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Effect of integrated nutrient management on performance of rainfed fodder maize-rapeseed cropping system

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Abstract
Field experiment was conducted on integrated nutrient management in rainfed fodder maize-rapeseed cropping system to know its effect on crop productivity, economics and soil fertility. Results showed that herbage yield (19.07 t ha^{-1}), rapeseed yield (596 kg ha^{-1}) and biomass yield (7209 kg ha^{-1}) of this cropping system increased significantly by supplying 50% recommended dose of nitrogen (RDN) through FYM/mustard cake + 50% recommended dose of NPK (RDF) through chemical fertilizers with or without *Azotobacter*. The above fertility treatments improved soil fertility, increased NPK balance in spite of greater NPK removal and paid high return over other fertility treatments. Integration of 50% N (30 kg N ha^{-1}) through organic manures (FYM/mustard cake) and 50% RDF (30 kg N, 6.7 kg P and 12.5 kg K ha^{-1}) through chemical fertilizers and biofertilizer (*Azotobacter*) was recommended for improving crop productivity, soil fertility, nutrient balance and maximizing economic return from this cropping system in *Terai* region of Indian sub-tropics.

Keywords: Crop productivity, Cropping system, Fodder maize, Nutrient management, Rainfed, Rapeseed

Introduction

Indian agriculture needs to be oriented towards mixed farming in which livestock rearing form an integral part of rural India. Most of the livestock population of our country is underfed. The fodder production does not match with the livestock population resulting in its low productivity (Hazra, 1998). Appropriate forage production technologies need to be generated to integrate forage in the existing cropping system. Uncertain rain, chance of flood and other abiotic factors have discouraged the farmers for investing more money in *kharif* season. At the same time livestock farming being more remunerative as compared to conventional agriculture may be considered as a viable option under such circumstances (Younas and Yaqoub, 2005). Maize (*Zea mays*), is widely used as an excellent livestock feed as grain, green fodder, or silage and has also been used for human consumption. Maize is considered an ideal forage crop because it grows quickly, produces high yield, rich in nutrients, palatable and helps in improving health and milk quality of cattle (Amanullah *et al.*, 2007). It can be grown on varying soil and climatic conditions. At present oilseed production in our country is much less than our requirement and West Bengal is the worst sufferer in oilseed crisis. We are producing only 40% of our requirement and huge gap of vegetable oil requirement exists. Rapeseed may be considered as a viable option for narrowing the deficit of oilseed requirement in our state (Karforma *et al.*, 2012). As fodder maize and rapeseed being exhaustive crops, the fodder maize-rapeseed cropping system needs a judicious nutrient management system for maintaining the sustainability of the cropping system. For sustainable agriculture, most efficient and profitable use of inputs particularly nutrient application along with organic manure is the need of the hour. An integrated approach recognizes that soils are the storehouse of most of the plant nutrients essential for plant growth and that the way in which nutrients are managed must have a major impact on plant growth, soil fertility, and agricultural sustainability (Ghosh, 2015). Proper nutrient management in fodder crops may also increase fodder productivity as well as residual fertility which may sustain the productivity of crops grown in future. Integrated nutrient management (INM) showed better performance than that of only inorganic fertilizers on productivity of many crops in different regions (Rafique *et al.*, 2012; Ping *et al.*, 2013). Realizing the importance of

the problem and considering the above views the present investigation was undertaken to study the effect of INM on productivity, soil fertility and economics of fodder maize - rapeseed cropping system.

