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Impact of different nutrient management practices on crop equivalent yield, economics and nutrient status response of Maize-Bengal gram cropping system under rainfed condition

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Abstract
A field experiment entitled *"Impact of Different Nutrient Management Practices on Crop Equivalent Yield, Economics, and Nutrient Status Response of Maize-Bengal Gram Cropping System under Rainfed Conditions"* was initiated during 2020-21 at the permanent site of the Organic Farming Research Institute, UAS, Raichur. The study was conducted with a maize-Bengal gram cropping system under rainfed conditions. The experiment comprised four nutrient management practices, *viz*., 100% organic, integrated (50% organic + 50% inorganic), 100% inorganic, and RDF + FYM. The design followed was a strip plot with five main plots, each replicated four times. The pooled data of two years on yield and economics revealed that significantly higher maize equivalent yield was recorded under the integrated nutrient management system (50% organic + 50% inorganic) with 6064 kg ha^{-1}, which was superior to the organic production system but on par with 100% inorganic and RDF + FYM systems (5497 and 6018 kg ha^{-1}, respectively). In terms of economics, the integrated system also recorded significantly higher net returns (₹64,851 ha^{-1}) and a benefit-cost ratio (B:C) of 3.48. These results were statistically comparable to those under RDF + FYM (₹62,912 ha^{-1} and 3.30, respectively) and 100% inorganic fertilizer application (₹58,451 ha^{-1} and 3.44, respectively). Soil organic carbon content was significantly influenced by nutrient management practices. Under 100% organic nutrient management, a substantial build-up of soil organic carbon (0.64%) was observed compared to the initial value (0.52%). Available nitrogen (179.29, 172.02, and 165.63 kg ha^{-1}), phosphorus (71.54, 70.53, and 68.21 kg ha^{-1} P_2O_5), and potassium (662.2, 652.1, and 658.0 kg ha^{-1} K_2O) showed improvement over the years under RDF + FYM, organic, and integrated nutrient management practices, respectively, as compared to 100% inorganic fertilization.

Keywords: Cropping system, economics, nutrient management practices, nutrient uptake, productivity, soil fertility. organic carbon, package of practice

Introduction
The green revolution has brought about a number of problems for india's agricultural situation, such as a stagnation or even a drop in the productivity and production of important crops, a decline in soil fertility, a decline in factor productivity, a lack of diversity in production systems and an increase in production costs. For india's food and nutritional security, soil quality must be improved and maintained in order to boost and sustain agricultural productivity. With an average yearly production of 329.7 million tonnes of food grains, india is currently a food surplus nation. However, given the current pattern of population growth, it will require an additional 4-5 million tonnes of food grains annually (Anon., 2023) [1]. The food, feed, fodder, fibre, fuel, pulses and oil seed products have been on a rapid rise because of the rising population pressure. increased planning and control of resources along with increased intensity of crop production would be required to satisfy the future demand. The forecast is that the total food grain demand in india during the year 2050 will be 400 million tonnes (Anon., 2023) [1]. One way to achieve this is by increasing crop productivity in terms of varieties and related production technology to preserve soil fertility and crop productivity in the future. As a result of extensive crop cultivation and production, the soil is lacking in macro and micronutrients. Agrochemicals applied haphazardly to the soil and crops, as well as continuous cropping

without sufficient attention to nutrient control, have contributed to the majority of these constraints (Sharma and Subehia, 2014) [17]. The use of only organic products or integrated nutrient management in crops or cropping systems over an extended period of time could be a potential remedy to mitigate all these negative effects. The long-term studies, in particular, offer a great one-time chance to test if these ideas can be applied to different cropping systems. Additionally, it provides us with data on the effects of land management techniques that are not otherwise accessible. in light of these factors, the Organic Farming Research institute, UAS, Raichur, launched a study in 2020-21 on the productivity, profitability, and soil fertility of the maize-bengal gramme cropping system as influenced by the long-term effects of organic, inorganic, and integrated nutrient management practices in vertisol. One of the useful cropping systems in Kalyana-Karnataka Region of Karnataka is maize-Bengal gram. The most important practice related to proper nutrient and moisture management is what defines the productivity of the system. The weakness of vertisols having low organic matter and the lack of balance in applying macro and micro nutrients to crops restricts the maximum yield potential and forms the primary yield constraint to crops (Ghosh *et al.* 2003) [8]. It was rather encouraging to consider the use of chemical fertilizers combined with organic manure as a means of sustaining an higher level of productivity besides offering a greater stability in crop production (Nambiar and Abrol 1992) [15]. However, the scarcity of farm yard manure restricts its use as a fertiliser source. Vermicompost is becoming more and more popular and farmers can produce it themselves. Green manure and crop residue are both recognised as sources of organic manures. There is a lack of information about the effects of all these organics. in order to investigate the impact of nutrient management techniques on the productivity, economic viability and package of strategies for the development of the maize-gram cropping system under rainfed conditions in the Kalyana-Karnataka region of Karnataka, an experiment was conducted.

