The Pharma Innovation Journal 2021; 10(7): 193-197

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(7): 193-197

www.thepharmajournal.com
Received: 14-04-2021
Accepted: 29-06-2021

Influence of differential levels of inorganic and organic sources of nutrients on growth and yield of Bun a (*Colocasia esculenta var. esculenta* L.) in an Inceptisol of Chhattisgarh plateau in India

Harshit Singh, GK Sharma, T Chandrakar, Padmakshi Thakur, DP Singh and AK Thakur

Harshit Singh
S.G. College of Agriculture and Research Station, Indira Gandhi Krishi Vishwavidyalaya, Jagdalpur, Chhattisgarh, India

GK Sharma
Directorate of Research Services, Rajmata Vijayaraje Scindia Krishi Vishwavidyalaya, Gwalior, Madhya Pradesh, India

T Chandrakar
S.G. College of Agriculture and Research Station, Indira Gandhi Krishi Vishwavidyalaya, Jagdalpur, Chhattisgarh, India

Padmakshi Thakur
S.G. College of Agriculture and Research Station, Indira Gandhi Krishi Vishwavidyalaya, Jagdalpur, Chhattisgarh, India

DP Singh
S.G. College of Agriculture and Research Station, Indira Gandhi Krishi Vishwavidyalaya, Jagdalpur, Chhattisgarh, India

AK Thakur
S.G. College of Agriculture and Research Station, Indira Gandhi Krishi Vishwavidyalaya, Jagdalpur, Chhattisgarh, India

Corresponding Author:
Harshit Singh
S.G. College of Agriculture and Research Station, Indira Gandhi Krishi Vishwavidyalaya, Jagdalpur, Chhattisgarh, India

Abstract
The present investigation was carried during the *kharif* 2019-20 at Indira Gandhi Krishi Vishwavidyalaya- College of Agriculture and Research Station, Jagdalpur, Bastar (Chhattisgarh). The experiment was laid out in a factorial randomized complete block design with sixteen treatment combinations 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 result revealed that the plant height, leaf area index, length of corm, width of corm, weight of corm plant^{-1}, dry matter (%) of tuber and tuber yield increased significantly at each level of fertilizer. The plant height and leaf area index at 3 month after planting, length of corm, weight of corm plant^{-1}, dry matter (%), tuber yield, increased significantly at each level of FYM, however, the plant height and leaf area index at 5 month after planting and width of corm, responded significantly up to FYM @ 20t ha^{-1}. The weight of corm was not influenced significantly with the FYM levels under $N_0P_0K_0$, and $N_{100}P_{80}K_{100}$ (except FYM @ 10t ha^{-1}) and it responded to each successive level of FYM under remaining two fertilizer doses. The successive doses of FYM were significantly responded by tuber yield under all the fertilizer doses except FYM @10 t ha^{-1} under $N_0P_0K_0$. It shows that the dose of FYM @10 t ha^{-1} might not be sufficient to improve the tuber yield significantly where no fertilizer was applied. The fertilizer dose @ $N_{100}P_{80}K_{100}$ kg ha^{-1} in conjunction with FYM @ 30t ha^{-1} was found better in terms of higher tuber yield (35.1 t ha^{-1}) of Bunda.

