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Impact of planting pattern and nutrient management strategy on productivity and comparative economics of maize (*Zea mays* L.) + cowpea (*Vigna unguiculata* L. Walp.) intercropping under rainfed condition

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ABSTRACT

A field experiment on planting pattern and nutrient management strategy for maize+ cowpea intercropping under rainfed condition was conducted during the kharif season of 2012 at Central Research Station, Orissa University of Agriculture and Technology, Bhubaneswar. maize (cv. Boom) and cowpea (cv.Utkal manic) were used as test crops. Three planting patterns (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 row) and four levels of nutrient management (N_1 : recommended dose of fertilizer or RDF, N_2: RDF+FYM @ 5 t/ha, N_3: RDF+ lime @ 0.2 LR and N_4: RDF+ FYM@ 5 t ha^{-1} + lime@ 0.2 lime requirement) were tried in factorial Randomised Block Design with three replications. Recommended NPK+FYM+ lime in maize+ cowpea (2:2) gave the maize grain yield of 7.40 t/ha. The same combination two gave fresh pod yield of cowpea of 2.29 t ha^{-1}. This combination also proved to be the best for system productivity and economics and gave the maximum maize equivalent yield of 9.71 tha^{-1}, gross return of Rs.95,193 ha^{-1}, the maximum net return of Rs. 64,367 t ha^{-1} and the maximum B : C ratio of 3.08. Maize + cowpea planting pattern in 2:2 in alternate paired rows and combined application of recommended dose of fertilizer (80-40-40 kg N, P_2O_5 and K_2O ha^{-1} for 100 per cent maize +10-20-10 kg N, P_2O_5 and K_2O ha^{-1} for 50 per cent cowpea population) + FYM @ 5 t ha^{-1} + Lime @ 0.2 LR (480 kg ha^{-1}) increased the productivity and profitability of maize + cowpea intercropping system comprising 'Boom' maize and 'Utkal manik' cowpea under rainfed condition and improved soil quality.

***Keywords*: C**owpea, maize, economics, rainfed, system yield

Agriculture in rainfed areas is complex, diverse and risk prone. Land in such environment most often becomes short of moisture and essential nutrients required for normal crop growth. Literally the land becomes thirsty, hungry and skeletonised. High variability in terms of commencement and cessation of SW monsoon, erratic distribution of rainfall both spatially and temporally, frequent and prolonged dry spells leading to drought and high intensity rainfall and flood affect crop productivity. Depending on length of growing season (LGS), many crops are grown as sole crops. Sole cropping of shallow rooted cereal crop like rice is very risky. Hence, there is a need to diversify cropping systems by introducing deep rooted crops or mixed cropping in place of rice. cropping . Mixed cropping is a promising technology to stabilize productivity and production in rainfed agro-ecosystem. Various types of mixed cropping as mixed intercropping (traditional), row intercropping, strip intercropping and relay intercropping are prevalent in Odisha. Farmers in tribal districts of Odisha grow several crops in irregular mixed cropping system (Behera *et al*., 2004) to stabilize productivity during years of aberrant weather and satisfy domestic need. One of such popular mixed cropping system is maize+ cowpea. The tribals mix seeds of local maize (*Kujimaka*) and long duration local cowpea (*Kathi jhudunga*) and broadcast over the field. Productivity of this system declines due to uneven distribution of component crops. Row intercropping involving high yielding varieties is a solution to the problem. Maize is a straight and quick growing plant with C_4-photosynthetic cycle. Cowpea is a legume with semi-trailing to trailing habit. Maize (*Zea mays* L.) + cowpea (*Vigna unguiculata* L. Walp.) intercropping is promising for tribal farmers of Odisha (Behera and Senapati, 2001). There is need to find out correct planting pattern for maize+ cowpea intercropping to enhance system productivity.

Being in sub humid zone, two-thirds of soils in Odisha are acidic. Top soils in rainfed upland are highly eroded resulting in reduced clay content, low soil organic carbon and low available plant nutrients. Liming checks soil acidity related problems and enhances availability of plant nutrients. Application of recommended NPK does not help in realizing normal yield due to deficiency of micronutrients. In such case, productivity is governed by the nutrient element available in the lowest quantity in accordance with Liebig's Law of Minimum. Application of FYM fulfills the micronutrient requirement besides improving the soil physical

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properties like bulk density and water holding capacity. There is a need to quantify the extent of yield gain due to application of lime, FYM or lime+ FYM over application of recommended NPK. Both maize and cowpea respond well to application of lime and FYM.

Keeping this in view, the experiment was undertaken to study the productivity of maize and cowpea intercropping as influenced by planting pattern and nutrient management.

