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Effect of nutrient source and their doses to Bunda (*Colocasia esculenta var. esculenta* L.) crop on physico-chemical properties of an inceptisol of Chhattisgarh Plateau in India

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Abstract
The present investigation was carried during the Kharif season (June- January) of the year 2019-20 at Indira Gandhi Krishi Vishwavidyalaya- College of Agriculture and Research Station, Jagdalpur (Chhattisgarh). The experiment was laid out in Factorial Randomized Block Design with sixteen treatment which are replicated three times, the treatment consist of four level of fertilizers ($N_0P_0K_0$, $N_{50}P_{40}K_{50}$, $N_{75}P_{60}K_{75}$ and $N_{100}P_{80}K_{100}$) and four levels of Farm Yard Manure (0, 10, 20 and 30 t per ha). The result revealed that the fertilizer levels didn't affect different soil physicochemical properties significantly, however, the soil available N increased significantly at each level of fertilizer. Availability of phosphorus improved significantly under $N_{100}P_{80}K_{100}$ as compared to $N_{50}P_{40}K_{50}$. Availability of soil potassium improved significantly with each successive level of fertilizer except fertilizer level $N_{75}P_{60}K_{75}$ which was at par with $N_{50}P_{40}K_{50}$. The cation exchange capacity of soil and soil available N increased significantly at each level of FYM however, the organic carbon content recorded significantly higher under FYM @ 20t ha^{-1} compared to 10t ha^{-1} and at par with 30t ha^{-1}. The soil porosity was found significantly higher under FYM @ 30t ha^{-1} in comparison to control but at par with other levels. The soil bulk density was significantly higher with farm yard manure @ 20 t ha^{-1} in comparison to control but at par with 10 and 30t ha^{-1}. The significant improvement in available P was recorded with FYM @ 30t ha^{-1} as compared to FYM @ 10t ha^{-1}. Application of FYM @ 20t ha^{-1} significantly improved the availability of soil potassium over control but at par with 10 and 30t FYM ha^{-1}, however, availability of soil potassium under FYM @ 30t ha^{-1} was significantly higher than 10t ha^{-1}.

Keywords: Bunda, colocasia, organic and inorganic nutrients, corm, soil properties

Introduction
Bunda (*Colocasia esculenta var. esculenta*) is a most important tuber vegetable crop of the world and is widely grown in Caribbean and Pacific Island including Fiji, New Hebrides, New Caledonia, New guinea and Solomon Islands. It occupied 9th positions among the food crops in the world (Kumar *et al.*, 2016) [13] and is widely grown in India in an area of 1.6 million ha, producing 11.66 million tonnes with an average production of 7.25 t ha^{-1} (FAO, 2010) [5]. In Chhattisgarh state it is grown in an area of 7008 ha producing 98931 tonnes with an average production of 14.11 t ha^{-1}. Despite of the importance of this crop, its cultivation anywhere in India is generally a subsistent to semi-commercial crop. (Anonymous, 2018) [2] It is well understood that there is a wide gap between potential yield and the yield obtained under actual field situations for tuber crops. Among the different factors contributing to this yield gap, soil-plant nutrition is worthy of mention as soil fertility management and proper nutrition of these crops can result in large yield gains. Many factors like soil fertility, imbalanced fertilization, deteriorated soil properties, cultivars being grown, weed infestation etc. also limit its yield worldwide. Now, swift economic development has led the farmers to use mineral fertilizers as they are more economical, affordable, easy to use and quick in response, but over reliance on chemical fertilizers is associated with not only decline in some soil properties and crop yields over time (Hepperly *et al.,* 2009) [7] but their intensive application is leading to land degradation, deteriorated soil health and leaching of nutrients into the underground water thereby posing environmental risks to human and animal health also. It is well known that addition of organic manures has shown considerable increase in yields of different crops, and significant influence on physical, chemical and biological properties of soil.