Keywords: Bunda, Colocasia, organic and inorganic nutrients, corm

1. Introduction
Roots and Tuber crops are the 2nd most principal food crops in the world after cereals, generally found in tropical and subtropical zone in the world, nearly 2.2 billion people depend upon roots and tuber crops in the world (FAO, 2018) [2]. Annual global production of roots and tuber crops are 836 million tones and Asia is a major producer followed by Africa, Europe and America. Tuber crops have an immense potential as functional foods and nutritional ingredients to be explored in disease risk reduction and wellness (Chandrasekara *et al.*, 2016) [6]. Bunda (*Colocasia esculenta var. esculenta*) is intensively produced in the Pacific Islands and forms a significant proportion of their diet; West Africa cultivates the largest area and is the leading producer of the crop in the world (FAOSTAT, 2010) [3]. It is a most important tuber vegetable crop of the world and it is commonly known as *Sakeen,* Arbi, Taro and Kochai in Chhattisgarh and Bunda in north India. Bunda is originated in Indo-Malaysian region of South East Asia and generally cultivated in most of the state of India and Malaysia. Bunda 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) [16]. Colocasia (Bunda) 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) [1]. In Chhattisgarh it is grown in Bastar, Surguja, Surajpur, Kawardha, Dantewada, Korba, Mahasamund, Kankar, Balrampur, Raigarh, Korea, Bilaspur and Raipur districts in an area of 7008 ha producing 98931 ton 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. Scientific cultivation of crops like Bunda (Colocasia) will not only increase food production, but also provide balanced nutrition to the deprived sections of the region (Chukwu and Nwosu, 2008) [7].

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. The Colocasia responds well to manure and fertilizer application, adequate supply of nutrition is a precondition of higher production. The nutrients requirement of Colocasia crops is high because of high biological yields so, sufficient plant nutrients have to be supplied to sustain rapid growth for higher production of corms. The information regarding nutritional requirement of Bunda is very scanty. There is a need to standardize the optimum dose of nutrients for improving the productivity of Bunda.

Some work on nutrient management in different tuber crops have been carried out in India. Ramesan *et al.* (1996) [23] reported that the application of nitrogen and potassium significantly increase yield component of arrowroot. Maheswarappa *et al.* (2000) [17] and Veena (2000) [26] reported highest uptake of N and K at the highest level of fertilization in arrowroot intercropped in coconut gardens. Suja *et al.* (2006) [24] reported that the application of NPK @ 50:25:75 kg ha^{-1} produce higher yield. Joshi *et al*. (2017) [11] reported that the application of NPK fertilizer @ 60:40:60 and vermicompost @ 20t ha^{-1} had significantly increased the tuber yield and growth parameters of tikhur (East Indian arrowroot).

It is well known that addition of organic manures has shown considerable increase in crop yield, quality and significant influence on physical, chemical and biological properties of soil (Joshi *et al*. 2018) [12]. For sustainable crop production, integrated uses of inorganic and organic source of fertilizers are highly beneficial. The uptake of nutrients by plants and yield of crops is highly depends on soil nutrient supply system through different sources (Kannaiyan, 1999 and Joshi and Sharma, 2017) [15, 11]. The proper information on nutrient management in Bunda crop is lacking. Hence, this study was undertaken with the objective to find out optimum doses of inorganic and organic sources of nutrients.

Methods and Materials

The present investigation was conducted during the Kharif season (June- January) of the year 2019-20 at S.G. Collage of Agriculture and Research Station, Jagdalpur, Chhattisgarh 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 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 8th 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 the 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 planting and crops are grown in rainfed field conditions. The crop was harvested at 22nd January 2020 after complete maturity, as indicated by the leaf drying and falling down of plants. For recording observations, randomly four plants were selected in each of the plot. The Plant height was recorded with the help of a meter scale from ground level to upper most point of plant, leaf area index was estimated by dividing the total leaf area of the plant by ground area, dry matter of corm (%) was calculated by dividing the dry weight of corm by fresh weight of corm multiplied by hundred.

Result and Discussion

Plant height

The data on plant height given in Table 1 revealed that the inorganic and organic nutrients had a significant effect on plant height of Bunda at 3 and 5 months after planting. Due to differential doses of inorganic fertilizers, the mean values of plant height of Bunda ranged from 67.0 to 77.3 cm and 83.0 to 98.1 cm at 3 and 5 months after planting respectively. The plant height increased with increase in fertilizer doses. The highest value of plant height was recorded due to application of inorganic fertilizer at the rate of $N_{100}P_{80}K_{100}$ kg ha^{-1} and it was significantly higher than $N_0P_0K_0$, $N_{50}P_{40}K_{50}$ and $N_{75}P_{60}K_{75}$.

