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Effect of Different Levels of Fertilizer and Residual Effect of INM on Yields and Economic of Broad bean under Black Aromatic Rice-Broad bean Cropping Sequence

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ABSTRACT

Background: Agricultural crop diversification is an important stress relieving option for economic growth of the farming community. Integration of pulses in crop rotation helps in sustainability enhancing overall productivity and profitability of the cropping system. Broad bean (*Vicia faba* L.) is one of the important pulse crop of Manipur grown in the cool season.

Methods: The present investigation was carried out at Central Agricultural University, Imphal during the *kharif* and *rabi* season of 2021-22 and 2022-23. The *kharif* rice experiment was laid out in randomized block design with 8 treatments as main plot replicated three times. During *rabi* season each main plot treatment was split into three sub plot treatments with three levels of recommended dose of fertilizers to broad bean resulting in twenty four treatment combinations replicated three times in split plot design.

Result: Residual effect of 100% RDF + Azolla + Azospirillum + Neem powder (N_5) applied to previous *kharif* rice crop recorded significantly higher yield attributes, seed and stover yields and economic of broad bean. Among the levels of RDF directly applied to *rabi* broad bean, application of 100% RDF (F_2) resulted in higher values of yield attributes, seed and stover yields and economic of broad bean.

Key words: Azolla, Broad bean, Residual effect.

INTRODUCTION

In Manipur most of the farmers practice mono-cropping of rice instead of taking up second crop after *kharif* rice, thus leaving the rice field fallow during *rabi* season. Agricultural crop diversification is a crucial strategy for enhancing the economic of farming communities. Through crop diversification, farming households can spread both production and economic risks over a broader range of crops, thus reducing financial risks associated with unfavourable weather or market shocks. Integration of pulses in crop rotation helps in sustainability enhancing overall productivity and profitability of the cropping system.

Broad bean (*Vicia faba* L.), also known as faba bean, horse bean, or Windsor bean, is one of the most popular legume crops cultivated in Manipur during the rabi season. It has diversified uses, as vegetable, fodder, green manure and concentrate for cattle feed, rich in vitamins, minerals, omega-3 fatty acids, essential amino acids and dietary fibres in addition to being a valuable source of protein. Increasing faba bean production is a major target to meet the increasing demand, since faba bean constitutes a major part of the diet of Manipuri people. Depending on genotype, protein amount in faba bean seeds ranges from 27-32% which is higher than many other grain legumes (Singh *et al.,* 2013). It has been recognized for its efficient biological nitrogen fixation capabilities which is maximum amongst *rabi* season grain legumes (Mekkei, 2014). Studies show that it can fix 50-330/ kg N/ ha and thus, faba bean inclusion in crop rotation decreases the need for inorganic N fertilizer (Jensen *et al.,* 2010).

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MATERIALS AND METHODS

The present investigation was conducted at the research field of College of Agriculture, Central Agricultural University, Imphal during the *kharif* and *rabi* season of 2021-22 and 2022-23. The experimental site is located at 24.45°N latitude and 93.56°E longitudes at an elevation of 790 m above mean sea level. Soil is clay and acidic in nature (pH 5.53), high in available organic carbon (1.57%), medium in available nitrogen (285.68 kg/ha), available phosphorus (18.74 kg/ha) and available potassium (225.83 kg/ha). The *kharif* rice experiment was laid out in randomized block design with 8 treatments as main plot replicated three times- N_1 (100% RDF), N_2 (100% RDF + Sesbania +

Azospirillum + Neem powder), N_3 (75% RDF + Sesbania + Azospirillum + Neem powder), N_4 (50% RDF + Sesbania + Azospirillum + Neem powder), N_5 (100% RDF + Azolla + Azospirillum + Neem powder), N_6 (75% RDF + Azolla + Azospirillum + Neem powder), N_7 (50% RDF + Azolla + Azospirillum + Neem powder) and N_8 (Sesbania + Azolla + Azospirillum + Neem powder). During *rabi* season each main plot treatment was split into three subplot treatments with three levels of recommended dose of fertilizers *viz*., F_0 - control, F_1 - 50% RDF and F_2-100% RDF to broad bean resulting in twenty four treatment combinations replicated three times in split plot design.

