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Crop nutrition and productivity of maize and cowpea intercropping system under different management practices

E. BARIK, B. BEHERA*, S. N. JENA, P.K. ROUL AND M. R. SATAPATHY

Department of Agronomy, College of Agriculture,
Orissa University of Agriculture and Technology, Bhubaneswar-751 003, Odisha, India

**bdbehera1@rediffmail.com*

ABSTRACT

Field experiment on "Crop nutrition and productivity of maize (*Zea mays*) and cowpea (*Vigna unguiculata*) intercropping system under various planting patterns and nutrient management practices" was conducted during *kharif* season of 2012 at Bhubaneswar, Odisha. 'Boom' hybrid maize and 'Utkal Manik' cowpea were used as test crops. Three patterns of planting (P_1: maize+ cowpea 1:1 in alternate rows, P_2: maize+ cowpea 2:2 in alternate paired rows and P_3: maize+ cowpea 1:1 within same rows and four practices of nutrient management (N_1 : recommended dose of fertilizer (RDF), N_2: RDF+FYM @ 5 t ha^{-1}, N_3: RDF+ lime @ 0.2 lime requirement or LR and N_4: RDF+ FYM@ 5 t ha^{-1} + lime@ 0.2 LR) were tried in factorial randomized block design with three replications. Among planting patterns, maize + cowpea (2:2) system recorded the maximum N uptake of 130.61 kg ha^{-1}, P uptake of 29.67 kg $ha^{-1}$and K uptake of 178.65 kg ha^{-1}. Among nutrient management practices, recommended dose of NPK+FYM+ lime @ 0.2 LR removed the maximum amount of nutrients i.e. 134.9 kg N, 31.94 kg P and 186.97 kg K ha^{-1}. The nutrient management practice comprising recommended NPK+FYM+ lime in maize + cowpea (2:2) intercropping system gave the maximum maize grain yield of 7.40 t ha^{-1}, fresh cowpea pod yield of 2.29 t ha^{-1} and system maize equivalent yield of 9.71 t ha^{1} under rainfed condition of East and South east-coastal plain agro-climatic zones of Odisha.

Key words: Land equivalent ratio, maize equivalent yield, nutrient uptake, rainfed

INTRODUCTION

Sole cropping of shallow rooted cereal crop like rice is very risky under rainfed conditions of Odisha. Crop and varietal diversification with low water requiring crops like maize (*Zea mays*), cowpea (*Vigna unguiculata*), black gram (*Vigna mungo*) and sesame (*Sesamum indicum*) is one of the best options to the farmers for management of drought and increased productivity of rainfed ecosystem with assured and sustainable return (Vittal *et al*. 2002). Maize, cowpea, black gram and green gram are grown as sole crops in rainfed areas of Odisha.

In Odisha, about 70% of soils are acidic. The yield of maize and cowpea under upland situation is low in several parts of the state due to soil acidity and deficiency of major and micro-nutrients. Application of FYM along with recommended fertilizer is likely to alleviate the problem of micro-nutrient deficiency. Shivran *et al*. (2013) found that application of 5t of FYM ha^{-1} significantly improved the cobs per plant, cob weight, grain weight per

cob, seed index and grain yield per plant over no FYM application. Soil acidity retards crop growth directly through H^+ and Al^{+3} ionic effects and toxicity and indirectly interfering with availability of plant nutrients (Nekesa, 2007). Soil acidity can be ameliorated by liming. Liming in acid soils raises the pH, enhances availability of nutrients viz. P, Ca, Mg, Mo etc. and improves crop yields. Mbakaya *et al.* (2009) reported significantly higher yield per hectare 3.6 t in lime + RDF in maize as compared to yield per hectare 2.2 t in only RDF.

The overall mixture densities and the relative proportion of component crops are important in determining yields and production efficiency of cereal-legume intercropping systems. The inability of legume to compete for nutrients is attributed to lesser ramification of its root system. The appropriate planting pattern should be found out for intercropping of semi-trailing cowpea cv. 'Utkal Manik' with objective of minimizing competition between component crops for resources and achieving best system performance under rainfed conditions of Odisha. Hence the experiment was conducted to find out appropriate planting pattern and best nutrient management practice for maize+cowpea intercropping system under rainfed condition.

