains/ear	Grain weight/ear (g)	1000 grain weight (g)	Grain yield (kg/ha)	Straw yield (kg/ha)
T_1	61.0	4.76	4.62	687	2.53	3.21	1197	2770
T_2	78.0	5.81	5.21	793	2.75	3.29	1738	3947
T_3	96.7	6.89	6.37	1038	3.47	3.39	2391	4879
T_4	85.3	6.01	5.76	873	2.94	3.33	2017	4549
T_5	85.3	6.07	5.79	893	2.98	3.34	2038	4601
T_6	85.7	6.12	6.12	921	3.12	3.35	2093	4637
T_7	86.3	6.15	6.15	929	3.15	3.35	2107	4643
T_8	104.7	7.02	7.42	1121	3.86	3.41	3258	6116
T_9	111.7	7.40	8.57	1203	4.19	3.45	3773	6983
T_{10}	107.3	7.13	8.34	1168	4.02	3.43	3542	7695
SE m ±	4.28	0.23	0.40	46.24	0.15	0.02	143	313
CD (P = 0.05)	12.73	0.69	1.19	137.33	0.45	NS	432.16	929.74
CV%	8.23	6.42	8.90	8.32	8.04	0.93	10.43	10.66

Table 2: Economics of production of finger millet as affected by integrated nutrient management practices

Treatment	Cost of cultivation (₹/ha)	Gross retun (₹/ha)	Net retun (₹/ha)	B:C ratio
T_1: Absolute control	13073	23916	10843	0.83
T_2: FYM (10 t/ha)	17073	34597	17524	1.03
T_3: Recommended dose of fertilizers (NPK @ 50:30:25 kg/ha, respectively)	15309	46770	31460	2.05
T_4: FYM (10 t/ha)+ Biofertilizers (*Azospirillum brasilense* + *Bacillus* spp. +*Pseudomonas fluorescens* @20 g/kg seed each)	17252	40104	22851	1.32
T_5: T_4 + $ZnSO_4$ (12.5 kg/ha)	18065	40528	22463	1.25
T_6: T_4 + Borax (5 kg/ha)	17977	41495	23517	1.35
T_7: T_4 + $ZnSO_4$ (12.5 kg/ha) + Borax (5 kg/ha)	18790	41734	22944	1.22
T_8: T_4 + $ZnSO_4$ (12.5 kg/ha) + Borax (5 kg/ha)+50% RDF	19908	62931	43022	2.16
T_9: T_4 + $ZnSO_4$ (12.5 kg/ha)+Borax (5 kg/ha) + 75% RDF	20467	72740	52272	2.55
T_{10}: T_4 + $ZnSO_4$ (12.5 kg/ha)+Borax (5 kg/ha) + 100% RDF	21027	69991	48964	2.33
SE m ±		2464	2464	0.135
CD (P = 0.05)		7319	7318	0.403
CV%		8.98	14.42	14.63

Finger millet grain selling price @ ₹16.5/kg
Finger millet straw selling price @ ₹1.5/kg

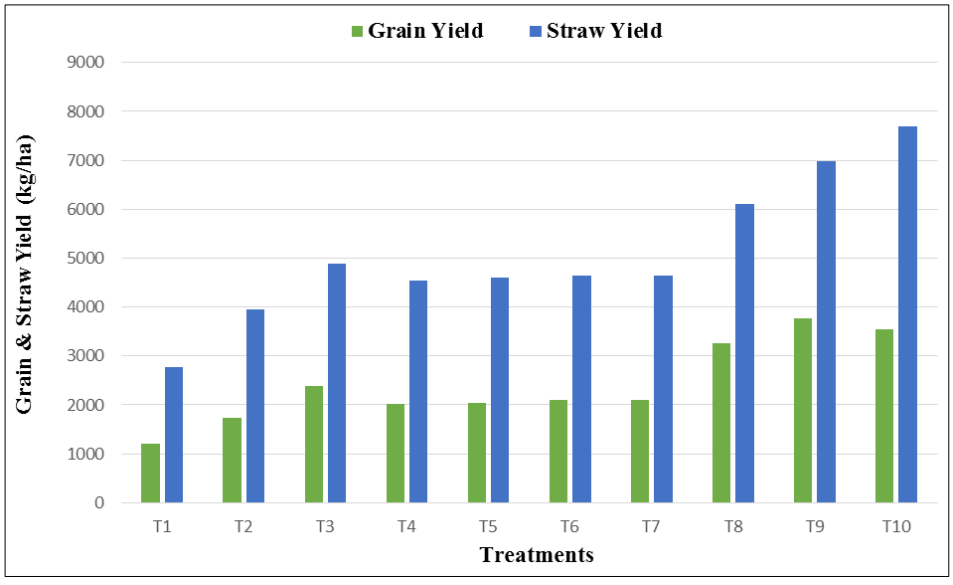

Fig 1: Grain yield (kg/ha) and Straw yield (kg/ha) of finger millet as affected by Integrated Nutrient Management practices

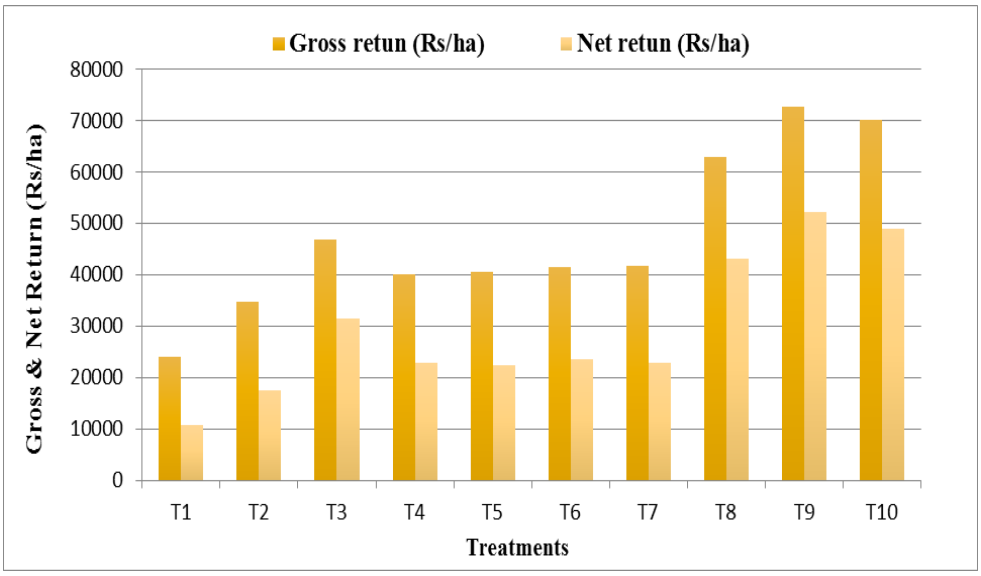

Fig 2: Economics of production of finger millet as affected by Integrated Nutrient Management practices

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