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Efficient Utilization of Rice Fallows in Sandy Loam Soils of Assam, India

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Authors' contributions

This work was carried out in collaboration among all authors. Author KDD performed the statistical analysis and wrote the first draft of the manuscript. Author MS designed the study and author MMD managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

During the *rabi* season of 2019-20, a field experiment was conducted at Jorhat, Assam to study the effect of integrated nutrient management (INM) practices on the efficiencies *viz.,* agronomic efficiency (AE), nutrient use efficiency (NUE), physiological efficiency (PE) and apparent recovery efficiency (ARE) and the effects of varieties and INM on economics of rapeseed and mustard in rice fallows. The experiment used three mustard varieties *viz*., PM 26 (V_1), PM 27 (V_2) and NRCHB-101 (V_3) along with one rapeseed variety *viz*.,TS-36 (V_4) in the main plot and five INM practices *viz*., control (No N-P-K) (F_1), 50% of the recommended dose (RD) of NPK + vermicompost (VC) @1t/ha (incubated with *Azotobacter* and PSB) applied at basal and 30 DAS (F_2), VC @ 2t/ha (incubated with *Azotobacter* and PSB) (F_3), FYM @ 2t/ha (incubated with *Azotobacter* and PSB) + quick lime @ 20 kg/ha + ash @ 2kg/ha applied at basal and 30 DAS (F_4) and RD of NPK @ 40-35-15 kg/ha (F_5) in the sub-plots and replicated thrice. The condition of the soil at the experimental site was found to be sandy loam in nature. Results showed the highest AE (kg/kg), NUE (kg/kg), PE (kg/kg)

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and ARE (%) in the INM treatment of FYM @ 2t/ha (incubated with *Azotobacter* and PSB) + quick lime @ 20 kg/ha + ash @ 2kg/ha applied at basal and 30 DAS (F_4) and could be viable to the farming community. Economically, variety PM 27 (V_2) produced the highest net returns of 40,965.11/ha with a B:C ratio of 2.34 followed by NRCHB 101(V_3) which registered a net returns of 38644.91/ha and B:C ratio of 2.22. In INM practice, the highest B:C ratio of 2.74 was recorded in F_5 with a net returns of 45,325.00/ha followed by F_4 treatment producing a B:C ratio of 2.59 with net returns of 39,629.63/ha.

Keywords: Fallow; agronomic efficiency; nutrient use efficiency; physiological efficiency; apparent recovery efficiency; rapeseed; mustard; economics.

1. INTRODUCTION

Rice fallow area are those in which *kharif* paddy are grown which are kept fallow in *rabi* season. Rice fallow (~11.7 million ha) is a mono–crop rice–based production system in India and mostly (82%) is concentrated in the eastern states, .i.e. Chhattisgarh, Jharkhand, Upper Assam, Bihar, eastern Uttar Pradesh, Odisha and West Bengal [1]. Assam is traditionally rice growing state and mostly mono-cropped with *sali* (*kharif)* rice. It occupies an area of about 18.18 lakh hectares (66.92% of the net cropped area) with an average productivity of 2002 kg/ha [2]. On the other hand, efficient utilization of these rice fallows is imperative for higher land productivity and economic enhancement for farmers. This may be achieved by cultivation of *rabi* crops in these rice growing areas instead of leaving them as fallow lands during the *rabi* season. Also, targeting for area expansion in the rice fallow lands is a major objective in improving rapeseed-mustard production, especially in Assam. It has been observed that in Assam, land after *kharif* rice, has been lying fallow or unutilized mainly due to the late harvesting of rice crop resulting from use of high yielding long duration rice varieties, *viz*., Ranjit, Bahadur, Gitesh, etc, lack of suitable late sown crops/varieties of *rabi* oilseed crops or difficulties in soil and nutrient management as well as scanty winter rainfall and lack of proper and efficint irrigation facilities resulting in inadequate soil moisture supply for optimum growth and development of succeeding *rabi* crops. Efficient utilization of these fallow lands may improve productivity and sustainability of the region. As rapeseed mustard is one of the most important oilseed crop in India, it has become a very profitable and common *Rabi* crop among the farmers. Moreover, in India, the refined mustard oil is imported from other countries against the negligible export. With the rising consumption of edible oil up to 2030 and projected population increase, this situation will become more challenging and on top of this, the limited and declining natural resources (land and water), and harsh competition from agriculture and non-agricultural sector for these limited resources jeopardize the scope to increase the acreage under oilseed crops. Therefore cultivation of rapeseed mustard under rice fallows may prove to be more advantageous for the farming community in terms of productivity and profit from rice fallows. Gangwar et al., [3] also stated that inclusion of pulses, oilseeds and vegetables in the system is more beneficial than cereals after cereals, and such inclusion in a sequence changes the economics of the crop sequences. There is a great challenge to the researchers, policy maker and stakeholder for extensive use of rice fallow areas in the eastern India. On the other hand, rapeseed and mustard is one of the most important oilseed crop in India and its refined edible oil is mainly imported from other countries against the negligible export. With the rising consumption of edible oil up to 2030 and projected population increase, this situation will become more challenging, and thereafter may increase at a decreasing rate with declining population growth rate. And on top of this, the limited and declining natural resources (land and water), and harsh competition from agriculture and non-agricultural sector for these limited resources jeopardize the scope to increase the acreage under oilseed crops. Therefore, cultivating rapeseed-mustard in these fallow lands may prove to be a an advantage to the farming community.With appropriate crop varieties and agricultural practices, productivity of pulses and oilseeds can be improved in rice fallows [4]. And thus, promotion of pulse/oilseed crops in these unutilized lands would improve the sustainability of paddy cultivation in addition to attractive productivity and augments the income of farming community of regions [5]. The objective of the experiment was to study the effect of integrated nutrient management (INM) practices on the efficiencies *viz.,* agronomic efficiency (AE), nutrient use efficiency (NUE), physiological efficiency (PE) and apparent recovery efficiency (ARE)) and the effects of varieties and INM on economics of rapeseed and mustard in rice fallows.

