International Journal of Farm Sciences **5(4)** : 1-10, 2015

Soil nutrient balance and economic viability of maize and field bean intercropping system as influenced by different nutrient management and row proportion

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ABSTRACT

A field experiment was conducted during Kharif 2012 at Zonal Agricultural Research Station, VC Farm, Mandya with maize + field bean intercropping system with different row proportion and nutrient management practices in factorial RCBD with three replications and 12 treatments. The observations on soil nutrient, plant uptake for nutrient balance and prevailing prices for economics were considered. The results revealed that the net returns (Rs 138911/ha) and B:C ratio (5.08) were superior in maize + field bean in 4:1 row proportion with SSNM. Total nutrient uptake (231.28 kg/ha nitrogen, 60.92 kg/ha phosphorous and 159.61 kg/ha potassium) and nutrient balance of NPK were also found superior in maize + field bean in 4:1 row proportion with SSNM.

Keywords: Maize; field bean; nutrient uptake; nutrient balance; intercropping

INTRODUCTION

Intercropping of legumes with cereals is a recognized practice for economizing the use of nitrogenous fertilizers and increasing the productivity and profitability. One of the main reasons for higher yields in intercropping is that component crops are able to use growth resources differently and make better use of natural resources than growing separately (Willey 1979). Among cereals maize being a widely spaced crop offers an opportunity of intercropping with legumes like field bean. In this regard legumes are considered to be profitable proposition because of additional yield and maintaining soil sustainability. However the benefits accrued from an intercrop vary according to the nature of crops and their adaptability in the local conditions. The important factor influencing the adoption of maize + field bean intercropping is to get the short term income from the selling of green pods apart from the other accrued advantages.

MATERIAL and METHODS

A field experiment was conducted during Kharif 2012 at Zonal Agricultural Research Station, VC Farm, Mandya. The soil of the experimental site was sandy loam in texture, having pH 6.69 with medium available nitrogen (246.78 kg/ha), phosphorous (27.91 kg/ha) and potassium (170.27 kg/ha) status. The treatments comprised of three nutrient management practices (RDF, LCC and SSNM) as factor N and four different row proportions (sole maize, 2:1, 3:1 and 4:1) of maize + field bean intercropping system as factor I and sole field bean as control. Crops were planted in line at 45 x 30 cm spacing for both the crops as per the treatment details. Seeds of maize (NAH 2049) and field bean (HA-4) were sown on 5 September 2012. The recommended doses of fertilizers for irrigated maize (150:75:40 N, P_2O_5 and K_2O kg/ha) were applied to RDF treatments in the form of urea, single super phosphate and muriate of potash. For LCC treatments basal dose of N and full dose of P and K (30:75:40 kg/ha N, P_2O_5 K_2O) were applied to the soil at the time of sowing followed by in-season N applications as guided by LCC. The subsequent N applications were done by matching the colour of youngest fully expanded top leaf of ten randomly selected maize plants from each plot at 7 days interval starting from 21 days after sowing of maize till initiation of silking. Based on the soil test results SSNM dose for maize was decided keeping target yield as 10 tons/ha which accounted for 263, 139 and 328 tons/ha N, P_2O_5 and K_2O respectively.

RESULTS and DISCUSSION

Effect on nutrient uptake and soil nutrient balance (Tables 1-6)

Uptake by maize: Nitrogen uptake by maize kernel, stover and total nitrogen uptake was significantly higher in site specific nutrient management practice. The higher nutrient uptake in SSNM could be attributed to enhanced nutrient availability to the plants resulting in higher dry matter production over LCC-based nutrient management practices and recommended doses.

Higher kernel and stover yields were observed in SSNM practice. It is known fact that the maize is an exhaustive field crop and N responsive producing higher biomass per unit of external application. The N uptake was very high in site specific nutrient management practice (231.28 kg/ha) compared to LCC and RDF. It might be due to favourable influence of nitrogen on root proliferation and anchorage which in turn absorbed higher amount of nutrients from rhizosphere and supplied to the crop resulting in higher dry matter production (Umesh 2008).

The enhanced values of yield attributing characters witnessed the tendency of nitrogen in accelerating growth, photosynthetic activity and translocation efficiency which might have contributed for higher nutrient uptake. This was reported earlier by Omraj et al (2007).

Significantly higher phosphorus uptake was also observed in site specific nutrient management practice (60.92 kg/ha) with maize + field bean row ratio of 4:1 and it was on par with sole crop of maize with site specific nutrient management practice (60.48 kg/ha). This was attributed further to the root proliferation.