Materials and Methods

Experimental site and design: The field experiment was conducted during 2007-08 and 2008-09 at KVK Instructional Farm of West Bengal University of Animal and Fishery Sciences, Ramshai, Jalpaiguri, West Bengal. The farm is situated in sub-humid sub-tropical region ($26^0 42^/$ N latitude, $88^0 53^/$ E longitude and an altitude of 43.5 m above the mean sea level). The experimental area received 31% less rainfall (1262.3 mm) in 2007 than normal rainfall (1828.8 mm) occurring in this area; but it received almost normal rainfall (1814.3 mm) in 2008. The soil of the experimental field was sandy loam in texture (65.2% sand, 20.3% silt and 14.5% clay), acidic in nature (pH 4.94) and low in fertility status (OC 0.75%, available N 173.0 kg ha^{-1}, available P 9.2 kg ha^{-1} and available K 127.5 kg ha^{-1}). The experiment was laid out in randomized complete block design (RCBD) with 11 nutrient management treatments in three replications of 5.0 m x 3.0 m plots. The treatments were T_1: control (no use of manures and fertilizes), T_2: 100% recommended dose (60 kg N +13.3 kg P + 25 kg K ha^{-1}) of fertilizer (RDF) through chemical fertilizers, T_3: 25% recommended dose (15 kg N ha^{-1}) of nitrogen (RDN) through farm yard manure (3.0 t FYM ha^{-1}) + 75% RDF (45 kg N +10.0 kg P + 18.3 kg K ha^{-1}) through chemical fertilizers, T_4: 50% RDN (30 kg N ha^{-1}) through 6.0 t FYM ha^{-1} + 50% RDF (30 kg N + 6.7 kg P + 12.5 kg K ha^{-1}) through chemical fertilizers, T_5: 25% RDN through mustard cake (312.5 kg ha^{-1} MC) + 75% RDF through chemical fertilizers, T_6: 50% RDN through 625 kg ha^{-1} MC + 50% RDF through chemical fertilizers, T_7: 100% RDF through chemical fertilizers + *Azotobacter,* T_8: 25% RDN through FYM + 75% RDF through chemical fertilizers + *Azotobacter,* T_9: 50% RDN through FYM + 50% RDF through chemical fertilizers + *Azotobacter,* T_{10}: 25% RDN through MC + 75% RDF through chemical fertilizers + *Azotobacter* and T_{11}: 50% RDN through MC + 50% RDF through chemical fertilizers + *Azotobacter*. Well decomposed FYM containing 0.5% N, 0.13% P and 0.45% K (dry weight basis) and MC containing 4.8% N, 1.7% P and 1.16% K were applied as per treatments at 7 days before sowing and mixed thoroughly with soil by spading. The chemical fertilizers were urea, single super phosphate, and muriate of potash for N, P and K respectively. Half dose of nitrogen and full dose of phosphorous and potassium as per treatments was applied as basal dose before sowing. The remaining half of nitrogen was applied as top dressing at 30 days after sowing. Maize seeds of variety 'J 1006' were inoculated with *Azotobacter* 25 g kg^{-1} of seeds as per treatment and dried in shade before sowing. The crop was sown on July 15, 2007 and July 16, 2008 at 30 cm rows apart. The fodder maize was harvested at 70 days after sowing when it attained flowering stage and green forage yield was recorded. After the harvest of fodder maize, the field was prepared by spade without damaging the layout and rapeseed var. Binoy (B-9) was sown on October 18, 2007 and October 19, 2008 at residual fertility on same plots of the same layout. Rapeseed did not receive any rainfall in November, December and January during both the years. Thinning of rapeseed was done at 20 days after sowing (DAS) and the crop was harvested at maturity on January 27, 2008 and January 28, 2009.

Observations and methods of analysis: The observations on forage maize yield (fresh weight basis), rapeseed yield (8% moisture basis) and biomass productivity (oven dry weight basis) were recorded at harvest of each crop. The cost of organic manures, chemical fertilizers and other inputs (labour, seeds, pesticides, etc) and outputs (fodder maize and rapeseed) were estimated as per prevailing market price. The gross returns, net returns and returns per rupee invested in INM were assessed by computing the cost of the inputs and price of the produce/output. Soil samples were collected (0-20 cm depth) from all plots after harvesting of each crop and analyzed for soil pH, organic carbon and available nutrient (NPK) status following standard procedures. The nutrient (N, P and K) contents in maize plant and rapeseed stover and grain at harvest were determined in the laboratory following standard methods of analysis. N, P and K removal by the crops were then estimated by multiplying plant biomass of maize and grain and stick yield of rapeseed with their respective N, P and K contents. All the data were analyzed statistically for analysis of variance following methods suggested by Gomez and Gomez (1984).