RESULTS AND DISCUSSION

Yield attributes and yield of broad bean

Residual effect of different INM applied to black aromatic rice on yield attributes and yield of broad bean (main-plot treatments)

The data of the present study showed that integrated nutrient management (INM) practices to preceding black aromatic rice crop had significant influence on yields attributes and yield of broad bean. Data in Table 1 revealed that number of pods per plant of broad bean was significantly higher (8.88, 9.69 and 9.28) under residual effect of 100% RDF + Azolla + Azospirillum+ Neem Powder (N_5) followed by 100% RDF + Sesbania+ Azospirillum + Neem Powder (N_2) (8.66, 9.46 and 9.06) which remained at par with treatment 75% RDF + Azolla + Azospirillum + Neem Powder (N_6) (8.54, 9.36 and 8.95) during both the years of experimentation and pooled analysis. The highest number of seeds per pod (3.37, 3.46 and 3.41) was recorded with treatment 100% RDF + Azolla + Azospirillum+ Neem Powder (N_5) but it was found on par with the application of 100% RDF + Sesbania + Azospirillum + Neem Powder (N_2) (3.30, 3.36 and 3.33). Further results showed that treatment N_2 was found statistically at par with 75% RDF + Azolla+ Azospirillum + Neem Powder (N_6) (3.18, 3.26 and 3.22) during both years of study and pooled data. The lowest number of seeds per pod was recorded with the treatment 100% RDF (N_1) (2.72, 2.87 and 2.80) during two consecutive years and pooled analysis (Table 1). Seed and stover yield also followed the same trend as number of seeds per pod (Table 2). The efficient utilization of mineralized nutrients from organic manures, biofertilizers and inorganic fertilizers might have enhanced the availability of beneficial nutrients throughout the crop growth period. This increased the assimilation of photosynthates, which in turn improved the source-sink relationship, ultimately leading to higher yield attributes and yield of the succeeding broad bean crop. Similar findings of enhancing the yield and yield attributes due to the residual effect of organics and inorganics sources applied to previous rice crop was reported by Subramani

Table 1: Effect of different levels of fertilizer and residual effect of INM on number of pods, number of seeds and seed index of broad bean.

Treatment	Number of pods/plant			Number of seeds/pod			Seed index (g)		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
I) Main plot treatment (N)									
N_1	7.83	8.48	8.16	2.72	2.87	2.80	50.85	50.92	50.89
N_2	8.66	9.46	9.06	3.30	3.36	3.33	52.31	52.74	53.04
N_3	8.45	9.20	8.83	3.11	3.17	3.14	51.99	52.45	52.22
N_4	8.14	8.75	8.45	2.88	3.05	2.97	51.28	51.33	51.43
N_5	8.88	9.69	9.28	3.37	3.46	3.41	53.02	53.07	52.36
N_6	8.54	9.36	8.95	3.18	3.26	3.22	52.07	52.64	51.88
N_7	8.22	8.88	8.55	2.92	3.09	3.01	51.25	51.61	51.31
N_8	8.36	9.04	8.70	3.01	3.13	3.07	51.76	52.01	52.53
S.Ed (±)	0.08	0.10	0.07	0.07	0.06	0.05	0.74	1.35	1.85
CD (P=0.05)	0.17	0.21	0.14	0.15	0.14	0.11	NS	NS	NS
II) Sub plot treatment (F)									
F_0	6.60	7.52	7.07	2.83	2.89	2.86	50.58	50.86	50.72
F_1	8.53	9.26	8.90	3.12	3.22	3.17	51.86	52.14	52.00
F_2	10.02	10.53	10.27	3.23	3.42	3.32	53.01	53.29	53.15
S.Ed (±)	0.07	0.06	0.03	0.03	0.04	0.03	0.96	0.99	0.98
CD (P=0.05)	0.14	0.12	0.07	0.07	0.08	0.07	NS	NS	NS
Interaction (N × F)									
S.Ed (±)	0.19	0.17	0.11	0.11	0.12	0.10	2.72	2.81	2.78
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

N_1- 100% RDF, N_2- 100% RDF + Sesbania + Azospirillum + Neem powder, N_3- 75% RDF + Sesbania + Azospirillum + Neem powder, N_4-50% RDF + Sesbania + Azospirillum + Neem powder, N_5- 100% RDF + Azolla + Azospirillum + Neem powder, N_6- 75% RDF + Azolla + Azospirillum + Neem powder, N_7- 50% RDF + Azolla + Azospirillum + Neem powder, N_8- Sesbania + Azolla + Azospirillum + Neem powder, F_0- 0% RDF (Control), F_1- 50% RDF and F_2- 100% RDF.

et al. (2008). Seed index (Table 1) and harvest index (Table 2) of broad bean did not differ significantly among the treatments in both the years of experimentation and pooled analysis. However, application of 100% RDF + Azolla + Azospirillum + Neem Powder (N_5) produced maximum harvest index and seed index. Lowest harvest index and seed index were observed in 100% RDF (N_1).