MATERIALS AND METHODS

The experiment conducted at Agronomy Main Research Farm, Orissa University of Agriculture and Technology, Bhubaneswar with latitude of 21^0 15' N, longitude of 85^0 52' E at an altitude of 25.9 m above the MSL. Bhubaneswar is located in under Agro climatic Zone no. 63 of National Agricultural Research Project classification. The climate is hot moist sub humid. The length of growing season varies from 180 to 210 days. The average annual rainfall is 1571.6 mm. The moisture deficit index (MDI) value is 0 to (-20). The soil of the experimental site was Arsenic Haplustalfs (alfisol). The textural class of the 0-15 cm soil layer was sandy loam (sand 72.2%, silt 11.4% and clay 16.4%) with pH of 5.08, EC of 0.035 dS m^{-1}, organic carbon 3.1 g kg^{-1} (low), available nitrogen 247.2 kg ha^{-1} (low), available P 39.6 kg ha^{-1} (medium), available K 175.0 kg ha^{-1} (medium), available S 10.5 kg ha^{-1} (low), available B 0.33 ppm (low), available Zn 0.46 ppm (low), available Ca 0.23 Cmole (P^+) kg^{-1} (low) and available Mg 0.18 Cmole (P^+) kg^{-1} (low). The physical and chemical properties of soil were congenial for growth of both maize and cowpea.

The treatments comprised two factors viz. planting pattern with three levels *i.e.* P_1: maize+cowpea (1:1) in alternate rows, P_2: maize+cowpea (2:2) in alternate paired rows, P_3: maize+cowpea (1:1) within same rows and nutrient management practices with four levels i.e. N_1 : recommended dose of fertilizer (RDF), N_2 : RDF+FYM @ 5 t/ha, N_3: RDF+lime@ 0.2 Lime Requirement (LR) and N_4: RDF+FYM@ 5 t ha^{-1} + lime@ 0.2 LR. For planting, furrows were drawn at 30 cm interval., In maize + cowpea 1 : 1 system, each row of maize was alternated with cowpea, whereas, in maize + cowpea 2 : 2 system, maize seeds were sown in two consecutive rows followed by cowpea in two consecutive rows. In maize + cowpea (1:1) within same rows, maize and cowpea seeds were put alternatively at 30 cm interval., In intercropping systems, maize and cowpea had 100 and 50 % population of respective sole crops. Fertilizer dose for component crops was based on proportion of plants of the component crops. The recommended fertilizer doses for sole maize, sole cowpea and maize + cowpea intercropping were 80+40+40, 20+40+20 and 90+60+50 Kg N-P_2O_5-K_2O ha^{-1}, respectively.

The treatments were applied in factorial randomized block design (RBD) with three replications. 'Boom' hybrid maize and 'Utkal Manik' cowpea were used as the test crops in the experiment. Both maize and cowpea were sown on 29th June 2012. Crops emerged successfully on 3rd July due to presence of sufficient moisture in the soil. Cowpea attained 50% flowering stage on 4 August 2012. Fresh pods were picked in 3 phases on 20 August, 25 August and 2 September. Maize came to tasseling stage on 13 August and silking on 18 August. The dried cobs were harvested on 20 September. The harvested well dried matured maize cobs were threshed mechanically for grain.

To compare treatment effects on system performance, the yields of component crops were converted to maize equivalent yield. Maize-equivalent yield (MEY) was calculated by the formula as follows:

MEY(t ha^{-1}) of cowpea = {Yield of fresh pod (t ha^{-1}) x price of fresh pod (Rs. t^{-1})}/ price of maize grain (Rs. t^{-1})

MEY (t ha^{-1}) for the intercropping system = Yield of maize per hectare(t)+ MEY(t ha^{-1}) of cowpea.