Results and Discussion

***Crop productivity*:** INM through organic manures, chemical fertilizers and biofertilizers favorably influenced the yield of the fodder maize, succeeding rapeseed and their biomass productivity. Application of 50% RDN through FYM + 50% RDF through fertilizers + *Azotobacter* produced the highest herbage yield of maize, seed yield of succeeding rapeseed and biomass yield of the system

Table 1. Effect of integrated nutrient management on productivity and economics of fodder maize-rapeseed cropping system (average data of 2 years)

Nutrient management	Herbage yield (t ha^{-1})	Rapeseed yield (kg ha^{-1})	Biomass yield (kg ha^{-1})	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	Return Re $^{-1}$ invested
Control (No manure and fertilizer)	9.74	323	3848	20850	9430	1.83
100% RDF* through chemical fertilizer	14.11	438	5307	29220	14435	1.98
25% RDN through FYM+75 % RDF through chemical fertilizer	16.04	460	6132	32120	15810	1.97
50% RDN through FYM+50% RDF through chemical fertilizer	18.71	577	7058	38640	19540	2.02
25% RDN through MC+75% RDF through chemical fertilizer	15.42	463	6014	31475	14975	1.91
50% RDN through MC+50% RDF through chemical fertilizer	18.23	570	6973	37960	18420	1.94
100% RDF through chemical fertilizer +*Azotobacter*	13.79	433	5296	28760	13705	1.91
25% RDN through FYM+75% RDF through chemical fertilizer +*Azotobacter*	17.13	478	6353	33435	16560	1.98
50% RDN through FYM+50% RDF through chemical fertilizer +*Azotobacter*	19.96	623	7447	41300	21150	2.05
25% RDN through MC+75% RDF through chemical fertilizer +*Azotobacter*	16.31	472	6100	32755	15570	1.91
50% RDN through MC+50% RDF through chemical fertilizer +*Azotobacter*	19.40	614	7360	40495	19815	1.96
S Em (±)	0.78	26.0	249.2	1525	710	0.08
C D at 5%	2.30	76.8	735.0	4500	2090	NS
C V (%)	8.3	9.1	7.0			

*RDF (Recommended dose of fertilizer) = 60 kg N +13.3 kg P + 25 kg K ha^{-1}; RDN (Recommended dose of N) = 60 kg N ha^{-1}; FYM=Farm yard manure; MC=Mustard oil seed cake. Cost of urea = Rs 12.00 per kg; SSP = Rs 28.00 per kg; MOP = Rs 8.50 per kg; FYM = Rs 500.00 per ton; MC= 15.00 per kg; Azotobacter = Rs 335.00 per kg; Labour = Rs 70.00 per man-day; price of fodder maize = Rs 1000.00 per ton; price of rapeseed = Rs 22.00 per kg

and was closely followed by the application of 50% RDN through MC + 50% RDF through fertilizers + *Azotobacter*, 50% RDN through FYM + 50% RDF through chemical fertilizers and 50% RDN through MC + 50% RDF through fertilizers during both the years (Table 1). The above fertility treatments produced significantly higher fodder yield, oilseed yield and biomass yield over most of the other fertility treatments. Our study showed that the treatments having N from organic and chemical sources in the ratio of 50:50 produced the highest yield of both the crops as well as total biomass productivity of the system. INM increased forage yield by 73.7%, rapeseed seed yield by

Table 2. Effect of integrated nutrient management on nutrient removal by fodder maize-rapeseed cropping system (average of 2 years data)

Nutrient management	N removal (kg ha^{-1})			P removal (kg ha^{-1})			K removal (kg ha^{-1})		
	Maize	Rapeseed	Total	Maize	Rapeseed	Total	Maize	Rapeseed	Total
Control (No manure and fertilizer)	31.9	13.3	45.1	3.58	4.54	8.12	45.8	17.6	63.3
100% RDF* through chemical fertilizer	55.8	18.5	74.3	7.53	6.15	13.67	75.3	24.5	99.7
25% RDN through FYM+75 % RDF through chemical fertilizer	60.1	19.7	79.7	8.03	6.66	14.68	86.0	26.5	112.4
50% RDN through FYM+50% RDF through chemical fertilizer	70.2	23.8	94.0	9.93	8.37	18.29	99.0	31.9	130.9
25% RDN through MC+75% RDF through chemical fertilizer	61.1	19.5	80.6	8.38	6.71	15.08	85.5	26.4	111.9
50% RDN through MC+50% RDF through chemical fertilizer	69.8	24.2	94.0	9.98	8.52	18.50	97.8	32.4	130.1
100% RDF through chemical fertilizer +*Azotobacter*	54.2	19.1	73.3	7.18	6.41	13.58	72.3	25.1	97.4
25% RDN through FYM+75% RDF through chemical fertilizer +*Azotobacter*	61.6	21.2	82.8	8.65	7.45	16.09	87.3	27.8	115.1
50% RDN through FYM+50% RDF through chemical fertilizer +*Azotobacter*	74.7	26.1	100.7	10.23	8.91	19.14	105.0	34.1	139.1
25% RDN through MC+75% RDF through chemical fertilizer +*Azotobacter*	62.1	20.7	82.8	8.57	7.02	15.58	84.9	26.8	111.7
50% RDN through MC+50% RDF through chemical fertilizer +*Azotobacters*	73.8	25.5	99.3	10.14	8.72	18.85	102.9	33.6	136.4
S Em (±)	2.75	0.84	2.92	0.35	0.31	0.70	3.2	1.1	4.5
C D at 5%	8.15	2.49	8.62	1.02	0.90	2.06	9.5	3.1	13.2
C V (%)	7.8	7.0	6.1	8.2	8.7	7.3	6.6	6.8	7.0