Effect of different levels of fertilizer (RDF) on yield attributes and yield of broad bean (sub-plot treatments)

Application of different levels of inorganic NPK fertilizers increased the yield of broad bean significantly. Data presented in Table 1 and 2 indicated that treatment F_2 (100% RDF) produced significantly the highest number of pods per plant (10.02, 10.53 and 10.27), number of seeds per pod (3.23, 3.42 and 3.32), seed yield (10.12, 10.57 and 10.33 q/ha) and stover yield (25.70, 26.19 and 25.94 q/ha) during both the years of study and in pooled analysis. The increased in yield components and yield may be the result of better utilization of NPK, which enhanced nutrient availability, leading to increased biosynthesis of photosynthates and ultimately higher yield. These findings are in agreement to the results obtained by Gupta *et al.* (2017) in broad bean. Dekhane *et al.* (2011) also reported in cowpea that increasing levels of RDF significantly increased settings of pods, number of seeds per pod, number of seeds per plant and finally seed and stover yield. The lowest number of pods per plant, number of seeds per pod, seeds and stover yield were recorded in treatment F_0 (control). Different levels of fertilizers applied to broad bean did not show its significant effect on harvest index and seed index during individual years of investigation and in pooled analysis (Table 1 and 2). Among the different levels of fertilizer applied in broad bean, F_2 (100% RDF) recorded the highest value of harvest index and seed index.

Interaction effect

The interaction effects due to INM applied to preceding black aromatic rice crop and different levels of NPK fertilizer to broad bean did not reach the level of significance for yields parameters and yield of broad bean in both years of study and pooled data.

Economic studies

The data on economics of broad bean as influenced by residual effect of INM applied to preceding black aromatic rice and different levels of NPK fertilizer to broad bean are shown in Table 3 and 4.

Residual effect of different INM applied to black aromatic rice on economic of broad bean (main-plot treatments)

The gross return, net return as well as B:C ratio for individual treatment and treatment combinations were worked out on the basis of prevailing local market prices. The pooled data showed that highest net returns of

Table 2: Effect of different levels of fertilizer and residual effect of INM on seed yield, stover yield and harvest index of broad bean.

Treatment	Seed yield (q/ha)			Stover yield (q/ha)			Harvest index (%)		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
I) Main plot treatment (N)									
N_1	8.49	8.87	8.68	22.85	23.07	22.96	27.06	27.72	27.39
N_2	9.41	9.82	9.62	24.17	24.55	24.36	27.98	28.53	28.26
N_3	9.12	9.54	9.33	23.81	24.24	24.02	27.66	28.22	27.94
N_4	8.78	9.19	8.98	23.20	23.54	23.37	27.41	28.04	27.72
N_5	9.55	9.96	9.75	24.33	24.67	24.50	28.15	28.72	28.43
N_6	9.24	9.65	9.45	23.99	24.34	24.17	27.78	28.35	28.07
N_7	8.90	9.32	9.11	23.33	23.70	23.52	27.58	28.20	27.89
N_8	9.01	9.45	9.23	23.58	23.94	23.76	27.64	28.28	27.64
S.Ed (±)	0.09	0.09	0.11	0.14	0.13	0.10	0.35	0.37	1.79
CD (P=0.05)	0.19	0.19	0.23	0.29	0.27	0.22	NS	NS	NS
II) Sub plot treatment (F)									
F_0	7.79	8.22	8.01	20.75	21.37	21.06	27.29	27.77	27.53
F_1	9.27	9.67	9.46	24.52	24.46	24.49	27.43	28.30	27.74
F_2	10.12	10.57	10.33	25.70	26.19	25.94	28.25	28.70	28.48
S.Ed (±)	0.05	0.07	0.05	0.09	0.08	0.07	0.43	0.37	0.89
CD (P=0.05)	0.10	0.13	0.10	0.19	0.17	0.15	NS	NS	NS
Interaction (N × F)									
S.Ed (±)	0.14	0.19	0.18	0.26	0.24	0.21	1.21	1.05	2.52
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