Due to application of differential doses of farm yard manure, the mean values of plant height of Bunda ranged from 67.1 to 76.0 cm and 84.9 to 95.3 cm at 3 and 5 month after planting respectively. In general, the plant height increased with increase in FYM doses. The highest value of plant height was recorded by the application of farm yard manure at the rate of 30 t per ha and it was significantly higher than 0, 10 and 20t ha^{-1} at 3 months after planting but at 5 months after planting the plant height under FYM @30 t ha^{-1} was at par with 20 t ha^{-1}. The interaction effect between inorganic and organic nutrient sources on plant height of Bunda was not found significant.

Similar findings were reported by many co-workers. Iwuagwu *et al*. (2017) [9] reported that plant height was significantly enhanced by the application of cow dung at the rate of 30 t ha^{-1}. Mama *et al*. (2016) [18] studied those highest values for plant height was observed due to conjunctive application of farm yard manure and potassium. Najm *et al.* (2013) [20] found that application of cattle manure with potassium fertilizer have significant effect on plant heights at 60th, 75th, 90th and 105th days after planting. Yourtchi *et al.* (2013) [25] observed that maximum plant height was found by the application of potassium @150 kg ha^{-1}.

Leaf area index

The data on leaf area index of Bunda as influenced by the doses of inorganic and organic nutrients given in Table 1 revealed that the inorganic and organic nutrient levels had a significant effect on leaf area index of Bunda at 3 and 5 months after planting. The mean values of leaf area index of Bunda ranged, due to different levels of inorganic fertilizers, from 0.65 to 0.85 and 1.09 to 1.61 at 3 and 5 months after planting respectively. The leaf area index of Bunda increased with increase in fertilizer levels with the highest value due to application of fertilizer at the rate of $N_{100}P_{80}K_{100}$ kg per ha and it was found significantly higher than $N_0P_0K_0$, $N_{50}P_{40}K_{50}$ and $N_{75}P_{60}K_{75}$ at both the stages.

The mean values of leaf area index of Bunda ranged, due to graded levels of farm yard manure, from 0.68 to 0.83 and 1.21

to 1.49 at 3 and 5 months after planting, respectively. In general, the leaf area index of Bunda increased with the increased in FYM level. The highest value of plant height was recorded due to application of Farm yard manure at the rate of 30 t ha^{-1} and it was significantly higher than FYM @ 0, 10 and 20 t ha^{-1} in case of 3 months after planting but in case of 5 months after planting it was significantly higher than FYM @ 0 and 10 t ha^{-1} and at par with 20 t ha^{-1}. The interaction effect of inorganic and organic sources of nutrients on leaf area index of Bunda was not found significant.

This result is in greater conformity with results found by different workers. Chamroy *et al.* (2015) [5] reported that the inorganic and organic nutrients application significantly increases leaf area index than control. Pratap *et al.* (2015) [22] reported that the application of Farm yard manure at the rate of 10 t per ha significantly increase leaf area index than absolute control.

Length of corm

The data on length of corm of Bunda is given in the Table 1 and it revealed that inorganic and organic fertilizers had significant effect on length of corm, which ranged from 12.9 to 18.0 cm and 13.7 to 17.0 cm due to application of inorganic and organic nutrients respectively. The increase in fertilizer levels resulted in increased length of corm of Bunda with the highest value recorded due to application of inorganic fertilizers at the rate of $N_{100}P_{80}K_{100}$ and farm yard manure at the rate of 30 t ha^{-1} which were significantly higher than each previous level of fertilizer and FYM. The interaction effect of inorganic and organic nutrient levels on length of corm of Bunda is not found significant. This result is in greater conformity with different workers. Isaac *et al*. (2015) [8] reported that the application of inorganic and organic fertilizers significantly increase corm length. Ahmad *et al.* (2018) [4] reported that Colocasia tuber length was significantly increase by the addition of fertilizers.

