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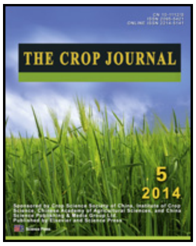

Productivity, quality and soil health as influenced by lime in ricebean cultivars in foothills of northeastern India

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ABSTRACT

To evaluate the response to lime on cultivars of ricebean (*Vigna umbellata*), a field experiment was conducted during the two consecutive *rabi* seasons of 2010–2011 and 2011–2012 in the Nagaland foothills, India. The experiment used a split-plot design with four levels of lime (control, 0.2, 0.4 and 0.6 t ha^{-1}) in main plots and four ricebean cultivars (RBS-16, RBS-53, PRR-2, and RCRB-4) in sub-plots with three replicates. The results revealed that increasing levels of lime (in the furrow) from 0 to 0.6 t ha^{-1} significantly increased growth, yield attributes and yield. The quality parameters of ricebean were also influenced significantly by the application of lime. Maximum gross return (INR 39,098 ha^{-1}), net return (INR 27,281 ha^{-1}), benefit:cost (B:C) ratio (2.29), production efficiency, and economic efficiency were also realized with the application of lime at 0.6 t ha^{-1}. Among the ricebean cultivars, RBS-53 produced significantly higher growth, yield attributes, grain yield, straw yield, biological yield, and harvest index. Similarly, yield and protein content were higher in RBS-53. Maximum gross return, net return, B:C ratio, production efficiency, and economic efficiency were observed for RBS-53.

1. Introduction

Ricebean (*Vigna umbellata*) is a grain legume crop grown in hilly areas of Nepal and northeastern India. It is an underutilized crop that is grown only by resource-poor farmers. It is grown as an intercrop with maize (*Zea mays*) in the *kharif* season. This small grain possesses enormous potential for becoming a more commonly utilized crop. The economic utility and production technology of ricebean have yet to be determined [1]. Among pulse crops, ricebean offers tremendous potential for expansion in northeastern India. As a short-duration and close-growing crop with tender stems and green foliage even at maturity, ricebean is ideal for catch-cropping, intercropping and multiple-cropping systems and also serves as an excellent cover crop and green

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manure crop. Ricebean is reported to produce 3000 kg of grain and up to 8000 kg ha^{-1} of dry herbage, serving as an important source of green forage during lean periods during April–June and November–December in northern India [2]. Ricebean grain, besides being a good source of protein with up to 24% seed protein concentration [3], has a very high in vitro digestibility of up to 82–85% [4].

In India, 30% of the cultivated land is considered acidic, where efficient fertilizer management is a problem. Of 49 million ha of acid soils, 26 million ha have a soil pH below 5.6 and 23 million ha have a pH between 5.6 and 6.5 [5]. The main causes of soil acidity in the region are intense weathering in association with humid climate and heavy precipitation [6]. In addition to temperature and precipitation, other factors affecting the process of acidic soil formation are topography and relief. Lime as an amendment for increasing nutrient availability in acid soils is considered to be the most important ameliorant for better growth, nodulation, and higher nitrogen fixation by legumes. Calcium deficiency in legumes depresses the calcium content of nodules, impairing nitrogen fixation owing to a deficiency of calcium for nodule structure and/or metabolism [7].

Under acidic conditions, calcium and magnesium supply is reduced and plant growth suffers. In addition to these effects, other beneficial nutrients, such as nitrogen, phosphorus, and sulfur, are also in deficient concentration. The low yields of groundnut are due to poor pod filling in acid soils, owing to poor calcium-supplying power of soils. For meeting calcium demands and creating favorable conditions for better uptake of other essential nutrients, particularly phosphorus, liming is an important management practice in acid soils. The improvement of these acid soils should also aim at eliminating the toxic effects of Al and Mn. The harmful effects of soil acidity can be eliminated by raising pH with suitable quantities of lime. Liming helps in raising the base saturation of the soil and inactivating iron, aluminum, and manganese in the soil solution. Liming also helps to minimize phosphate fixation by iron and aluminum. Kamprath [8] reported the need for raising soil pH beyond the point of neutralizing exchangeable aluminum, particularly for legumes.

Recently, high-yielding cultivars of ricebean in northeastern states of India including Nagaland have been developed with extra short duration, bold seed, and dwarf plant types suitable for cultivation. These cultivars must be evaluated under different levels of lime in acid soils of the Nagaland foothills in the post-rainy season. The present investigation was undertaken with the following objectives: (i) to evaluate the effect of lime on growth, yield attributes, yield, economics, and quality parameters, (ii) to evaluate the effect of lime on soil health, and (iii) to prescribe the best ricebean cultivars under foothill conditions during the post-rainy season.

