Indian Journal of Agricultural Sciences **91** (9): 1307–10, September 2021/Article
https://doi.org/10.56093/ijas.v91i9.116075

Productivity of upland rice (*Oryza sativa*) as affected by organic manure and lime

BISWORANJITA BISWAL[1,2]*, S L MEENA[1], SUBHASH BABU[1], B N MANDAL[3], Y S SHIVAY[1] and MOUTUSI TAHASHILDAR[4]

ICAR-Research Complex for North-Eastern Hill Region, Umiam, Meghalaya 793 103, India

Received: 12 August 2020; Accepted: 15 February 2021

ABSTRACT

A field experiment was conducted at ICAR-Research Complex for NEH Region, Umiam, Meghalaya to study the effect of organic manure along with lime on upland rice (*Oryza sativa* L.) in hilly region during *kharif* 2018 in FRBD with 3 replications and 12 treatment combinations: control, 100% inorganic, 100% FYM, 50% FYM + 50% VC (vermicompost), 50% FYM + 50% PM (poultry manure) and 50% FYM + 50% SM (pig manure), each treatment alternated with lime @ 400 kg/ha. Results support that among organic manures, 50% FYM + 50% SM resulted in highest grain yield (3.98 t/ha), and production efficiency that was at par with chemical fertilizer. Grain yields from 50% FYM + 50% SM were 9.6%, 7.2%, 1.5% and 1.2% higher over 100% FYM, 50% FYM + 50% VC, 50% FYM + 50% PM and 100% inorganic, respectively. 50% FYM + 50% SM gave highest production efficiency (29.4 kg/ha/day) of 1% and 1.3% higher over 100% inorganic and 50% FYM + 50% PM, respectively. The application of organic manure 50% FYM + 50% SM was found to be the best treatment as it improved the soil physical, chemical and biological properties as well and reduced nutrient losses. Therefore, substantial amount of NPK fertilizers and also fertilizer cost can be saved by application of farm available organic manures.

Keywords: Lime, Monetary return, Organic manure, Pig manure, Production efficiency, Yield

Rice (*Oryza sativa* L.) is grown in various agro-ecological regions and plays a pivotal role in India's food security. The average productivity of rice in North-Eastern Himalayan region of India is 1.57 tonnes/ha that is much below the national average of 2.08 tonnes/ha (Ngachan *et al*. 2011). High soil acidity and imbalanced soil nutrient replenishment are the major cause for low production. Acid soils of Meghalaya lose most exchangeable basic ions to leaching. Low soil *p*H of 3.8-4.5, Fe^{+2}, Al^{+2} and Mn^{+2} toxicity. Therefore, application of finely rumpled limestone ($CaCO_3$) is an effective hands-on option to moderate soil *p*H for optimum plant growth (Meena *et al.* 2019). The North Eastern Region (NER) of India is still far from the chemical approaches for cultivation due to minimum use of fertilizer, availability of plant and livestock-excreta-based organic manure (Das *et al.* 2019) and a positive climate for widespread crop species (Bujarbaruah 2004). The average fertilizer consumption of NER is only about 82.63 kg/ha while the overall consumption of fertilizer in the country is 128.08 kg/ha (Department of Fertilizers GOI 2017). A balance nutrient source will maintain soil fertility and productivity. Nutrient management basically depends on native soil fertility and external input. Addition of organic manures improves water holding capacity and assists the soil to maintain better aeration for seed germination and plant root development. The available quantity of organic manure is a good amount for a cultivated area of slightly higher than 4 million ha (Das *et al.* 2014). The North-Eastern Hills particularly Meghalaya are the wettest areas of the world that attracts natives to grow rice in flooded conditions. Previous investigations confine to low land rice cultivation, and current experimental trial focuses on the other possible rice production ecosystem, viz. upland ecosystem, to study its feasibility together with organic manures and lime. The reason for substituting chemical fertilizers with organic manures is because the families in hills keep livestock producing sufficient quantity of on-farm manures that may effectively curb some cost of chemical inputs.