*RDF (Recommended dose of fertilizer) = 60 kg N +13.3 kg P + 25 kg K ha^{-1};
RDN (Recommended dose of nitrogen) = 60 kg N ha^{-1}; FYM=Farm yard manure; MC=Mustard oil seed cake.

58.9% and system biomass yield by 66.4% over those of the control plots and that of 19.8, 17.1 and 20.7% respectively over those obtained with the use of only fertilizers. Even combined application of 50% RDN through organic manure and 50% RDF through fertilizers with or without biofertilizer increased forage yield by 17.6%, seed yield of succeeding rapeseed by 27.3% and the system biomass yield by 17.2% over those having 25% RDN through organic manures and rest through fertilizers. Yield improvement under these treatments might be because of enhanced availability and use of plant nutrients and other associated soil improving benefits from organic manures. INM might help the crop in attaining desired growth by supplying plant nutrients as per its demand (Tiwana *et al.*, 2014), which in turn resulted in better absorption and utilization of solar energy leading to higher photosynthesis and greater productivity (Ramesh *et al.,* 2009; Shafi *et al*., 2012).

***Economics of fodder maize-rapeseed cropping system*:** The nutrient management practices exerted significant effect on gross and net returns from the fodder

Table 3. Effect of integrated nutrient management on nutrient balance in soil after 2 years of fodder maize-rapeseed cropping system

Nutrient management	Nutrient added in 2 crop cycle (kg ha^{-1})			Nutrient removed by 2 crop cycle (kg ha^{-1})				Soil available nutrient after 2 crop cycle (kg ha^{-1})			Nutrient balance (gain/loss) over initial status (kg ha^{-1})**		
	N	P	K	N	P	K	OC%	N	P	K	N	P	K
Control (without nutrient supply)	0.0	0.0	0.0	90.2	16.23	127	0.70	139.0	8.2	98.7	-34.0	-1.0	-28.8
100% RDF* through chemical fertilizer	120.0	26.7	50.0	148.5	27.34	199	0.76	170.7	10.3	125.8	-2.3	1.1	-1.7
25% RDN through FYM+75 % RDF through chemical fertilizer	120.0	27.8	64.5	159.4	29.36	225	0.80	184.3	12.0	130.6	11.3	2.8	3.1
50% RDN through FYM+50% RDF through chemical fertilizer	120.0	28.9	79.0	187.9	36.58	262	0.89	193.0	13.8	139.1	20.0	4.6	11.6
25% RDN through MC+75% RDF through chemical fertilizer	120.0	30.6	44.8	161.2	30.16	224	0.78	183.7	11.5	129.8	10.7	2.3	2.3
50% RDN through MC+50% RDF through chemical fertilizer	120.0	34.6	39.5	187.9	36.99	260	0.80	192.3	13.4	138.8	19.3	4.2	11.3
100% RDF through chemical fertilizer +*Azotobacter*	120.0	26.7	50.0	146.5	27.16	195	0.77	172.0	10.4	129.5	-1.0	1.2	2.0
25% RDN through FYM+ 75% RDF through chemical fertilizer +*Azotobacter*	120.0	27.8	64.5	165.5	32.18	230	0.80	187.0	12.1	132.2	14.0	2.9	4.7
50% RDN through FYM+ 50% RDF through chemical fertilizer +*Azotobacter*	120.0	28.9	79.0	201.4	38.28	278	0.90	196.3	14.5	141.8	23.3	5.3	14.3
25% RDN through MC+ 75% RDF through chemical fertilizer +*Azotobacter*	120.0	30.6	44.8	165.6	31.16	223	0.79	184.0	12.0	131.2	11.0	2.8	3.7
50% RDN through MC+50% RDF through chemical fertilizer +*Azotobacter*	120.0	34.6	39.5	198.5	37.70	273	0.81	193.3	13.5	139.5	20.3	4.3	12.0
S Em (±)				3.24	0.98	4.61	0.02	3.49	0.43	2.21	0.72	0.17	0.21
C D at 5%				9.4	2.90	13.6	0.07	10.2	1.26	6.5	2.1	0.50	0.6