Significant improvement in K uptake by maize kernel and stover was observed with application of higher levels of K in SSNM practice followed by LCC and was least in RDF. The increased K concentration in the soil with SSNM might have resulted in increased uptake. Further the nutrient losses are very less in K besides maize being the explorative crop. Potassium has a key role in activation of enzymes, photosynthesis and protein synthesis. The continuous availability of K and higher efficiency resulted in more uptake of potassium as compared to recommended doses. Similar results were reported earlier by Arun Kumar et al (2007).

Uptake by field bean: The N uptake by field bean was high in site specific nutrient management practice (50.6 kg/ha) compared to LCC and RDF. It might be due to nitrogen fixation from atmosphere to soil that createed favourable influence on root proliferation and anchorage which in turn absorbed higher amount of nutrients from rhizosphere and supplied to the crop resulting in higher dry matter production (Umesh 2008, Mohankumar et al 2012).

Higher phosphorus uptake was also observed in site specific nutrient management practice (11.2 kg/ha). Maize + field bean row ratio of 4:1 recorded higher uptake of phosphorous (12.1 kg/ha).

Significant improvement in K uptake by field bean was observed with application of higher levels of K in SSNM practice followed by LCC and was least in RDF. The increased K concentration in the soil with SSNM might have resulted in increased uptake of K. Further the nutrient losses are very less in K besides maize being the explorative crop field bean can also compete for K uptake significantly. Potassium has a key role in activation of enzymes, photosynthesis and protein synthesis. The continuous availability of K and higher efficiency resulted in more uptake of potassium as compared to recommended doses. Similar results were reported earlier by Lingaraju et al (2007) and Arun Kumar et al (2007).

Table 1. Nitrogen uptake of maize as influenced by nutrient management and row proportion in maize and field bean intercropping system

Treatment	Nitrogen uptake (kg/ha)		
	Kernel	Stover	Total
Nutrient management (N)			
N_1: RDF	121.50	39.81	161.31
N_2: LCC	126.88	39.70	166.58
N_3: SSNM	129.80	43.42	173.22
SEm±	1.39	0.42	1.45
$CD_{0.05}$	4.09	1.25	4.27
Intercrop row proportion (I)			
I_1: Sole maize	145.55	51.07	192.62
I_2: Maize + field bean (2:1)	132.40	46.10	178.50
I_3: Maize + field bean (3:1)	134.14	49.79	184.03
I_4: Maize + field bean (4:1)	139.77	49.89	189.56
SEm±	1.61	0.49	1.68
$CD_{0.05}$	4.73	1.45	4.94
Interaction (N x I)			
N_1I_1	123.66	43.61	167.27
N_1I_2	119.06	31.05	150.11
N_1I_3	121.03	40.19	161.22
N_1I_4	122.24	44.38	166.62
N_2I_1	145.17	43.18	188.35
N_2I_2	130.77	45.94	176.71
N_2I_3	132.15	46.02	178.17
N_2I_4	142.53	42.97	185.50
N_3I_1	167.82	63.46	231.28
N_3I_2	147.37	54.43	201.80
N_3I_3	149.23	61.32	210.55
N_3I_4	154.53	62.01	216.54
SEm±	2.79	0.85	2.91
$CD_{0.05}$	8.19	2.51	8.55
CV (%)	5.75	7.31	7.12

Table 2. Phosphorous uptake of maize as influenced by nutrient management and row proportion in maize and field bean intercropping system

Treatment	Phosphorous uptake (kg/ha)		
	Kernel	Stover	Total
Nutrient management (N)			
N_1: RDF	32.36	15.03	47.39
N_2: LCC	33.64	16.60	50.24
N_3: SSNM	39.00	19.11	58.11
SEm±	0.53	0.51	0.66
$CD_{0.05}$	1.57	1.52	1.96
Intercrop row proportion (I)			
I_1: Sole maize	36.54	17.57	54.11
I_2: Maize + field bean (2:1)	32.87	15.99	48.86
I_3: Maize + field bean (3:1)	34.17	16.83	51.00
I_4: Maize + field bean (4:1)	36.42	17.25	53.67
SEm±	0.61	0.59	0.77
$CD_{0.05}$	1.81	1.75	2.26
Interaction (N x I)			
N_1I_1	34.10	15.82	49.92
N_1I_2	30.25	14.18	44.43
N_1I_3	30.98	15.61	46.59
N_1I_4	34.10	14.51	48.61
N_2I_1	35.40	16.55	51.95
N_2I_2	31.12	16.20	47.32
N_2I_3	33.49	16.70	50.19
N_2I_4	34.56	16.93	51.49
N_3I_1	40.13	20.35	60.48
N_3I_2	37.22	17.60	54.82
N_3I_3	38.04	18.17	56.21
N_3I_4	40.61	20.32	60.84
SEm±	1.07	1.03	1.33
$CD_{0.05}$	3.14	3.04	3.92
CV (%)	5.30	10.62	4.47