Width of corm

The result given in the Table 1 on length of corm of Bunda revealed that inorganic and organic fertilizers had significant effect on width of corm, and ranged from 16.5 to 19.6 cm and 15.8 to 19.8 cm due to application of inorganic and organic fertilizers respectively. The highest value of the width of corm of Bunda was recorded under the application of inorganic fertilizers at the rate of $N_{100}P_{80}K_{100}$ which was significantly higher than all the other levels of fertilizer, and the application of farm yard manure at the rate of 30 t ha^{-1} was recorded with the highest width of corm of Bunda which was significantly higher than other levels of FYM except FYM @ 20 t ha^{-1} which was at par with FYM @ 30 t ha^{-1}. The interaction effect of inorganic and organic nutrients on width of corm is not found significant. This result is in greater conformity with different workers. Isaac *et al.* (2015) [8] reported that the application of inorganic and organic fertilizers had significant effect on corm width of Colocasia. Omid *et al*. (2018) [21] reported that application of NPK fertilizer dose at the rate of 120:30:60 significantly affect corm width of Colocasia. Markam *et al.* (2018) [19] reported that application of 130% NPK fertilizer significantly produces higher corm width (13.03 cm)

Weight of corm per plant

The data given in the Table 1 and 2 revealed that the inorganic and organic fertilizers had significant effect on the weight of corm $plant^{-1}$ of Bunda, mean values of it ranges from 0.26 to 0.58 and 0.37 to 0.49 kg $plant^{-1}$ by to application of inorganic and organic fertilizers respectively. Highest value recorded due to application of inorganic fertilizers at the rate of $N_{100}P_{80}K_{100}$ and Farm yard manure at the rate of 30 t ha^{-1} which was significantly higher than other doses of inorganic and organic, respectively.

Interaction effect of inorganic and organic sources of nutrients on weight of corm of Bunda was found significant (Table 2). The weight of corm of Bunda increased significantly at each successive level of fertilizer doses under all levels of FYM. Increasing the FYM levels under no fertilizer i.e. $N_0P_0K_0$ didn't produce significant difference in the values of weight of corm similarly, under the highest level of fertilizer under study i.e. $N_{100}P_{80}K_{100,}$ the FYM levels didn't produce any significant difference in the values of weight of corm except FYM @ 10t ha^{-1} and the weight of corm responded to each successive level of FYM under remaining two other fertilizer doses. FYM doses without fertilizer could not increase the weight of corm significantly; similarly the FYM doses couldn't increase the weight of corm significantly above the rate of 10 t ha^{-1}.

This result is in greater conformity with different workers. Jurri *et al.* (2008) [13] reported that the application of 200 kg vermi-compost along with 75% recommended dose of NPK per ha significantly produced higher weight of corm and weight of side cormels per plant. Similar finding also recorded by Joshi *et al*. (2017) [11].

Dry matter (%) of tuber

The data given in the Table 1 revealed that the application of inorganic and organic fertilizers had significant effect on dry matter (%) of tuber of Bunda, which ranges from 24.7 to 31.7 (%) and 26.0 to 29.6 (%) due to application of inorganic and organic fertilizers respectively. The highest value of dry matter (%) of Bunda was recorded due to application of inorganic fertilizers at the rate of $N_{100}P_{80}K_{100}$ and Farm yard manure at the rate of 30 t per ha respectively which was significantly higher than all other doses of both the sources of nutrients. The interaction effect of both the sources of nutrients on the dry matter (%) of tuber of Bunda was not found significant. This result is greater conformity with different workers. Joshi *et al.* (2017) [11] reported that conjunctive application of $N_{90}P_{60}K_{90}$ and vermi-compost 30t per ha produces higher dry matter % of tuber, addition of graded dose of fertilizers also increase dry matter % of tuber, similar finding also recorded, Verma *et al.* (2012) [27] and Hota *et al.* (2014) [14].

Tuber yield of Bunda

The data given in the Table 1 and 3 revealed that the inorganic and organic fertilizers had significant effect on yield of Bunda, which ranges from 16.1 to 32.7 t ha^{-1} and 21.1 to 28.1 t ha^{-1} due to application of inorganic and organic fertilizers respectively. The highest value of yield of Bunda was recorded due to application of inorganic fertilizers at the rate of $N_{100}P_{80}K_{100}$ and farm yard manure at the rate of 30 t ha^{-1} respectively which was significantly higher than all the other doses. Each successive level of inorganic and organic nutrients had significantly improved the tuber yield of bunda.