*RDF (Recommended dose of fertilizer) = 60 kg N +13.3 kg P + 25 kg K ha^{-1}; RDN (Recommended dose of nitrogen) = 60 kg N ha^{-1}; FYM=Farm yard manure; MC=Mustard oil seed cake

**Initial status= 0.75% OC; 173, 9.2 and 127.5 kg available N, P and K ha^{-1} respectively.

maize-rapeseed cropping system; but returns per rupee invested did not vary much among the fertility treatments. All the fertility treatments markedly increased the gross and net returns over that of the control plots. The highest gross Rs 41300/- ha^{-1}) and net returns (Rs 21150/- ha^{-1}) were recorded in the plots receiving 50% RDN (30 kg N ha^{-1}) through FYM + 50% RDF (30 kg N, 6.7 kg P and 12.5 kg K ha^{-1}) through chemical fertilizers + *Azotobacter* and was comparable to that having 50% RDN through MC + 50% RDF through chemical fertilizers + *Azotobacter*, 50% RDN through FYM + 50% RDF through chemical fertilizers and 50% RDN through MC + 50% RDF through chemical. All these treatments significantly outperformed the other fertility treatments in respect of both gross and net returns from fodder maize-rapeseed cropping system (Table 1). Crop receiving 25% RDN through organic manures and 75% RDF through chemical fertilizers or 100% RDF through only chemical fertilizers with or without biofertilizer were less effective in paying gross and net returns as compared to those obtained at 50% RDN replacement through organic manures and 50% RDF through chemical fertilizers. High economic return from fodder maize-rapeseed cropping system at 50% RDN through organic manures and 50% RDF through chemical fertilizers was mainly due to high yield of both the crops under this system. Similar beneficial effect of INM on economy of different cropping systems was also noticed by Lakho *et al.* (2004), Ramesh *et al.* (2009) and Tiwana *et al.*, (2014). The crop at control plots paid the lowest gross (Rs 20850/-) and net returns (Rs 9430/-) mainly due to low productivity of both the crops grown in sequence. The results suggest the need of integrated use of 50% RDN through organic and remaining 50% RDF through chemical fertilizers for obtaining high gross and net returns from fodder maize–rapeseed cropping system in rainfed uplands of *terai* region of North Bengal.

***Nutrient removal*:** The nutrient management treatments recorded significantly higher removal of N, P and K by fodder maize, succeeding rapeseed and their total removal by fodder maize- rapeseed system over that of the control plots. The highest removal of N, P and K by fodder maize, succeeding rapeseed and their total removal by fodder maize- rapeseed system were recorded by the crop having 50% RDN through FYM + 50% RDF through fertilizers + *Azotobacter* and was closely followed by the treatments of 50% RDN through MC + 50% RDF through fertilizers + *Azotobacter*, 50% RDN through FYM + 50% RDF through fertilizers and 50% RDN through MC + 50% RDF through fertilizers (Table 2). The above fertility treatments recorded significantly greater removal of N, P and K by both the crops as well as by the cropping system over those of other fertility treatments under this study. INM through both organic and inorganic sources at 50:50 ratios in addition to biofertilizer probably enhanced nutrient availability in the soil by increasing soil organic matter which in turn improved growth and increased productivity of both the crops resulting in greater nutrient removal by the crops under the system (Munda *et al.*, 2008; Ramesh *et al.*, 2009). The combined application of 50% RDN through organic manure and 50% RDF through chemical fertilizers with or without biofertilizer removed higher N, P and K by 21.9, 25.0 and 23.6% respectively through fodder maize, 25.8, 28.2 and 26.0% through succeeding rapeseed and 22.9, 26.5 and 24.2% though fodder maize-rapeseed cropping system over other fertility treatments; even they removed greater N, P and K by 17.8, 19.8 and 17.7% respectively through fodder maize, 22.8, 24.0 and 22.8% through succeeding rapeseed and 19.0, 21.7 and 18.9% though fodder maize-rapeseed cropping system over those having 25% RDN through organic manures and rest through chemical fertilizers with or without biofertilizer. Results showed that replacement of 25% RDN through organic sources and 75% RDF through chemical fertilizers or 100% RDF through only chemical fertilizers with or without biofertilizer though recorded greater removal of N, P and K over those of the control plots, but exerted much less effect on N, P and K removal by fodder maize, succeeding rapeseed and fodder maize-rapeseed cropping system as compare to those obtained with the replacement of 50% RDN through organic sources and 50% RDF through chemical fertilizers with or without biofertilizer. Adequate and balanced nutrition of crop with 50% N through organic sources and 50% NPK through chemical fertilizers along with biofertilizer probably alleviated the hidden nutrient deficiency in the soil and became responsible for increased growth and productivity of the crops that ultimately led to higher N, P and K removal under this system. The results are in conformity with the findings of Bakht *et al.* (2009).