2. MATERIALS AND METHODS

During the *rabi* season of 2019-20, a field experiment was conducted at Assam Agricultural University, Jorhat. The experiment was laid out in a split-plot design and replicated thrice. The soil condition of the experimental site was found to be sandy loam in texture, acidic in soil reaction (5.99), high in organic carbon (0.89%), low in available N (219.1 kg/ha), low in available P_2O_5 (17.4 kg/ha) and medium in available K_2O (281.8 kg/ha). Four rapeseed and mustard varieties were used i.e., PM 26 (V_1), PM 27 (V_2), NRCHB-101 (V_3) and TS-36 (V_4) in the main plot and five INM practices *viz*., control (No N-P-K) (F_1), 50% of RD of NPK + VC @1t/ha (incubated with *Azotobacter* and PSB) applied at basal and 30 DAS (F_2), VC @ 2t/ha (incubated with *Azotobacter* and PSB) (F_3), FYM @ 2t/ha (incubated with *Azotobacter* and PSB) + quick lime @ 20 kg/ha + ash @ 2kg/ha applied at basal and 30 DAS (F_4) and RD of NPK @ 40-35-15 kg/ha (F_5) in the sub-plots. After harvesting, the seed and stover yield from each plot was individually recorded. The vermicompost and FYM used in the experiment as well as the seed and stover were also quantified for nitrogen content employing Micro-Kjeldahl Method [6] using 'Kel-Plus' apparatus, for phosphorus by tri-acid digestion and Vanadomolybdate yellow colour method as outlined by Jackson, [7] and potassium was determined by flame photometer as described by Jackson, [7]. The uptake of N (kg/ha), P (kg/ha) and K (kg/ha) by seed and stover was calculated separately, multiplying the percent N, P and K content by the respective yield of seed and stover (kg/ha) in each plot. The Agronomic Efficiency (AE), Nutrient Use Efficiency (NUE), Physiological Efficiency (PE) and Apparent Recovery Efficiency (ARE) were calculated using standard methods [8].

AE (kg seed / kg of nutrient applied) = Yf – Yc/ Na,

NUE (kg seed / kg of nutrient applied) = Yf/Na,

PE (kg biological yield/kg nutrient uptake) = BYf – BYc/ NUf – NUc

and

ARE (% of nutrient taken up by the crop) = NUf – NUc/ Na X 100

Where:
Yf = Yields in fertilized plots (kg/ha),
Yc = Yields in control plots (kg/ha),
Na = Amount of nutrient applied (kg/ha),
BYf = Biological yield in fertilized plot (kg/ha),
BYc = Biological yield in control plot (kg/ha),
NUf = Amount of nutrients taken up by a crop in fertilized plot (kg/ha),
NUc = Amount of nutrients taken up by a crop in control plot (kg/ha)].

On the other hand, using the prevailing market prices of inputs used and output, economics was calculated. The cost of cultivation was calculated on per hectare basis by taking into account the cost of all inputs, labour and operational cost prevailing at that time for each treatment. Gross and net return per hectare was calculated against each treatment combination in rupees. Gross return was the value of the economic yield calculated at prevailing market price. Net return was calculated by subtracting the cost of cultivation from the gross return on per hectare basis. The benefit-cost ratio was computed by dividing net return by the total cost of cultivation.