The plant samples collected for determination of dry matter were used for chemical analysis to determine nutrient content in plant parts and estimate the uptake of nutrients by the cropping system. The methods used to determine contents of N, P and K were Micro Kjeldahl (Tandon, 1993), HNO_3 : $HClO_4$ (9:4) digestion and color development by Vanadomolybdate solution followed by spectrophotometric determination (Tandon, 1993) and Flame photometric determination after digestion in HNO_3:$HClO_4$ (9:4) system (Tandon, 1993), respectively. Nutrient uptake by crops was determined by multiplying nutrient content of grain and stover of maize and pod and haulm of cowpea with respective dry matter production. Nutrient uptake (kg ha^{-1}) = {Nutrient content(%) x Dry matter (kg ha^{-1}) oven dry basis }/100

The data on yield and nutrient uptake were compiled in appropriate tables and analyzed statistically as per the standard procedure prescribed for randomized block design (Gomez and Gomez, 1984). The analysis of variance (ANOVA) for the design was worked out and the significance was known by 'F' test. Standard error of mean value was computed in all cases, but critical difference values were worked out at 5% level of significance for planned pair comparison. The land equivalent ratio(LER) is the relative land area under sole crops that is required to produce the yields achieved in intercropping. The formula for calculation of LER is as given below.

LER = Ymc/Ymm+Ycm/Ycc,

Where, Ymc = yield of maize in intercropping, Ycm = yield of cowpea in intercropping, Ymm = yield of maize in pure stand, Ycc = yield of cowpea in pure stand.

RESULTS AND DISCUSSION

Nutrient uptake by maize

Maize + cowpea (2:2) among planting patterns and recommended NPK + FYM + lime among nutrient management practices facilitated the maximum uptake of N, P and K through plant parts (Table 1**)**. This is due to higher content of these three nutrients in plant parts and biomass production. Among planting patterns, maize+ cowpea (2:2) system removed 61.95 kg N, 15.32 kg P and 20.50 kg K through grain and 35.43 kg N, 10.95 kg P and 114.50 kg K through stover amounting to total uptake of 97.38 kg N, 26.27 kg P and 135.0 kg K. Other two planting patterns removed significantly less N, P and K from soil through grain and stover, except P by stover, for which maize+ cowpea (2:2) and maize+ cowpea (1:1) in alternate rows remained statistically at par. Among nutrient management practices, recommended NPK removed 41.37 kg N, 9.77 kg P and 11.0 kg K through grain and 26.72 kg N, 8.07 kg P and 79.78 kg K through stover amounting to total uptake of 68.09 kg N, 17.84 kg P and 90.78 kg K/ha. Application of recommended NPK+lime recorded higher uptake of N, P and K as compared to application of recommended NPK only, but both were statistically at par. Recommended NPK+ FYM and recommended NPK+ FYM+ lime facilitated significantly higher uptake of N, P and K through grain and stover than recommended NPK only. Recommended NPK + FYM + lime removed significantly higher NPK through grain and stover, except P and K through stover for which both were at par. Lime application to acid soils raises the pH of soils and enhances availability and uptake of nutrients (Nekesa, 2007).

Recommended NPK + lime + FYM facilitated uptake of 33% higher N, 37% higher P and 50% higher K through grain and 26% higher N, 34% higher P and 32% higher K through stover leading to uptake of 30% higher N, 36% higher P

and 35% higher K by the crop (grain + stover) as compared to application of recommended fertilizer alone. The corresponding enhanced uptake values due to recommended NPK+FYM were 26, 25 and 41% N, P and K through grain and 15, 28 and 25% N, P and K through stover leading to 15, 28 and 25 % higher N, P and K through the crop, respectively.