***Soil fertility and nutrient balance*:** The available N, P and K contents in soil increased considerably and organic carbon increased marginally after two crop cycles due to the application of recommended dose of nutrients through both organic manures and chemical fertilizers. All fertility treatments markedly enhanced available N, P and K contents in the soil over their initial values. The plots having 50% RDN through FYM + 50% RDF through chemical

fertilizers + *Azotobacter* registered the highest available N (196.3 kg ha^{-1}), P (14.5 kg ha^{-1}) and K (141.5 kg ha^{-1}) contents in soil and were closely followed by the plots having 50% RDN through MC + 50% RDF through chemical fertilizers + *Azotobacter*, 50% RDN through FYM + 50% RDF through chemical fertilizers and 50% RDN through MC + 50% RDF through chemical fertilizers. The above fertility treatments significantly increased the available N, P and K contents in soil over those obtained at other fertility treatments (Table 3). Accordingly the INM through both organic manures and chemical fertilizers markedly increased N, P and K balance of the experimental soil after 2 years of fodder maize-rapeseed cropping and the balance was higher by replacing 50% RDN through organic manure and remaining 50% RDF through chemical fertilizers over that obtained with replacement of 25% RDN through organic manures and 75% RDF through chemical fertilizers. Use of biofertilizer further enhanced the N, P and K balance in soil. The plots having 50% RDN through FYM + 50% RDF through chemical fertilizers + *Azotobacter* registered the highest N (23.3 kg ha^{-1}), P (5.3 kg ha^{-1}) and K (14.3 kg ha^{-1}) balance in soil which were significantly greater than all other fertility treatments under study. Our study was supported by the findings of Munda *et al.* (2008). Mineralization of organic matter and the residual effect of plant nutrient from organic sources probably enhanced the nutrient levels of the soil (Kaur *et al*., 2008; Shafi *et al.,* 2012). Nutrient contents of organic sources served as soil amendment for crops and provided appreciable quantities of plant nutrients. Organic nutrient sources release nutrients slowly as they mineralize comparatively slowly than mineral nutrient and contribute to the residual pool of organic N, P and K in the soil and reduce nutrient loss from the soil by improving soil organic matter (Njoku and Mbah, 2012). Organic sources of plant nutrients, thus, exerted long lasting residual effects on crop yield and soil properties by improving soil nutrients and soil organic matter (Wang *et al*., 2013). Our study also showed that balanced nutrient supply with 50% RDN through organic manure + 50% RDF through chemical fertilizers + *Azotobacter* was most conducive for improving soil organic matter and maintaining long term soil productivity.

Conclusion

The results showed that fodder maize–rapeseed cropping system required balanced nutrient management through organic manure, chemical fertilizer and biofertilizer. The crop receiving 30 kg N ha^{-1} (50% RDN) through organic manure and remaining 30 kg N, 6.7 kg P and 12.5 kg K ha^{-1} (50% RDF) through chemical fertilizers along with *Azotobacter* increased herbage yield of fodder maize, seed yield of succeeding rapeseed and total biomass yield. It improved fertility status of the experimental soil in spite of greater removal of plant nutrients (N, P and K) and resulted in greater N, P and K balance. It also paid higher return from rainfed fodder maize–rapeseed cropping system.

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