Materials and Methods

The field experiment was done at Organic Farming Research institute, University of Agricultural Sciences, Raichur (Karnataka) in 2020-21 and 2021-22. The experimental site is that of medium black soil of clay texture. Experiment There were four treatments that included viz., T_1: 100 percent N through organics, T_2: integrated N management (50 percent N through organics and 50 percent N through organics), T_3: 100 percent N through organics, T_4: Recommended package of practice (RPP) and were replicated in strip plot format and in each strip plot four replications. Optimum NPK i.e.,100 percent NPK (100-50-37.5 kg N-P2O5-K2O ha^{-1} maize and 10-25-00 kg N-P2O5-K2O ha^{-1} Bengal gram was optimized at the beginning of experiment under the same layout and treatments are being followed till date. The experiment was done using RCRMH-2 and JG-11 varieties of maize and Bengal gram respectively. in organic nutrient management practices 100% recommended dose of nitrogen (RDN) applied through 1/3rd farm yard manure (FYM), 1/3rd vermicompost (VC) and 1/3rd green leaf manure (GLM) was applied to the both crops in integrated nutrient management practices 50% RDN applied through fertilizers and 50% RDN applied through 1/3rd FYM, 1/3rd VC and 1/3rd GLM, in inorganic nutrient management practices The rest of the agronomic practices were also observed according to the package.

Results and Discussion

The pooled data of the two-year nutrient management practices indicated that, much higher maize equivalent yield was obtained in the integrated (50%:50%) production system of production (6064 kg ha^{-1}) than in the organic production system. Application of recommended dose of fertiliser of recommended farm yard manure (RDF+FYM) and inorganic fertilisers was found to be the next best treatment (Recommended dose of fertilise poultry manure @ 1.0 t/ha with 100% RDF. (5497 and 6018 kg ha^{-1}, respectively). The increased yield of maize and bengal gram in the treatments that yielded higher maize equivalent were attributed to the higher yield of maize with the application of FYM, vermicompost and green leaf manure. Channabasavanna *et al.* (2007) [6], Ashok Kumar *et al.* (2005) [2] also reported the beneficial effect of FYM, Vermicompost and green leaf manure in enhancing the maize productivity. Inorganic fertilizer use, application of 100 per cent RDF yielded much more yield of maize (5578 kg ha^{-1}) and bengal gram (1495 kg ha^{-1}) hence maize equivalent yield (10986 kg ha^{-1}). The growth of the levels of NPK by 50 percent to 100 percent led to high growth in the yields of the two crops. Channabasavanna *et al.* (2007) [6] have also found similar results. Use of 100 per cent NPK gave 13.0 and 5.4 per cent elevated maize equivalent yield of over 50 and 75 per cent NPK, respectively. The interaction effect between inorganic and organic fertilizer was not found significant (Table 2). This was simply because of provision of greater amount of nutrients using FYM, vermicompost and green leaf manure and inorganic fertilisers. FYM, poultry manure and vermicompost were also found to have positive effect on the productivity of maize (Meena *et al.* 2007, Pattanashetti *et al.* 2002) [13, 16].

Economics

With respect to economics, significantly higher net returns (₹64,851 ha^{-1}) and benefit-cost ratio (B:C) of 3.48 were recorded under the integrated application of inorganic fertilizers and organic manures (50% inorganic + 50% organic). This treatment was statistically on par with the application of the recommended dose of fertilizers along with farmyard manure (RDF + FYM: ₹62,912 ha^{-1} and 3.30, respectively) and 100% inorganic fertilizer application (RDF: ₹58,451 ha^{-1} and 3.44, respectively) (Table 2). The higher net returns obtained under the integrated nutrient management system were mainly due to the higher yield and lower cost of cultivation compared to the organic treatment. These findings are in close agreement with the results reported by Channabasavanna *et al.* (2007) [6] and Meena *et al.* (2007) [13].

With respect to the physico-chemical properties of soil, there were no significant differences observed in soil pH, available K_2O, Fe, and Mn status among the different nutrient management practices. However, soil organic carbon content was significantly influenced by the treatments. Under 100% organic nutrient management, a notable buildup of soil organic carbon (0.64%) was recorded (Table 1) compared to the initial value (0.52%). This increase can be attributed to the continuous use of organic manures such as farmyard manure (FYM), vermicompost, and green leaf manure, which enrich soil organic matter. Organic carbon content in soil is known to change rapidly with the addition of organic residues. Bellakki and Badanur (1994) also reported similar increases in soil organic carbon with the addition of subabul and sorghum stubbles. In contrast, under inorganic nutrient management practices, organic carbon levels remained stagnant, possibly due to the exclusive use of fertilizers over a prolonged period, leading to the gradual depletion of soil organic matter.