Nutrient uptake by cowpea

Among the different planting patterns, maize + cowpea (2:2) system removed 25.80 kg N, 7.02 kg P and 27.74 kg K ha^{-1} through pod and 7.38 kg N, 2.66 kg P and 15.90 kg K ha^{-1} through stover amounting to total uptake of 33.18 kg N, 9.68 kg P and 43.64 kg K ha^{-1}. In case of P and K uptake by pod, maize + cowpea (1:1) in alternate rows remained statistically at par with maize + cowpea (2:2) system while in all other cases, the other two planting patterns remained statistically inferior to maize + cowpea (2:2) system. Cowpea crop, receiving recommended NPK + FYM + lime removed the maximum of 29.0 kg N, 7.49 kg P and 29.62 kg K through pod and 7.40 kg N, 2.87 kg P and 17.21 kg K ha^{-1} through stover. Application of FYM and lime along with the recommended NPK in acid soil enhances soil pH, promotes nodulation and nitrogen fixation and improves availability and uptake of nutrients in pulses. For P and K uptake by pod and K uptake by stover, recommended NPK + FYM + lime remained at par with recommended NPK + FYM. The other two nutrient management practices remained significantly inferior to recommended NPK + FYM + lime in all the cases.

System nutrient uptake

Among planting patterns, maize + cowpea (2:2) system recorded the maximum N uptake of 130.61 kg ha^{-1}, P uptake of 29.67 kg ha^{-1} and K uptake of 178.65 kg ha^{-1} (Table 2). The other two planting patterns remained statistically inferior to it for nutrient uptake by the system. Among nutrient management practices, recommended dose of NPK+FYM+ lime removed the maximum amount of nutrients i.e. 134.9 kg N, 31.94 kg P and 186.97 kg K ha^{-1}. Other nutrient management practices remained statistically inferior to this system except in case of K where recommended NPK + FYM remained at par with recommended NPK + FYM + lime.

Maize equivalent yield (MEY) of the system

Among different planting patterns, maize+ cowpea (2:2) recorded the maximum MEY of 7 t ha^{-1} (Table 2). Maize+ cowpea (1:1) in alternate rows and maize+ cowpea (1:1) within same rows remained statistically inferior to it and recorded 14 and 27% less yield as compared to the former, respectively. Pandey *et al.,* (1999) reported the maximum grain equivalent yield of cereal + legume mixture *viz.*, maize + soybean (2:2). Among nutrient management practices, application of recommended NPK+ FYM+ lime recorded the highest MEY of 7 t ha^{-1} closely followed by recommended NPK+ FYM. Recommended NPK alone and recommended NPK + lime were significantly inferior to it. This is because both maize and cowpea responded well to combined application of lime and FYM. Behera *et al.,* (2012) reported significant role of FYM on system productivity of cereal + pulse intercropping comprising rice and pigeon pea. Nutrient uptake pattern of the component crops in cereal + legume intercropping differs. Cereal component requires more N compared to the legume component. Application of high inorganic N affects nodulation and nitrogen fixation in legumes. Integrated supply of chemical fertilizers, FYM and lime harmonizes demand and supply of nutrients in both the crops in the system and ensures steady supply of nutrients leading to the maximum system productivity (Behera *et al*. 2012).

Land equivalent ratio (LER)

Maize+ cowpea (2:2) recorded the maximum LER value of 1.60 closely followed by maize+ cowpea (1:1) in alternate rows with LER value of 1.40 (Table 2). Maize+ cowpea (1:1) within same rows recorded the lowest LER value of 1.20 and remained statistically inferior to other two planting patterns. Sharma *et al.,* (2008) reported higher LER value of 1.84 with maize+ cowpea (2:2) system as against 1.21 in maize+ cowpea (1:1) system. Among nutrient management practices, recommended NPK+ FYM+ lime recorded

maximum LER value of 1.61 closely followed by recommended NPK +FYM with LER value of 1.50. Other two nutrient management practices proved significantly inferior to recommended NPK+ FYM and recommended NPK+ FYM+ lime.