N_1- 100% RDF, N_2- 100% RDF + Sesbania + Azospirillum + Neem powder, N_3- 75% RDF + Sesbania + Azospirillum + Neem powder, N_4-50% RDF+ Sesbania + Azospirillum + Neem powder, N_5- 100% RDF + Azolla + Azospirillum + Neem powder, N_6- 75% RDF + Azolla + Azospirillum + Neem powder, N_7- 50% RDF + Azolla + Azospirillum + Neem powder, N_8- Sesbania + Azolla + Azospirillum + Neem powder, F_0- 0% RDF (Control), F_1- 50% RDF and F_2- 100% RDF.

Rs. 104232.50/ha and B:C ratio of 2.01 were recorded with the applications of 100% RDF + Azolla + Azospirillum + Neem Powder (N_5) followed by 100% RDF+ Sesbania+ Azospirillum + Neem Powder (N_2) with the maximum net returns of Rs. 102026.30/ha and B:C ratio of 1.96. The lowest net returns of Rs. 87068.30/ha and B: C ratio of 1.67 were obtained in treatment 100% RDF (N_1). This clearly indicates that the application of organic manures and biofertilizers along with optimal levels of the recommended dose of inorganic fertilizers to the preceding black aromatic rice crop provides an additional advantage in enhancing overall net monetary returns.

Table 3: Effect of different levels of fertilizer and residual effect of INM on economic of broad bean.

Treatment	Total cost	Gross return (Rs/ha)			Net return (Rs/ha)			B:C ratio		
		2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
1) Main plot treatment (N)										
N_1	51816.67	135808.52	141961.40	138885.00	83991.85	90144.74	87068.30	1.61	1.73	1.67
N_2	51816.67	150558.16	157127.80	153842.98	98741.49	105311.14	102026.30	1.90	2.03	1.96
N_3	51816.67	145849.44	152692.10	149270.80	94032.77	100875.40	97454.11	1.81	1.94	1.88
N_4	51816.67	140423.02	147089.70	143756.40	88606.36	95273.02	91939.69	1.70	1.83	1.77
N_5	51816.67	152804.77	159293.60	156049.20	100988.10	107477.00	104232.50	1.94	2.07	2.01
N_6	51816.67	147909.38	154380.49	151144.93	96092.71	102674.93	99383.82	1.85	1.97	1.91
N_7	51816.67	142376.39	149060.83	145718.61	90559.72	97244.16	93901.94	1.74	1.87	1.81
N_8	51816.67	144213.66	151182.55	147698.11	92397.00	99365.88	95881.44	1.78	1.91	1.85
2) Sub plot treatment (F)										
F_0	46350.00	124659.99	131540.70	128100.30	78309.99	85190.65	81750.32	1.69	1.84	1.76
F_1	52750.00	148330.25	154542.90	151436.60	95580.25	101834.60	98707.42	1.81	1.93	1.87
F_2	56350.00	161988.50	168712.10	165350.30	105638.50	112362.10	109000.30	1.87	1.99	1.93

Table 4: Interaction effect of different levels of fertilizer and residual effect of INM on economics of broad bean.