MATERIALS AND METHODS

The experiment was conducted at Agronomy Research Farm, Central Research Station, OUAT, Bhubaneswar having latitude of $21^0 15^{'}$N, longitude of $85^0 52^{'}$E and an altitude of 25.9 m above the MSL. The soil of the experimental site was *Arenic 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%). The physical properties of soil was congenial for growth of maize and cowpea. The pH of the experimental soil was 5.083 having EC of 0.035 dSm^{-1}, low in organic carbon (3.1 g kg^{-1}), low in available nitrogen (247.2 kg ha^{-1}), medium in available P (39.6 kg ha^{-1}), medium in available K (175.0 kg ha^{-1}), low in available S (10.50 kg ha^{-1}), available B (0.33 ppm), available Zn(0.46 ppm), available Ca (0.23 C. mole $P^+ kg^{-1}$) and available Mg (0.18 C. mole $P^+ kg^{-1}$).

The treatments consisted of two factors viz. planting pattern with 3 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 4 levels *i.e.* N_1 : recommended dose of fertilizer (RDF), N_2: RDF+FYM @ 5 tha^{-1}, N_3: RDF+ lime@ 0.2 LR and N_4: RDF+ FYM@ 5 tha^{-1} + lime@ 0.2 LR. The treatments were tried in factorial Randomised Block Design with three replications.

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 per cent flowering stage on 4th August, 2012. Fresh pods were picked in 3 phases on 20th, 25th August and 2nd September. Maize came to tasseling stage on 13th August and silking on 18th August. The dried cobs were harvested on 20th September and threshed after proper sun drying. System yield was expressed as maize equivalent yield. Prevailing market price was taken into account for computing economic indicators.

Table 1: Productivity of maize, cowpea as influenced by planting pattern and nutrient management

Treatments	Planting pattern			Mean
	Mz+Cp(1:1) in alternate rows	Mz+Cp(2:2) in alternate paired rows	Mz+Cp(1:1) in the same row	
Grain yield of maize(tha^{-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**
LSD (P=0.05) for PP = 0.69	*LSD (P=0.05) for NM = 0.80*	*LSD (P=0.05) for NM x PP = 1.40*		
Green pod yield of cowpea(tha^{-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**
LSD (P=0.05) for PP = 0.24	*LSD (P=0.05) for NM = 0.28*	*LSD (P=0.05) for interaction = 0.49*		
Maize equivalent yield of the system(tha^{-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**
LSD (P=0.05) for PP = 0.7	*LSD (P=0.05) for NM = 0.8*	*LSD (P=0.05) for interaction = 1.4*		

RESULTS AND DISCUSSION

Weather conditions

During crop growthperiod i.e. 26th (25 June - 1st July) to 38th Standard Meteorogical Week(17-23 September), 10 SMWs received below normal rainfall and only 3 SMWs received above normal rainfall. The 27th and 29th SMWs coinciding with seedling stage and 33rd SMW coinciding with tasseling stage of maize and flowering and pod formation stage of cowpea received excess rainfall. During growing period, the crops received 781.2 mm rainfall as against the normal of 1028.9 mm indicating a shortfall of 24%. Average weekly rainfall declined from normal of 79.1 mm to 60.1 mm. The crops were subjected to drier soil and atmospheric conditions than normal, however, the crops received sufficient rainfall for normal growth and development.

Crop yield

Maize+ cowpea (2:2) gave maize grain yield of 5.04 t $ha^{-1}$and recommended NPK+FYM +lime gave maize grain yield of 5.07 t ha^{-1} (Table 1). Recommended NPK+FYM+ lime in maize+ cowpea (2:2) gave the maize grain yield of 7.40 t ha^{-1}. Similarly in case of cowpea, maize+ cowpea (2:2) and recommended NPK+FYM+ lime recorded fresh pod yield of 1.91 and 1.95 tha^{-1}, respectively.