Table 3. Potassium uptake of maize as influenced by nutrient management and row proportion in maize and field bean intercropping system

Treatment	Potassium uptake (kg/ha)		
	Kernel	Stover	Total
Nutrient management (N)			
N_1: RDF	28.00	50.91	78.91
N_2: LCC	27.18	54.66	81.84
N_3: SSNM	37.64	87.03	124.67
SEm$\pm$	0.57	0.50	0.77
$CD_{0.05}$	1.68	1.47	2.26
Intercrop row proportion (I)			
I_1: Sole maize	32.42	74.96	107.38
I_2: Maize + field bean (2:1)	28.16	70.10	98.26
I_3: Maize + field bean (3:1)	31.29	70.92	102.21
I_4: Maize + field bean (4:1)	31.89	76.07	107.96
SEm$\pm$	0.66	0.57	0.89
$CD_{0.05}$	1.94	1.69	2.61
Interaction (N x I)			
N_1I_1	29.59	53.36	82.95
N_1I_2	22.91	48.87	71.78
N_1I_3	29.94	49.64	79.58
N_1I_4	29.56	51.77	81.33
N_2I_1	29.64	53.25	82.89
N_2I_2	25.32	54.94	80.26
N_2I_3	26.44	54.84	81.28
N_2I_4	27.33	55.61	82.94
N_3I_1	38.03	118.27	156.30
N_3I_2	36.25	105.72	141.97
N_3I_3	37.49	109.04	146.53
N_3I_4	38.78	120.83	159.61
SEm$\pm$	1.14	1.00	1.54
$CD_{0.05}$	3.37	2.94	4.52
CV (%)	6.43	8.13	7.52

Table 4. Total nutrient uptake of field bean as influenced by nutrient management and row proportion in maize and field bean intercropping system

Treatment	Nitrogen (kg/ha)	Phosphorous (kg/ha)	Potassium (kg/ha)
Nutrient management (N)			
N_1: RDF	46.6	10.5	58.1
N_2: LCC	48.6	10.9	60.7
N_3: SSNM	50.6	11.2	62.8
SEm$\pm$	1.08	0.48	0.83
$CD_{0.05}$	3.26	NS	2.51
Intercrop row proportion (I)			
I_2: Maize + field bean (2:1)	56.3	12.0	66.9
I_3: Maize + field bean (3:1)	52.5	11.4	64.6
I_4: Maize + field bean (4:1)	57.0	12.1	67.9
SEm$\pm$	1.08	0.48	0.83
$CD_{0.05}$	3.26	NS	2.51
Sole field bean	101.4	17.80	63.70
Interaction (N x I)			
N_1I_2	47.2	10.5	57.9
N_1I_3	44.3	10.2	55.9
N_1I_4	48.3	10.8	60.5
N_2I_2	53.4	11.6	65.8
N_2I_3	50.3	11.2	62.2
N_2I_4	52.7	11.4	64.4
N_3I_2	68.3	13.9	77.0
N_3I_3	63.0	12.9	75.7
N_3I_4	70.0	14.0	79.0
SEm$\pm$	1.88	0.84	1.45
$CD_{0.05}$	5.65	2.52	4.35
CV (%)	15.33	22.17	9.13

Soil nutrient balance

Nutrient balance is an important parameter in deciding the sustainability in soil fertility management. The crop removal, actual balance and net gain of N, P_2O_5 and K_2O were higher with SSNM practice (Table 1). The higher net gain with SSNM was associated with application of higher doses of NPK and higher nutrient uptake by both the crops. A similar result with

Table 5. Nutrient balance as influenced by nutrient management and row proportion in maize and field bean intercropping system