MATERIALS AND METHODS

The experiment was conducted during *Kharif* 2018 at ICAR–Research Complex for North Eastern Himalayan Region, Barapani, Meghalaya (950 MSL, 2500-3500

Present address: ICAR-National Dairy Research Institute, Karnal; [2]ICAR-Indian Agricultural Research Institute, New Delhi; [3]ICAR-Indian Agricultural Statistics Research Institute, New Delhi; [4]ICAR- Research Centre for NEH region, Umiam, Meghalaya. *Corresponding author e-mail: bisworanjita15@gmail.com.

mm average annual rainfall and 20.0°C mean annual temperature). The initial available NPK was 256 kg/ha (Subbiah and Asija 1956), 6.3 kg/ha (Brays and Kurtz 1954) and 354 kg/ha (Hanway and Heidel 1952), respectively, organic carbon 1.62% (Walkley and Black 1934) and initial soil *p*H 3.8 ($CaCl_2$ method). Three replications were laid in factorial randomised block design (FRBD) with six nutrient sources in factor A namely control, 100% inorganic, 100% FYM, 50% FYM + 50% VC (vermicompost), 50% FYM + 50% PM (poultry manure) and 50% FYM + 50% SM (pig manure); and two doses of lime in factor B namely without lime and with lime @ 400 kg/ha. Making total of 12 treatment combinations. Application of 400 kg lime/ha, 30 kg P/ha and 30 kg K/ha was broadcast at the time of final ploughing on desired plots. The doses of nutrients applied on the basis of soil test and content in the source. ICAR-RCNEH developed local ruling rice variety Bhalum 3 was direct seeded in the first fortnight of July in *kharif* 2018 at 80 kg/ha in continuous lines at a row spacing of 20 cm which was later thinned into 10 cm between plants and harvested in second fortnight of November (135 DAS). Field observations were taken at 40, 80 and 120 days after sowing (DAS). Plant height was recorded from the base to the average length of few tall leaves/panicle using a standard meter scale. The plants were marked for taking height each time. Leaf area (Evans 1972) was measured by leaf area meter (Model LICOR 3000, USA). The CGR and RGR were calculated between 80-120 DAS. Tillers/plant, panicles/plant, panicle weight, panicle length and filled grains/panicle were taken at random from 20 plants or panicles. A seed counter recorded test weight. Harvested plants were dried to 14% moisture content followed by total dry weight and threshed weight. F-test (Gomez and Gomez 1984) was used for statistical analysis. Significance of difference between various treatment means were determined by LSD (Least square difference) at P=0.05.

RESULTS AND DISCUSSION

Growth parameters: Among various growth parameters plant height (98.9 cm), LAI (4.81), dry matter (1118 g/m^2), RGR (6.85 mg/g/day) and CGR (13.12 g/m^2/day) were highest in 50% FYM + 50% SM. Plant height, LAI, dry matter and CGR were 1.6%, 1.6%, 6.9% and 1.6% higher, respectively over 100% inorganic. Organic manures and 100% inorganic treatment were at par with each other and superior over control. Lime application showed significant 6.8 % increase in case of dry matter (1105 g/m^2) only (Table 1). Myint *et al*. (2011) reported similar results. The nutrient content of pig manure taken in the concerned experiment was quite higher compared to rest of the organic manures (Table 1). Organic manures improve the soil physical conditions and make it suitable for optimum or enhanced plant growth. The diet of the animals in the farm was quite nutritious and balanced for which the manure made from their excreta was quite higher in nutrients (Liu and Chen 2014). Moreover, higher dry matter accumulation due to liming was because of correction in soil *p*H that lead to better soil chemical and biological condition to support plant growth.