Stable beneficial effects of organic materials are also observed in soil humic substances (due to an increase in the complexity of their molecular structure, which increases the humic/fulvic acid ratio), as well as in soil sorption properties (with increased CEC and base saturation) (Weber *et al*., 2007) [21]. Sole application of farm yard manure (FYM) resulted in increased crop yield (Anatoliy and Thelen, 2007) [1], higher SOM content (44%), improved soil porosity (25%) and 16 times more water holding capacity (Gangwar *et al.*, 2006) [6]. A long term residual effect on soil organic C and soil P (about 7 to 8 years) were reported by Kihanda *et al*., (2006) [12] when organic manure was applied in a semi-arid dryland agriculture. Organic manures also affect the soil biological activity (Arau Jo and Monteiro, 2006) [3], while enhanced phosphorous (P) availability is also well reported with the application of organic manures in the soil (Toor and Bahl, 1997) [20]. Ancient farmers used to rely on organic manures for crop production that proved good for soil health but was slow in response on crop yields.

Use of organic manures alongside inorganic fertilizers often lead to increased soil organic matter (SOM), soil structure, water holding capacity and improved nutrient cycling and helps to maintain soil nutrient status, cation exchange capacity (CEC) and soil's biological activity (Saha *et al*., 2008 and Joshi *et al.,* 2018) [16, 18]. Combining approaches of organic and inorganic nutrients not only improve the quality of the produce but also help in improving the soil fertility, texture, structure, water holding capacity including the biosphere. Therefore, an integrated use of inorganic fertilizers with organic manures is a sustainable approach for efficient nutrient usage which enhances efficiency of the chemical fertilizers while reducing nutrient losses (Schoebitz and Vidal, 2016) [17]. Synergistic effects of organic manures with inorganic fertilizers accumulate more total nitrogen in soils (Huang *et al.*, 2007) [8]. Collective application of inorganic and organic fertilizers ensures balanced fertilization of crops. Use of organics nutrients to improve physical, chemical and biological properties of soil has been successfully observed in literature (Srinivasan and Angayarkanni (2008) [19], Bhaduri and Gautam (2012) [4], Regar and Singh (2014) [15] and Joshi and Sharma (2017) [9, 10].

Proper nutrient management strategies would ensure improvement in soil fertility, besides the economical up scaling of farmers. There is a need to standardize the optimum dose of nutrients from organic and inorganic sources not only for improving the yield but physico-chemical properties of soil as well. So, there is a need to find out better-way between organic, inorganic and integrated approach that may sustain soil health and fertility and/or productivity without declining in yield. Keeping all these aspects in consideration, the present study was therefore conducted to evaluate the effects of organic and inorganic manures on their residual impacts on soil properties.

Methods and Materials

The present investigation was conducted during the *Kharif* -2019 at S.G. Collage of Agriculture and Research Station, Jagdalpur, Chhattisgarh in factorial randomized complete block design with sixteen treatments and three replications. The treatments were consisted of four levels of fertilizers ($N_0P_0K_0$, $N_{50}P_{40}K_{50}$, $N_{75}P_{60}K_{75}$ and $N_{100}P_{80}K_{100}$) and four levels of Farm Yard Manure (0, 10, 20 and 30 t ha^{-1}). The initial soil physicochemical properties of the experimental field were recorded. The soil had a loamy texture with 5.9 pH, 0.07 dSm^{-1} electrical conductivity, 0.74% organic carbon, 1.52 g cm^{-3} bulk density, 16.1 C mol (p+) kg^{-1} cation exchange capacity, 213 kg ha^{-1} available N, 14.1 kg ha^{-1} available P and 191.6 kg ha^{-1} available K. The planting of Bunda was done on 8 June 2019. Full dose of farm yard manure, phosphorus and potassium and 1/3 dose of nitrogen, as per treatment, were applied in the form of diammonium phosphate, muriate of potash and urea, at the time of planting and there remaining dose of nitrogen was applied at 60 and 75 days after planting. The Intercultural operation like, hand weeding done two times at 45 and 90 days after planting respectively, earthing up done at 60 days after planting, spraying of Mancozeb (0.25%) for the control of leaf blight of Colocasia *(Phytopthora infestance*) at 100 days after sowing and crops are grown in rainfed field conditions. The crop was harvested at 22 Jan 2020 after complete maturity, and plot wise soil sampling was done after harvesting for the purpose of analyzing soil bulk density and for analysis of physicochemical parameters and nutrient availability. Soil samples were processed and analyzed for different soil physicochemical parameters and primary nutrients availability using standard analytical procedures.