The nutrient management practices had a significant effect on the soil fertility status. The available nitrogen (179.29, 172.02, and 165.63 kg ha⁻¹), phosphorus (P_2O_5) (71.54, 70.53, and 68.21 kg ha⁻¹), and potassium (K_2O) (662.2, 652.1, and 658.0 kg ha⁻¹) showed a noticeable buildup in soil over the years under RDF + FYM, organic, and integrated nutrient management practices, respectively, as compared to 100% inorganic fertilization alone (Table 2; Fig. 2). The available nutrient content was significantly higher under organic and integrated nutrient management practices compared to the inorganic treatment, although the integrated and organic systems were statistically at par at the harvest of both maize and Bengal gram. In contrast, under 100% inorganic nutrient management, a declining trend in available nutrient status was recorded.

Soil organic matter plays a crucial role in maintaining soil fertility and influences the carbon and nitrogen mineralization capacities of the soil, which determine the availability of essential plant nutrients. A decline in soil organic matter consequently leads to reduced soil productivity. The continuous application of FYM and other organic sources enhances soil fertility through the solubilizing action of organic acids produced during decomposition, along with their capacity to retain potassium in available form. This improvement in soil fertility can be attributed to the addition of organic manures that stimulate microbial growth and activity. These microorganisms participate in the biological cycling of elements and transformation of mineral compounds, thereby increasing nutrient availability in the soil (Vidyavathi *et al.*, 2011) [19].

Inclusion of organic manures in organic agriculture is highly beneficial, as they improve soil fertility and enhance crop productivity. The incorporation of organic sources in nutrient management has shown greater advantages, as reported by Jawale *et al*. (1998) [10] and Das *et al*. (2010) [7]. This improvement is attributed to the gradual and sustained release of nutrients from organic materials. In contrast, under inorganic nutrient management practices, nutrient status tends to decline over time due to the exhaustive nature of crops and the lack of replenishment in the soil.

Integrated nutrient management (INM) practices recorded significantly higher uptake of N, P, and K in crops compared to inorganic or purely organic nutrient management. This is due to the continuous availability of nutrients—wherein inorganic fertilizers supply nutrients during early growth stages, while organic sources such as FYM, vermicompost, and green leaf manure (GLM) ensure slow and sustained nutrient release during later stages. The addition of these organic sources enhances soil enzyme activity, leading to increased mineralization and nutrient transformation into available forms.

Similarly, soil phosphorus availability increases with organic amendments, as decomposition of organic matter releases organic acids that solubilize phosphate-bearing minerals and reduce fixation. Manna *et al*. (2006) [12] observed increased available phosphorus content with FYM application compared to initial and control levels. The build-up of available potassium through FYM or green manuring is due to the additional K supplied and improved nutrient cycling.

Application of FYM along with N and P fertilizers has been shown to result in the highest total uptake of N, P, and K by soybean, attributed to better nutrient availability and enhanced soil nutrient reserves. Basavaraju (2007) [4] reported that the uptake of N, P, and K was highest when organic manures (FYM, vermicompost, crop residues, and green manuring) and inorganic fertilizers were applied in equal proportions to meet the recommended N level (150 kg ha⁻¹) in maize. Overall, the combined use of organic and inorganic sources ensures continuous nutrient supply throughout crop growth, leading to sustainable soil fertility and higher productivity.

Table 1: Effect of different treatments on Maize equivalent yield and economics

Treatments	Eq. Yield (kg/ha)			COC	GR (Rs/ha.)	NR (Rs/ha.)	B:C
	2020-21	2021-22	Pooled				
Organic (100%N)	5572	5316	5444	28800	81659	52859	2.84
integrated (50:50)	6567	5560	6064	26100	90951	64851	3.48
inorganic (RDF)	5863	5130	5497	24000	82451	58451	3.44
RDF+FYM	6736	5299	6018	27350	90262	62912	3.30
S.Em. ±	288	394	199	-	-	2983	0.11
CD@ 5%	627	851	613	-	-	9192	0.35

Table 2: Physico-chemical properties of soil at harvest of Chickpea in Maize-chickpea cropping system

Treatments	Parameters									
	pH (1:2.5)	EC (dSm^{-1})	OC (%)	N	P_2O	K_2O	Zn	Cu	Fe	Mn
				Kg/ha			mg/kg			
T_1: 100% Rec ‘N’/P through organics	7.60	0.16	0.64	172.02	70.53	652.1	0.61	1.48	3.33	7.71
T_2: Integrated system (50% through organics + 50% through in organics)	7.48	0.17	0.62	165.63	68.21	658.0	0.52	1.47	3.47	7.78
T_3: RDF	7.65	0.24	0.52	161.78	53.31	645.9	0.46	1.38	3.32	7.40
T_4: RDF+ FYM (+Recommended package)	7.47	0.23	0.61	179.29	71.54	662.2	0.56	1.55	2.87	7.84
S. Em±	0.05	0.01	0.03	3.5	2.76	23.39	0.03	0.04	0.14	0.33
C. D. at 5%	NS	0.02	0.09	10.2	7.88	NS	0.08	0.11	NS	NS

Conclusion

Thus it can be concluded that application of organic manure along with chemical fertilizers is efficient nutrient management practice which can be applied @ 50% through organic and 50% through inorganic fertiliser application to maize and bengal gram crops to realize higher yield and monitory returns in maize-bengal gram cropping system.

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