Yield and yield attributes: Various yield attributes like number of tillers (251 m^2), number of panicles (228 m^2), panicle length (28 cm), panicle weight (4.64 g), filled grains (110 panicle) and spikelet fertility (86%) were found to be

Table 1 Growth and yield parameters of upland rice as influenced by nutrient sources and lime

Treatment	Plant height at 120 DAS (cm)	LAI	Dry matter (g/m^2) at 120 DAS	CGR (g/m^2/day)	RGR (mg/g/day)	No. of tillers/m^2	No. of panicles/m^2	Panicle length (cm)	Panicle weight (g)	Filled grains/panicle	Spikelet fertility (%)
Source of manure											
Control	91.7	4.48	878	10.57	6.62	239	207	23	3.43	90	75
100% inorganic	97.3	4.73	1045	11.27	6.79	250	230	28	4.64	106	84
100% FYM	94.7	4.67	1050	12.20	6.79	242	220	25	3.88	104	82
50% FYM + 50% VC	96.7	4.69	1089	12.75	6.83	248	219	26	4.38	106	85
50% FYM + 50% PM	96.8	4.71	1088	12.65	6.83	248	221	27	4.45	109	86
50% FYM + 50% SM	98.9	4.81	1118	13.12	6.85	251	228	28	4.60	110	86
SEm(±)	2.31	0.12	15.2	1.02	0.64	3.15	7.26	0.88	0.30	2.46	0.45
LSD (P=0.05)	6.76	0.35	44.50	2.98	1.87	9.22	21.25	2.57	0.87	7.20	1.31
Lime											
No lime	94.2	4.58	1034	11.85	6.78	240	217	24	3.82	103	82
Lime (400 kg/ha)	97.3	4.71	1105	12.92	6.84	246	228	26	4.30	108	85
SEm(±)	2.08	0.10	14.78	0.89	0.34	2.78	6.91	0.42	0.18	2.16	0.37
LSD (P=0.05)	NS	NS	43.26	NS	NS	NS	NS	1.22	NS	NS	1.08

higher in 50% FYM + 50% SM (Table 1). All the nutrient sources were superior over control. Application of 100% inorganic and 50% FYM + 50% PM were at par with 50% FYM + 50% SM for number of tillers, number of panicles, panicle weight, filled grains per panicle. Whereas, in case of spikelet fertility 50% FYM + 50% SM was significantly higher over 100% inorganic treatment and 100% FYM by 2.3% and 4.8%, respectively. Considering the effect of liming on yield attributes significant increase in panicle length (8.3%) and spikelet fertility (3.6%) was recorded over the non–limed plots. There was no effect of organic manure and liming on the test weight of rice. Though the yield from various nutrient sources were at par with each other, higher grain yield was obtained from 50% FYM + 50% SM (3.98 t/ha) followed by 100% inorganic (Table 2). Straw yield (7.43 t/ha) and biological yield (11.35 t/ha) were highest in 50% FYM + 50% PM and was followed by 50% FYM + 50% SM. Grain yields from 50% FYM + 50% SM were 9.6%, 7.2%, 1.5% and 1.2% higher over 100% FYM, 50% FYM + 50% VC, 50% FYM + 50% PM and 100% inorganic, respectively. Straw yields from 50% FYM + 50% PM were 5.2%, 4.5%, 3.1% and 1.8% higher over 50% FYM + 50% VC, 100% inorganic, 50% FYM + 50% SM and 100% FYM, respectively. There was no significant effect of liming on grain, straw yield and biological yield. Despite this, a higher grain yield by 6.2%, straw yield by 3.2% and biological yield 4.2% was recorded due to liming. There was no effect on harvest index either due to organic manures or liming. Similar results were reported by Myint *et al.* (2011). This is because the treatment with 50% FYM + 50% SM, though released nutrients slowly, but over a longer period of time with minimum loss of nutrients by leaching, denitrification and runoff. Application of 100% inorganic treatment supplied the plant nutrients readily and in easily available form (Baghdadi *et al.* 2018) was more subjected to losses in upland rice ecosystem. Well decomposed organic manures with low C:N ratio make the soil healthy and biologically active. Though it was upland ecosystem, water was sufficiently available to the crop due to the fact that Meghalaya is one of the wettest area in the world. Sufficient moisture and aeration along with beneficial effect of rich organic manures particularly pig manure must have boosted the root growth. Proper root growth and controlled release of nutrients might have resulted in better yield performance of the crop (Bais *et al.* 2006). However effect of liming was not satisfactory may be because the amount of lime (400 kg/ha) applied was insufficient to meet the desired *p*H change in the experimental plot. This might be due to previous cropping history or due to buffering action of organic manures. If not significant some increase in yield was recorded because of higher spikelet fertility and lesser chaffy grains as lime was applied at the recommended dose for the region.