Treatment	Initial	Applied	Crop uptake	Expected balance	Actual balance	Net gain (+) or loss (-)
	1	2	3	4= 1+2-3	5	6= 5-4
Nitrogen						
N_1I_1	246.78	150	167.27	229.51	227.24	-2.27
N_1I_2	246.78	150	197.31	199.47	231.88	32.41
N_1I_3	246.78	150	205.52	191.26	230.65	39.39
N_1I_4	246.78	150	214.92	181.86	225.65	43.79
N_2I_1	246.78	180	188.35	238.43	232.18	-6.25
N_2I_2	246.78	180	230.11	196.67	236.83	40.16
N_2I_3	246.78	180	228.47	198.31	238.75	40.44
N_2I_4	246.78	180	238.20	188.58	237.97	49.39
N_3I_1	246.78	263	231.28	278.50	271.68	-6.82
N_3I_2	246.78	263	270.10	239.68	272.83	33.15
N_3I_3	246.78	263	273.46	236.32	274.49	38.17
N_3I_4	246.78	263	286.55	223.23	273.43	50.20
Phosphorus						
N_1I_1	27.91	75	49.92	52.99	30.11	-22.88
N_1I_2	27.91	75	54.94	47.97	30.15	-17.82
N_1I_3	27.91	75	56.79	46.12	31.41	-14.71
N_1I_4	27.91	75	59.41	43.50	31.57	-11.93
N_2I_1	27.91	75	51.95	50.96	31.98	-18.98
N_2I_2	27.91	75	58.93	43.98	31.81	-12.18
N_2I_3	27.91	75	61.39	41.52	31.58	-9.94
N_2I_4	27.91	75	62.89	40.02	31.87	-8.15
N_3I_1	27.91	139	60.49	106.42	35.61	-70.81
N_3I_2	27.91	139	68.72	98.19	35.89	-62.30
N_3I_3	27.91	139	69.11	97.80	36.32	-61.48
N_3I_4	27.91	139	74.92	91.99	36.61	-55.38
Potassium						
N_1I_1	170.27	40	82.95	127.32	159.50	32.18
N_1I_2	170.27	40	130.44	79.83	159.93	80.11
N_1I_3	170.27	40	134.71	75.56	160.45	84.89
N_1I_4	170.27	40	141.83	68.44	161.04	92.60
N_2I_1	170.27	40	82.90	127.37	161.44	34.06
N_2I_2	170.27	40	146.07	64.20	161.99	97.79

N_2I_3	170.27	40	143.48	66.79	162.93	96.14
N_2I_4	170.27	40	147.35	62.92	163.64	100.72
N_3I_1	170.27	328	156.30	341.97	170.76	-171.21
N_3I_2	170.27	328	218.97	279.30	172.53	-106.77
N_3I_3	170.27	328	222.23	276.04	175.02	-101.02
N_3I_4	170.27	328	238.61	259.66	176.36	-83.30

Nutrient management= N_1: RDF, N_2: LCC, N_3: SSNM
Intercrop row proportion= I_1: Sole maize, I_2: Maize + field bean (2:1),
I_3: Maize + field bean (3:1) I_4: Maize + field bean (4:1)

Table 6. Economics of effect of nutrient management and row proportion in maize and field bean intercropping system on economics and B:C ratio

Treatment	Cost of cultivation (Rs)	Gross returns (Rs)	Net returns (Rs)	B:C ratio
N_1I_1	28148.5	138330.0	112258.5	4.91
N_1I_2	28148.5	137549.2	111477.7	4.89
N_1I_3	28148.5	136710.8	110639.3	4.86
N_1I_4	28148.5	143233.5	117162.0	5.09
N_2I_1	28494.71	145376.7	118959.0	5.10
N_2I_2	28494.71	145228.2	118810.5	5.10
N_2I_3	28494.71	145646.5	119228.8	5.11
N_2I_4	28494.71	149935.3	123517.6	5.26
N_3I_1	32765.21	157176.7	129555.8	4.80
N_3I_2	32765.21	160853.0	133618.1	4.91
N_3I_3	32765.21	160355.5	133020.2	4.89
N_3I_4	32765.21	166371.8	138911.5	5.08
Sole field bean	14723	29795	15042	2.02

Nutrient management= N_1: RDF, N_2: LCC, N_3: SSNM
Intercrop row proportion= I_1: Sole maize, I_2: Maize + field bean (2:1),
I_3: Maize + field bean (3:1), I_4: Maize + field bean (4:1)

respect to nutrient balance in maize production with field bean intercropping at different row proportions was reported by Jemal (2010). Higher available NPK status after harvest of maize with graded levels of NPK application was observed by Jayaprakash et al (2005).

Effect on economic viability of the intercropping system

The monitory advantage indicated superior economic viability of maize + field bean intercropping in 4:1 row proportion with SSNM over other row proportions of intercropping system with LCC and RDF

(Table 2). Maize + field bean intercropping in 4:1 row proportion with SSNM recorded highest net returns (Rs 138911.5/ha) and B:C ratio was higher (5.26) in maize + field bean intercropping in 4:1 row proportions with LCC followed by maize + field bean in 2:1 row proportion with LCC (5.11) and B:C ratio (2.84) indicating the superiority of these systems over sole maize and sole field bean. This was due to increased proportion of net returns in relation to cost of cultivation that resulted in higher B:C ratio. From the present investigation it can be concluded that intercropping of maize and field bean at 4:1 row proportion is more productive and remunerative than sole crop of maize or field bean with SSNM approach of nutrient management. Similar results were reported earlier by Sawargaonkar et al (2008).

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Received: 21.2.2015 ***Accepted: 17.6.2015***