Result and Discussion

The data illustrated in Table 1 revealed the effect of inorganic and organic sources of nutrients on different physicochemical properties of soil *viz.* soil pH, soil electrical conductivity, soil organic carbon, soil bulk density, soil porosity and soil cation exchange capacity.

Soil PH

The data on soil pH presented in the Table 1 ranged from 6.4 to 6.6 and 6.4 to 6.6 with no significant effect of the doses of fertilizers and FYM and their interaction.

Electrical conductivity

The data illustrated in Table 1 revealed that the soil electrical conductivity didn't affect with the different levels of both the sources of nutrients. It ranges from 0.14 to 0.15dSm^{-1} and 0.15 to 0.16dSm^{-1} under inorganic and organic sources of nutrients respectively. No interaction effect of fertilizer and FYM doses was seen in case of soil electrical conductivity.

Organic carbon

The data presented in the Table 1 reveals that the soil organic carbon ranges from 0.64 to 0.65% and 0.63 to 0.67% under inorganic and organic sources of nutrients respectively. The organic carbon content was not affected with the levels of fertilizer whereas; FYM levels @ 20 and 30t ha^{-1} significantly improved the organic carbon content of the soil over control but at par with each other. Interaction effect of inorganic and organic sources of nutrients was not found significant in case of organic carbon content of the soil.

Soil porosity

Soil porosity ranges from 39.5 to 39.7% and 39 to 40.2% with highest values recorded with the application of farm yard manure at the rate of 30 t per ha which was significantly higher than control but at par with other levels.

Soil bulk density

Soil bulk density ranges from 1.60 to 1.60 g cm^{-3} and 1.59 to 1.62 g cm^{-3} under inorganic and organic nutrient sources respectively with lowest value recorded with the application of farm yard manure at the rate of 20 and 30t ha^{-1} which was significantly higher than control but at par with farm yard manure at the rate of 10t ha^{-1}. Interaction effect between inorganic and organic sources of nutrients was not found significant in case of soil bulk density.

Cation exchange capacity

Soil cation exchange capacity ranges from 10.9 to 11.9 cmol (p^+) kg^{-1} soil and 9.2 to 13.7 cmol (p^+) kg^{-1} under inorganic and organic nutrient sources respectively with higher values recorded with the application of fertilizer at the rate of $N_{100}P_{80}K_{100}$ and farm yard manure at the rate of 30t ha^{-1}. Increasing levels of fertilizer didn't increased the CEC of soil, however, increasing levels of farm yard manure increased cation exchange capacity at all the successive levels.

Singh *et al*. (2015) [15] reported that pH, electrical condutivity, organic carbon of soil improved by the application of farm yard manure at the rate of 20 t ha^{-1}. Joshi *et al* (2017) [9, 10] reported that application of 30 t per ha of vermin-compost also improved physical condition of soil.

Table 1: Effect of different levels of inorganic and organic sources of nutrients on physicochemical properties of soil and available primary nutrients in soil