Interaction effect of inorganic and organic nutrient was found significant with respect to tuber yield of bunda (Table 3). The successive doses of FYM were significantly responded by tuber yield of Bunda under all the fertilizer doses except the

10 t ha^{-1} dose of FYM under $N_0P_0K_0$. It shows that the dose of FYM @10 t ha^{-1} might not be sufficient to improve the tuber yield significantly where no fertilizer was applied. This result is in greater conformity with different workers. Joshi *et al.* (2017) [11] reported that conjunctive application of fertilizer @ $N_{90}P_{60}K_{90}$ and Vermi-compost @ 30 t ha^{-1} produced significantly higher yield. Similar findings were also recorded by Jurri *et al*., (2008) [13] and Verma *et al.* (2012) [27].

Table 1: Effect of different levels of inorganic and organic sources of nutrients on growth parameters and tuber yield of Bunda

Fertilizer Nutrient (kg ha^{-1}) / FYM (t ha^{-1})	Plant height (cm)		Leaf area index		Length of corm (cm)	Width of corm (cm)	Weight of corm (kg $plant^{-1}$)	Dry matter of tuber (%)	Tuber yield (t ha^{-1})
	3MAP	5MAP	3MAP	5MAP					
$N_0P_0K_0$	67.0	83.0	0.65	1.09	12.9	16.5	0.26	24.7	16.1
$N_{50}P_{40}K_{50}$	69.0	88.8	0.72	1.27	14.9	17.6	0.38	26.3	21.0
$N_{75}P_{60}K_{75}$	72.4	93.2	0.78	1.46	16.2	18.6	0.50	29.2	28.8
$N_{100}P_{80}K_{100}$	77.3	98.1	0.85	1.61	18.0	19.6	0.58	31.7	32.7
CD(P=0.05)	2.39	2.55	0.04	0.08	0.63	0.90	0.02	0.60	0.15
FYM_0	67.1	84.9	0.68	1.21	13.7	15.8	0.37	26.0	21.1
FYM_{10}	69.7	89.8	0.73	1.32	15.1	17.6	0.42	27.5	23.5
FYM_{20}	73.0	93.0	0.77	1.42	16.2	19.1	0.45	28.8	25.9
FYM_{30}	76.0	95.3	0.83	1.49	17.0	19.8	0.49	29.6	28.1
CD(P=0.05)	2.39	2.55	0.04	0.08	0.63	0.90	0.02	0.60	0.81
Interaction CD(P=0.05)	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	0.04	N.S.	1.16

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

Table 2: Interaction effect of different levels of inorganic and organic source of nutrients on weight of corm (kg $plant^{-1}$) of Bunda

FYM levels (t per ha)	Fertilizer levels (kg per ha)			
	$N_0P_0K_0$	$N_{50}P_{40}K_{50}$	$N_{75}P_{60}K_{75}$	$N_{100}P_{80}K_{100}$
FYM0	0.24	0.29	0.41	0.51
FYM10	0.26	0.34	0.48	0.58
FYM20	0.26	0.41	0.54	0.61
FYM30	0.28	0.47	0.58	0.63

Where, FYM0, FYM10, FYM20 and FYM30 = Farm yard manure t ha^{-1}, CD (P=0.05) for Interaction= 0.04

Table 3: Interaction effect of different levels of inorganic and organic source of nutrients on tuber yield of Bunda

FYM levels (t ha^{-1})	Fertilizer levels (kg per ha)			
	$N_0P_0K_0$	$N_{50}P_{40}K_{50}$	$N_{75}P_{60}K_{75}$	$N_{100}P_{80}K_{100}$
FYM0	14.2	16.8	23.9	29.7
FYM10	15.0	19.1	27.5	32.3
FYM20	16.6	22.4	30.9	33.9
FYM30	18.7	25.7	32.7	35.1

Where, FYM0, FYM10, FYM20 and FYM30 = Farm yard manure t ha^{-1}, CD (P=0.05) for Interaction= 1.16

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