3. RESULTS AND DISCUSSION

3.1 Efficiencies

The study revealed that the highest AE (12.22 kg/kg), NUE (44.60 kg/kg), PE (42.52 kg/kg) and ARE (60.80 %) were registered in the treatment consisting of FYM @ 2t/ha (incubated with *Azotobacter* and PSB) + quick lime @ 20 kg/ha + ash @ 2kg/ha applied at basal and 30 DAS (F_4) showing better effect of organic manures in combination with bio fertilizers coupled with lime and ash (Table 1). This could be due to more efficient utilization of the nutrients applied in treatment F_4 as compared to all other treatments and the findings are similar to those reported by Keerthi et al., [9]. A tendency of decreased AE, ARE and NUE with the increase in amount of nutrient applied was observed which was in line with the findings by Keerthi et al., [9]. The increase in nitrogen dose, decrease in AE, ARE and NUE could be due to comparatively lower uptake and low seed yield and biological yield, and this fact could be explained by law of diminishing returns according to Tedone et al., [10]. The varying soil properties, methods used, amounts, and timing of fertilizer applications and other adapted management practices, led to varies in the percentage of nutrient recovery as reported by Fageria and Baligar, [8]. In F_4 treatment, the population of beneficial

Table 1. Effect of INM practices on different efficiencies of rapeseed and mustard

Treatments	AE (Kg/Kg)	NUE (Kg/Kg)	PE (Kg/Kg)	ARE (%)
F_1	0.00	0.00	0.00	0.00
F_2	4.05	11.82	11.03	35.59
F_3	3.61	10.67	28.72	24.20
F_4	12.22	44.60	42.52	60.80
F_5	4.72	13.35	16.74	44.96
SEd(±)	0.23	0.24	0.31	0.26
C.D.(P=0.05)	0.52	0.55	0.71	0.59

Table 2. Effect of varieties and INM practices on gross returns, net returns and B:C ratio of rapeseed and mustard

Treatment	Gross returns (□/ha)	Net returns (□ /ha)	B:C ratio
Varieties (V)			
V_1	56274.40	37186.51	2.11
V_2	60053.00	40965.11	2.34
V_3	57732.80	38644.91	2.22
V_4	48095.00	28917.11	1.59
INM practices (F)			
F_1	40166.75	27634.25	2.21
F_2	60539.63	37710.69	1.65
F_3	60175.00	31842.50	1.12
F_4	54962.13	39629.63	2.59
F_5	61850.50	45325.00	2.74

microorganisms might have expanded in the composts during the 15 days incubation period thus providing large amounts of beneficial microbes to the soil in which it was applied and increasing the availability of the applied nutrient dose to the crops and also there might be reduction in C:N ratio in the FYM after incubation due to significant decrease in total carbon content. Similar findings were also observed by Borah et al., [11].

3.2 Economics

In case of varieties, the study has revealed that PM 27 produced the highest B:C ratio of 2.34 with a net returns of □40,965.11/ha indicating to be the most profitable followed by NRCHB 101 which produced a B:C ratio of 2.22 with net returns of □38644.91/ha (Table 2). In the case of INM practice with the recommended NPK @ 40-35-15 kg/ha (F_5) with a net return of □45,325.00/ha and highest B:C ratio of 2.74 followed by application of FYM @ 2t/ha (incubated with *Azotobacter* and PSB) + quick lime @ 20 kg/ha + ash @ 2kg/ha at basal and 30 DAS (F_4) recorded a B:C ratio of 2.59 with net returns of □39,629.63/ha was found to be profitable economically. This also indicates that under these treatments the crop received optimum nutrient supply so much so that its vegetative and reproductive capacity could be manifested to its highest potential. Similar findings were also reported by B De and Sinha, [12]. Singh et al., [13] reported that the highest net return and benefit: cost ratio were realized with 100% RDF which was significantly higher than other fertilizer levels.

4. CONCLUSION AND RECOMMENDATIONS

In conclusion it can be inferred that for achieving higher efficiency of nutrients applied, the treatment consisting of FYM @ 2t/ha (incubated with *Azotobacter* and PSB) + quick lime @ 20 kg/ha + ash @ 2kg/ha at basal and 30 DAS (1000:10:1) outperformed the other treatments with reference to rapeseed and mustard and could be viable to the farming community. Economically, the mustard variety PM 27 (V_2) produced the highest net returns of □40,965.11/ha with a B:C ratio of 2.34 followed by NRCHB 101(V_3) which produced a net returns of □38644.91/ha and B:C ratio of 2.22. Amongst the INM practices, the highest B:C ratio of 2.74 was recorded in F_5 with a net returns of □45,325.00/ha followed by F_4 treatment that registered a ratio of 2.59 with net returns of □39,629.63/ha.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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