Production and monetary efficiency: The nutrient sources were significantly more efficient with respect to production and monetary efficiency over control. Production efficiency of all the organic manures and 100% inorganic treatment were at par with each other (Table 2). Application of 50% FYM + 50% SM gave highest production efficiency (29.4 kg/ha/day) of 1% and 1.3% higher over 100% inorganic and 50% FYM + 50% PM, respectively. However, production efficiency of 100% FYM was also at par with control. Application of 50% FYM + 50% SM had 18.5% higher production efficiency over 100% FYM. Monetary efficiency of 100% inorganic (378 ₹ ha/day) was 33% and 34.5% highly significant over the 50% FYM + 50% SM (284 ₹ ha/day) and 50% FYM + 50% PM (281 ₹ ha/day), respectively. Monetary efficiency of 100% FYM was similar to control. There was no promising effect of liming on either of the efficiencies (Table 2). Kumar *et al.* (2020) also reported similar increase in production and monetary efficiency. The reason for higher production efficiency in

Table 2 Yields, harvest index and efficiency of upland rice as influenced by nutrient sources and lime

Treatment	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest Index	Production efficiency (kg/ha/day)	Monetary efficiency (₹/ha/day)
Source of Manure						
Control	3.27	6.34	9.61	0.34	24.2	214
100% inorganic	3.93	7.11	11.04	0.35	29.1	378
100% FYM	3.63	7.31	10.94	0.33	24.8	218
50% FYM + 50% VC	3.71	7.06	10.77	0.34	27.4	251
50% FYM + 50% PM	3.92	7.43	11.35	0.34	29.0	281
50% FYM + 50% SM	3.98	7.20	11.18	0.35	29.4	284
SEm(±)	0.15	0.18	0.22	0.03	0.95	12.3
LSD (P=0.05)	0.44	0.52	0.65	NS	2.81	36.1
Lime						
No lime	3.53	6.86	10.39	0.33	26.1	256
Lime (400 kg/ha)	3.75	7.08	10.83	0.34	27.7	264
SEm(±)	0.14	0.16	0.21	0.03	0.58	10.8
LSD (P=0.05)	NS	NS	NS	NS	NS	NS

50% FYM + 50% SM is due to higher grain yield. Monetary efficiency of 100% inorganic treatment was highest because of lesser cost of cultivation. Organic manures being bulky price higher compared to inorganic fertilizers considering the total amount required to meet the crop demand. The price calculation was done according to the market price of manures and fertilizers. But, in this experiment the organic manures requirement was completely met from the farm bringing the input cost of manures to zero. The purpose here is to say that every farm house in Meghalaya has certain units of livestock especially pigs. If we completely recycle the wastes as manures within farm we can achieve similar or higher yield as compared to inorganic fertilizers. Doing so, higher monetary efficiency and ecosystem safety can be ensured.

Application of organic manure particularly combination of pig manure and FYM (50% FYM + 50% SM), poultry manure and FYM (50% FYM + 50% PM) and inorganic fertilizers gave higher yield, production efficiency and monetary return. Higher liming rate is recommended for better *p*H correction and yield increase in acid soils of Meghalaya.