Interaction	Gross return (Rs/ha)			Net return (Rs/ha)			B:C ratio		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
N_1F_0	116457.31	122169.30	119313.30	70107.31	75819.31	72963.31	1.51	1.64	1.57
N_1F_1	138080.00	143840.00	140960.00	85330.00	91090.00	88210.00	1.62	1.73	1.67
N_1F_2	152888.25	159874.90	156381.60	96538.25	103524.91	100031.60	1.71	1.84	1.78
N_2F_0	130691.59	136504.90	133598.25	84341.59	90154.91	87248.25	1.82	1.95	1.88
N_2F_1	152586.67	160480.00	156533.33	99836.67	107730.00	103783.30	1.89	2.04	1.97
N_2F_2	168396.22	174398.50	171397.36	112046.20	118048.51	115047.40	1.99	2.09	2.04
N_3F_0	125629.92	132723.30	129176.60	79279.92	86373.25	82826.59	1.71	1.86	1.79
N_3F_1	150453.33	156101.30	153277.30	97703.33	103351.30	100527.30	1.85	1.96	1.91
N_3F_2	161465.07	169251.70	165358.40	105115.10	112901.70	109008.40	1.87	2.00	1.93
N_4F_0	119833.07	125699.70	122766.40	73483.07	79349.73	76416.40	1.59	1.71	1.65
N_4F_1	144320.00	150506.70	147413.30	91570.00	97756.67	94663.33	1.74	1.85	1.79
N_4F_2	157116.00	165062.70	161089.30	100766.00	108712.70	104739.30	1.79	1.93	1.86
N_5F_0	132106.23	138666.20	135386.20	85756.23	92316.20	89036.21	1.85	1.99	1.92
N_5F_1	156160.00	162453.30	159306.70	103410.00	109703.30	106556.70	1.96	2.08	2.02
N_5F_2	170148.08	176761.40	173454.70	113798.10	120411.40	117104.70	2.02	2.14	2.08
N_6F_0	127073.28	134273.28	130673.28	80723.28	87923.28	84323.28	1.74	1.90	1.82
N_6F_1	151762.03	157842.03	154802.03	99012.03	105425.36	102218.70	1.88	1.99	1.93
N_6F_2	164892.83	171026.16	167959.49	108542.80	114676.16	111609.50	1.93	2.04	1.98
N_7F_0	121343.05	130303.05	125823.05	74993.05	83953.05	79473.05	1.62	1.81	1.71
N_7F_1	145706.67	151360.00	148533.33	92956.67	98610.00	95783.33	1.76	1.87	1.82
N_7F_2	160079.44	165519.44	162799.44	103729.40	109169.44	106449.40	1.84	1.94	1.89
N_8F_0	124145.49	131985.49	128065.49	77795.49	85635.49	81715.49	1.68	1.85	1.76
N_8F_1	147573.33	153760.00	150666.67	94823.33	101010.00	97916.67	1.80	1.91	1.86
N_8F_2	160922.16	167802.16	164362.16	104572.20	111452.16	108012.20	1.86	1.98	1.92

Similar benefits of the residual effect of integrated nutrient management were reported earlier by Mansuri (2016) under rice-chickpea, Shanwad *et al.* (2010) in maize-bengal gram and Nawale *et al.* (2009) in forage sorghum-chick pea cropping sequence.

Effect of different levels of fertilizer (RDF) on economic of broad bean (sub-plot treatments)

Applications of different levels of inorganic fertilizers had significant influence on economic of broad bean (Table 3). Among the different fertilizer levels, highest net returns (Rs.109000.30/ha) and B:C ratio (1.93) were recorded with 100% RDF treatment (F_2) followed by treatment 50% RDF (F_1) with the maximum net returns of Rs. 98707.42/ha and B: C ratio of 1.87. The control treatment (F_0) recorded the lowest net returns (Rs. 81750.32/ha) and B:C ratio (1.76). Similar results were also reported by Gudadhe *et al.* (2016), Shahid *et al.* (2015) and Shubhashree *et al.* (2011) in french bean. Additionally, Jat *et al.,* (2012) found that the application of 100% RDF was more profitable for achieving higher seed yield in green gram compared to the control and 50% RDF.

Interaction effect

The highest net returns of Rs. 117104.70/ha and B:C ratio (2.08) were recorded under treatment combination of N_5F_2 (100 % RDF + Azolla + Azospirillum + Neem Powder along with 100% RDF), followed by N_2F_2 (100 % RDF + Sesbania + Azospirillum + Neem Powder along with 100% RDF) with net returns of Rs. 115047.40/ha and B:C ratio of 2.04. The lowest net returns (Rs. 72963.31/ha) was observed with treatment combination of N_1F_0 (100% RDF along with control) with the lowest B:C ratio of 1.57 (Table 4).

CONCLUSION

Experimental outcome revealed that application of 100% RDF + Azolla + Azospirillum + Neem powder (N_5) to the preceding black aromatic rice showed beneficial residual effect on broad bean for enhancing the values of yield attributing characters including the number of pods per plant and number of seeds per pod, seed and stover yield, harvest index, seed index and economic. Among the different fertilizers applied to *rabi* broad bean, application of 100% RDF (F_2) resulted in higher values of yield attributes, seed and stover yields and economic of broad bean.

Conflict of interest

The authors declare that there are no conflicts of interest within them.

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