Organic/ Inorganic dose	Soil pH	Soil EC (dSm^{-1})	Soil organic carbon (%)	Soil bulk density (g cm^{-3})	Soil porosity (%)	CEC [c mol (p+) kg^{-1} soil]	Available primary nutrients in soil (kg ha^{-1})		
							N	P	K
$N_0P_0K_0$	6.4	0.15	0.64	1.60	39.6	10.9	212	15.8	133
$N_{50}P_{40}K_{50}$	6.6	0.15	0.65	1.60	39.5	11.3	219	17.7	138
$N_{75}P_{60}K_{75}$	6.5	0.14	0.65	1.60	39.6	11.6	223	19.6	141
$N_{100}P_{80}K_{100}$	6.5	0.15	0.65	1.60	39.7	11.9	228	20.5	146
CD(P=0.05)	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	3.6	2.2	3.0
FYM_0	6.4	0.15	0.63	1.62	39.0	9.2	213	16.1	135
FYM_{10}	6.5	0.15	0.65	1.61	39.4	10.5	217	17.6	138
FYM_{20}	6.6	0.15	0.66	1.59	39.8	12.2	223	19.4	141
FYM_{30}	6.5	0.16	0.67	1.59	40.2	13.7	229	20.6	143
CD(P=0.05)	N.S.	N.S.	0.02	0.02	0.85	0.80	3.6	2.2	3.0
Interaction CD (P=0.05)	N.S.	N.S.	N.S.	N.S.	N.S	N.S.	N.S.	N.S	N.S.

Where, FYM0, FYM10, FYM20 and FYM30 = Farm yard manure t ha^{-1}

Available nitrogen, phosphorus and potassium

The data recorded in Table 1 revealed that inorganic and organic fertilizers had significant effect on soil available nitrogen phosphorus and potassium however interaction effect between inorganic and organic sources of nutrients was not found significant in case of soil available N, P and K.

Available nitrogen

The data presented in the Table 1 revealed that available soil nitrogen ranged from 212 to 228 kg ha^{-1} and 213 to 229 kg ha^{-1} under application of different levels of inorganic and organic sources of nutrients respectively with maximum values recorded with the application of fertilizer at the rate of $N_{100}P_{80}K_{100}$ kg ha^{-1} and farm yard manure at the rate of 30t ha^{-1}. Availability of nitrogen improved significantly at each successive level of fertilizer and FYM. The interaction effect of inorganic and organic nutrients was not found significant.

Available phosphorus

The data presented in the Table 1 revealed that the available soil phosphorus ranged from 15.8 to 20.5 kg ha^{-1} and 16.1 to 20.6 kg ha^{-1} under inorganic and organic nutrient sources respectively and maximum values recorded with the application of inorganic fertilizer at the rate of $N_{100}P_{80}K_{100}$ kg ha^{-1} and farm yard manure at the rate of 30t ha^{-1}. Availability of phosphorus improved significantly under $N_{100}P_{80}K_{100}$ as compared to control and $N_{50}P_{40}K_{50}$. Similarly, the significant improvement in available P was recorded with FYM @ 30t ha^{-1} as compared to control and FYM @ 10t ha^{-1}. The interaction effect of inorganic and organic nutrients was not found significant in case of available soil P.

Available potassium

The data presented on the Table 1 revealed that the available soil potassium ranged from 133 to 146 kg ha^{-1} and 135 to 143 kg ha^{-1} due to application of inorganic and organic nutrients, respectively and the maximum values recorded with the application of inorganic fertilizer at the rate of $N_{100}P_{80}K_{100}$ kg ha^{-1} and farm yard manure at the rate of 30t ha^{-1}. Availability of soil potassium improved significantly with each successive level of fertilizer except fertilizer level $N_{75}P_{60}K_{75}$ which was at par with $N_{50}P_{40}K_{50}$. Application of FYM @ 20t ha^{-1} significantly improved the availability of soil potassium over control but at par with 10 and 30 t FYM ha^{-1}, however, availability of soil potassium under FYM @ 30t ha^{-1} was significantly higher than 10t ha^{-1}. The interaction effect of inorganic and organic sources of nutrients on availability of soil potassium was not found significant.

Similar findings were also recorded by Laxminarayana (2013) [14] that the application of farm yard manure, neem cake, green manure and 50% NPK significantly increase nutrients use efficiency of soil. Joshi *et al*. (2017) [9, 10] reported that application of inorganic and organic sources of nutrients significantly improved nutrients availability of soil.

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