ACKNOWLEDEGMENTS

The authors are grateful to the ICAR for providing financial assistance to carry out the research programme and thanks are also due to the Division of Agronomy and Research Complex for North-Eastern Hill Region, Umiam, Meghalaya for providing the necessary field and laboratory facilities during the course of study.

REFERENCES

Baghdadi A, Halim R A, Ghasemzadeh A, Ramlan M F and Sakimin S Z. 2018. Impact of organic and inorganic fertilizers on the yield and quality of silage corn intercropped with soybean. *PeerJ Preprints* **6**: 52–80.

Bais H P, Weir T L, Perry L G, Gilroy S and Vivanco J M. 2006. The role of root exudates in rhizosphere interactions with plants and other organisms. *Annual Review of Plant Biology* **57**: 233–66.

Bray R H and Kurtz L T. 1945. Determination of total, organic and available forms of phosphorus in soils. *Soil Science* **59** (1): 39–46.

Bujarbaruah K M. 2004. Organic farming: opportunities and challenges in North Eastern region of India. In *Souvenir, International conference on organic food,* pp 14–17.

Das A, Layek J, Ramkrushna G, Babu S, Devi M T, Dey U and Prakash N. 2019. Integrated organic farming system: An innovative approach for enhancing productivity and income of farmers in north eastern hill region of India. *Indian Journal of Agricultural Sciences* **89** (8): 1267–72.

Das A, Patel D P, Kumar M, Ramkrushna G I, Ngachan S V, Layek J and Lyngdoh M. 2014. Influence of cropping systems and organic amendments on productivity and soil health at mid altitude of North East India. *Indian Journal of Agriculture Sciences* **84** (12): 1525–30.

Department of Fertilizers GOI. 2017. Fertilizer Scenario http://fert.nic.in/page/fertilizers-scenario.

Evans G C.1972. The quantitative analysis of plant growth (Vol.1). University of California Press.

GOI. 2019. 20th livestock Census. 2019. Ministry of Agriculture Department of Animal Husbandry, Dairying and Fisheries, Government of India. *All India Report*.

Gomez K A and Gomez A A. 1984. Statistical procedures for agricultural research. John Wiley & Sons.

Hanway J J and Heidal H. 1952. Soil Analysis Methods as used in Iowa State College Soil Testing Laboratory. Iowa state college of Agriculture, USA.**57**: 131.

Kumar R, Deka B C, Kumawat N and Thirugnanavel A. 2020. Effect of integrated nutrition on productivity, profitability and quality of French bean (*Phaseolus vulgaris*). *Indian Journal of Agricultural Sciences* **90**(2): 431–5.

Liu Y and Chen J. 2014. Phosphorus cycle 181–91.

Majji A K, Reddy G O and Sarkar D. 2012. Acid Soils of India: Their Extent and Spatial Variability. *NBSS publication* **145**.

Meena R S, Kumar S, Bohra J S, Lal R, Yadav G S and Pandey A. 2019. Response of alley cropping-grown sesame to lime and sulphur on yield and available nutrient status in an acidic soil of Eastern India. *Energy, Ecology and Environment* **4** (2): 65–74.

Myint A K, Yamakawa T, Zenmyo T, Thao H T B and Sarr P S. 2011. Effects of organic-manure application on growth, grain yield, and nitrogen, phosphorus, and potassium recoveries of rice variety Manawthuka in paddy soils of differing fertility. *Communications in Soil Science and Plant Analysis* **42** (4): 457–74.

Ngachan S V, Mohanty A K and Pattanayak A. 2011. Status paper on rice in North East India. ICAR Research Complex for NEH Region, Rice Knowledge Management Portal (RKMP) Directorate of Rice Research.

Subbiah V and Asija G L. 1956. A rapid procedure for estimation of available N in soil. *Current science* **25**: 259–60.

Walkley A and Black I A. 1934. An examination of Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Science* **37**: 29–37.