But the combination of the two gave fresh pod yield of 2.29 tha^{-1} due to synergism between the two. The maize+ cowpea (2:2) system facilitated proper execution of cultural operations, permitted penetration of light to lower canopy of cowpea and helped in proper utilization of added nutrients through lime and FYM. Recommended NPK+FYM+ lime in maize+ cowpea

Table 2: Net return and benefit : cost ratio of maize + cowpea intercropping system as influenced by planting pattern and nutrient management

Treatments	Planting pattern			Mean
	Mz+Cp(1:1) in alternate rows	Mz+Cp(2:2) in alternate paired rows	Mz+Cp(1:1) in the same row	
Cost of cultivation (Rs. ha^{-1})				
RDF	24,171	30,639	29,439	28,083
RDF+FYM	35,900	23,250	33,377	30,842
RDF+ lime	28,511	25,894	34,971	29,792
RDF+FYM+lime	32,021	36,662	30,821	33,168
Mean	**30,151**	**29,111**	**32,152**	**30,471**
LSD (P=0.05) for PP =1136	***LSD (P=0.05) for NM =1312***		***LSD (P=0.05) for PP×NM = 2272***	
Gross return (Rs. ha^{-1})				
RDF	48,217	57,263	46,123	50,534
RDF+FYM	70,070	61,183	59,487	63,580
RDF+ lime	50,043	60,760	49,327	53,377
RDF+FYM+lime	67,327	95,193	45,080	69,200
Mean	**58,914**	**68,600**	**50,004**	**59,173**
LSD (P=0.05) for PP =6977	***LSD (P=0.05) for NM =8057***		***LSD (P=0.05) for PP×NM = 13954***	
Net return (Rs. ha^{-1})				
RDF	24,033	26,633	16,700	22,456
RDF+FYM	34,167	37,933	26,133	32,744
RDF+ lime	21,500	34,833	14,367	23,567
RDF+FYM+lime	35,333	64,367	8433	36,044
Mean	**28,758**	**40,942**	**16,408**	**28,703**
LSD (P=0.05) for PP =6909	***LSD (P=0.05) for NM =7977***		***LSD (P=0.05) for PP×NM = 13817***	
Benefit : cost ratio				
RDF	2.00	1.87	1.57	1.81
RDF+FYM	1.95	2.65	1.80	2.13
RDF+ lime	1.75	2.35	1.41	1.84
RDF+FYM+lime	2.10	3.08	1.22	2.13
Mean	**1.95**	**2.50**	**1.50**	**2.00**
LSD (P=0.05) for PP =0.24	***LSD (P=0.05) for NM =0.30***		***LSD (P=0.05) for PP×NM = 0.50***	

Price : Maize grain Rs. 9800 t^{-1} and cowpea fresh pod Rs. 10000 t^{-1}

(2:2) gave the maximum system yield of 9.71 t ha^{-1}in terms of maize equivalent yield.

Economics

Among planting patterns, maize+ cowpea (1:1) in the same row incurred the maximum cost of cultivation of Rs. 32,152(Table 2). Maize+ cowpea (2:2) system recorded 10 per cent less cost of cultivation due to less expenditure for cultural operations. Row arrangement in this system made hoeing, weeding, top dressing and spraying easier as compared to other two planting patterns.

Cost of cultivation was the minimum with recommended fertilizer (Rs.28,083.00 per ha) and increased with application of lime @ 0.2 LR or FYM @ 5t ha^{-1} along with recommended fertilizer. Among planting patterns, maize+ cowpea (2:2) gave the maximum gross return and net return. Maize+ cowpea (1:1) in alternate rows gave the next best gross and net return and maize+ cowpea (1:1) in the same row gave the least gross and net return. Maize+ cowpea (2:2) gave 14 and 27 per cent higher gross return and 29 and 59 per cent higher net return than maize+ cowpea (1:1) in alternate rows and maize+ cowpea within the same row respectively. Among nutrient management practices, recommended NPK+ lime+ FYM gave the maximum gross and net return although the maximum expenditure was incurred for application of manures and fertilizers. This is due to higher yield and return realized from this treatment.

Among planting patterns, maize+ cowpea (2:2) gave the maximum B:C ratio (2.49:1). In case of nutrient management, recommended dose of fertilizer+ FYM+ lime and recommended dose of fertilizer+ FYM recorded the maximum benefit- cost ratio of 2.13:1. Sharma *et al*. (2008) also reported higher net return (Rs.16,104 per ha) and benefit-cost ratio of 1.84 in maize+ cowpea (2:2) system as compared to 1:1, 1:2 and 2:1 proportion of maize and cowpea. Considering all economic indicators, maize+ cowpea (2:2) system and recommended NPK+ FYM + lime proved to be the best.

Based on the above results and discussion, it can be concluded that Maize+ cowpea (2:2) planting pattern along with combined application of recommended dose of fertilizer (80-40-40 kg N, P_2O_5 and K_2O ha^{-1} for 100 per cent maize +10-20-10 kg N, P_2O_5 and K_2O ha^{-1} for 50 per cent cowpea population) + FYM @ 5 t ha^{-1}+ Lime @ 0.2 LR (480 kg ha^{-1}) be followed for higher productivity and profitability of maize + cowpea intercropping system under rainfed condition.

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