Grain yield of maize

Maize+ cowpea (2:2) system recorded the maximum grain yield of 5.04 t ha^{-1} (Table 3). Other two planting patterns were at par for grain yield and recorded significantly less grain yield as compared to maize + cowpea (2:2). Maize+ cowpea (1:1) in alternate rows and maize + cowpea (1:1) in same row recorded 17 and 30% less grain yield, respectively, as compared to the best performing planting pattern. Among nutrient management practices, application of recommended NPK gave the minimum maize grain yield of 3.57 t ha^{-1}. Supplementation of lime @ 0.2 LR increased grain yield marginally, but the increase was not statistically significant. Application of recommended NPK+FYM + lime gave the maximum grain yield of 5.07 t $ha^{-1}$and recommended NPK + FYM was statistically at par with grain yield of 4.64 t ha^{-1}. Stover yield of maize followed a similar trend as that of grain yield. Shivran *et al.* (2013) reported 11.2% higher grain yield of maize with application of 5t FYM ha^{-1} as compared to no organic manure.

Pod yield of cowpea

Maize+ cowpea (2:2) system gave higher green pod yield than other two planting patterns and maize+ cowpea (1:1) in alternate rows remained at par with it. Maize+ cowpea (1:1) in the same row recorded significantly less pod yield of cowpea as compared to maize+ cowpea (2:2) in alternate paired rows and maize+ cowpea (1:1) in alternate rows. This is in agreement with findings of Dalal (1977) who reported advantages in arranging component crops in alternate rows rather than arranging in the same rows. Maize + cowpea (2:2) recorded 1.6 and 22.9% higher pod yield than maize+ cowpea (1:1) in alternate rows and maize+ cowpea (1:1) in the same row, respectively, in the present investigation. Behera *et al.* (1998) reported 11 % higher pod yield of cowpea in maize+ cowpea (2:2) system as compared to maize+ cowpea (1:1) system. Myaka (1995) got 57% higher pod yield with maize+ cowpea (2:2) system than maize+ cowpea (1:1). Application of recommended fertilizer only gave the minimum pod yield (1.55 t ha^{-1}). Application of recommended NPK+FYM and recommended NPK+ lime enhanced pod yield by 0.25 t ha^{-1} (14%) and 0.12 t ha^{-1} (7.2%) respectively, but the differences were not statistically significant. Combined application of recommended NPK+ FYM+ lime increased pod yield by 20% over application of recommended NPK alone. Cowpea like other legumes responds well to application of FYM and lime. Farm yard manure enhances availability of macro and micronutrients, water holding capacity, pH and soil structure. It acts as an energy source for symbiotic N_2 fixing bacteria *Rhizobium*. Thus, the combined application helped in improving pod yield significantly as compared to recommended fertilizer alone. Maruthi Sankar *et al.,* (2013) established significant role of FYM on improving productivity of legume crops.

CONCLUSION

Maize + cowpea (2:2) among planting patterns and recommended NPK + FYM @ 5 t ha^{-1} + lime @ 0.2 LR among nutrient management practices in maize + cowpea intercropping system facilitated the maximum uptake of N, P and K by component crops. The nutrient management practice comprising recommended NPK+FYM+ lime in maize+ cowpea (2:2) gave the maximum maize grain yield of 7.40 t ha^{-1}, fresh cowpea pod yield of 2.29 t ha^{-1} and maize grain equivalent yield of 9.71 t ha^{-1} under rainfed condition of East and South Eastern Coastal Plain agro climatic zone of Odisha.

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Table 1. Effect of planting pattern and nutrient management on nutrient uptake (kg ha^{-1}) by component crops

Treatments	N (kg ha $^{-1}$)		P (kg ha^{-1})		K (kg ha^{-1})	
	Maize					
	Grain	Stover	Grain	Stover	Grain	Stover
Planting pattern						
Mz + Cp(1:1) in alternate rows	50.2	29.27	11.97	10.45	16.25	95.13
Mz + Cp(2:2) in alternate paired rows	61.9	35.43	15.32	10.95	20.50	114.50
Mz + Cp(1:1) in the same row	40.9	27.25	9.92	8.45	11.91	84.94
CD (P=0.05)	8.6	3.66	2.11	1.23	2.91	18.12
Nutrient management						
RDF	41.3	26.72	9.77	8.07	11.00	79.78
RDF+FYM	56.3	31.56	13.19	11.27	18.69	107.34
RDF+ lime	44.5	27.85	10.98	8.14	13.02	87.65
RDF + FYM + lime	62.0	36.46	15.69	12.32	22.14	117.98
CD (P=0.05)	9.9	4.22	2.44	1.42	3.36	20.92
	Cowpea					
	Pod	Stover	Pod	Stover	Pod	Stover
Planting pattern						
Mz+Cp(1:1) in alternate rows	20.8	5.79	6.36	2.28	26.67	13.99
Mz+Cp(2:2) in alternate paired rows	25.8	7.38	7.02	2.66	27.74	15.90
Mz+Cp(1:1) in the same row	19.7	4.45	5.33	2.28	20.65	10.33
CD (P=0.05)	3.50	0.58	0.88	0.30	3.70	1.25
Nutrient Management						
RDF	18.0	4.63	4.97	1.89	19.96	9.86
RDF+FYM	21.0	6.67	6.73	2.74	26.10	15.94
RDF+ lime	20.6	4.89	5.75	2.13	24.50	10.63
RDF+FYM+lime	29.0	7.40	7.49	2.87	29.62	17.21
CD(P=0.05)	4.00	0.67	1.02	0.34	4.28	1.44

Table 2. Effect of treatments on system nutrient uptake, maize equivalent yield and land equivalent ratio

Treatments	System nutrient uptake (kg ha^{-1})			System yield (t ha^{-1})	LER
	N	P	K		
Planting pattern					
Mz + Cp(1:1) in alternate rows	106.22	26.50	152.14	6.0	1.40
Mz + Cp(2:2) in alternate paired rows	130.61	29.67	178.65	7.0	1.60
Mz + Cp(1:1) in the same row	92.43	22.92	127.83	5.1	1.20
CD (P=0.05)	12.51	1.66	20.70	0.7	0.14
Nutrient Management					
RDF	90.70	21.37	120.62	5.2	1.21
RDF+FYM	115.42	28.58	168.08	6.5	1.50
RDF+ lime	97.83	23.52	135.81	5.4	1.30
RDF+FYM+lime	134.94	31.94	186.97	7.0	1.61
CD (P=0.05)	14.42	1.92	23.91	0.8	0.16

Table 3. Interaction effects of planting pattern and nutrient management on yield of maize, cowpea and maize+ cowpea intercropping system

Nutrient Management	Planting pattern			
	Mz + Cp(1:1) in alternate rows	Mz + Cp(2:2) in alternate paired rows	Mz + Cp(1:1) in the same row	Mean
Grain yield of maize(t ha^{-1})				
RDF	3.14	4.34	3.22	3.60
RDF+ FYM	5.60	4.24	4.08	4.64
RDF+ lime	3.34	4.23	3.63	3.74
RDF+FYM +lime	4.64	7.40	3.20	5.07
Mean	4.18	5.04	3.53	4.25
CD (P=0.05) for PP* = 0.69	CD (P=0.05) for NM** = 0.80	CD (P=0.05) for interaction = 1.40		
Green pod yield of cowpea(t ha^{-1})				
RDF	1.73	1.47	1.45	1.55
RDF+ FYM	1.51	1.96	1.94	1.80
RDF+ lime	1.72	1.92	1.37	1.67
RDF+FYM +lime	2.18	2.29	1.38	1.95
Mean	1.78	1.91	1.53	1.74
CD (P=0.05) for PP = 0.24	CD (P=0.05) for NM = 0.28	CD (P=0.05) for interaction = 0.49		
Maize equivalent yield of the system(t ha^{-1})				
RDF	5.00	5.84	4.70	5.15
RDF+ FYM	7.15	6.24	6.07	6.48
RDF+ lime	5.10	6.20	5.03	5.44
RDF+FYM +lime	6.87	9.71	4.60	7.06
Mean	6.01	7.00	5.10	6.03
CD (P=0.05) for PP = 0.7	CD (P=0.05) for NM = 0.8	CD (P=0.05) for interaction = 1.42		

PP* – Planting pattern NM** - Nutrient management

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