2. Materials and methods

2.1. Site description

The field experiment was conducted during the post-rainy seasons of 2010–2011 and 2011–2012 at the Agricultural Research Farm of ICAR, RC for NEH Region, Nagaland Centre, Jharnapani, Nagaland, India. The experimental site was located at 25.45° N latitude 93.53° E longitude with a mean altitude of 295 m ASL. The climate of the experimental site was subtropical with high humidity and medium to high rainfall. The soil was sandy loam and acidic in reaction (pH 4.9). The soil contained 0.95% oxidizable organic carbon, 235 kg ha^{-1} mineralizable nitrogen, 136 kg ha^{-1} available potassium, and 10.3 kg ha^{-1} available phosphorus. During the experimental period the maximum and minimum temperatures varied from 23.0 °C to 31.1 °C and 9.7 °C to 24.0 °C, respectively, during 2010–2011 and 24.3 °C to 31.2 °C and 9.5 °C to 24.2 °C during 2011–2012. The maximum and minimum relative humidities ranged from 75% to 84% and 38% to 67%, respectively, during 2010–2011 and 78% to 85% and 78% to 63% during 2011–2012. Total precipitations of 225.2 mm and 315.8 mm were received during 2010–2011 and 2011–2012, respectively.

2.2. Treatments

The experiment used a split-plot design with four levels of lime (control, 0.2, 0.4 and 0.6 t ha^{-1}) in main plots and four ricebean cultivars (RBS-16, RBS-53, PRR-2 and RCRB-4) in sub-plots with three replicates. Sowing was done with spades using a seeding rate of 30 kg ha^{-1} on September 1, 2010 and September 4, 2011. Lime treatments were applied in the furrow 15 days prior to sowing. The crop was sown in line at a row spacing of 30 cm × 10 cm. The gross and net plot sizes were 12.0 m^2 (4.0 m × 3.0 m) and 5.40 m^2 (3.0 m × 1.8 m), respectively. Fertilizers were applied uniformly to all plots at recommended rates (20 kg N ha^{-1}, 40 kg P_2O_5 ha^{-1} and 40 kg K_2O ha^{-1} in the form of urea, di-ammonium phosphate and muriate of potash, respectively).

2.3. Growth, yield and quality characters

Growth characters, including plant height, primary branches $plant^{-1}$, trifoliate leaves $plant^{-1}$, dry matter $plant^{-1}$, nodules $plant^{-1}$, root length, root dry weight, and root volume, were recorded for five randomly selected plants from the representative net plot. Crop growth rate (CGR) at harvest was calculated following the equation

$$\mathrm{CGR}\left(\mathrm{g\ \ days}^{-1}\right)=\frac{W_2-W_1}{t_2-t_1}$$

where, W_1 = dry weight per unit area at t_1, W_2 = dry weight per unit area at t_2, t_1 = first sampling, and t_2 = second sampling.

Leaf area index (LAI) was measured at 45 days after seeding (DAS) directly with a plant canopy meter or analyzer model LP-80 AccuPAR (Decagon Devices Inc., NE Hopkins Court Pullman, WA, USA) from each plot in three places and the average was calculated. Different yield attributes including pods $plant^{-1}$, pod length, grains pod^{-1}, grains $plant^{-1}$ and filled pods $plant^{-1}$ were also recorded at harvest from five randomly selected plants of the net plot area. One thousand grains from the representative samples taken from the produce after sun drying of each plot were counted and weighed. The crop was harvested when the pods matured, and normally 3–4 pickings were taken. Grain and straw yields were recorded at harvest. Biological yield was determined by summing grain and straw yield. Harvest index (%) was computed by dividing grain yield by biological yield.

2.4. Soil analysis

Surface soil samples (0–15 cm) were collected, ground, passed through a 2 mm sieve, and assayed for different physico-chemical parameters by standard methods. pH in a soil water suspension (1.0:2.5) was measured with a digital pH meter (Cyberscan pH tutor, Eutech Instruments, Singapore). Oxidizable organic carbon was determined by the wet digestion method of Walkley and Black [9]. Mineralizable nitrogen in soil samples was determined by the alkaline $KMnO_4$ method as described by Subbaih and Asija [10]. Available phosphorus was extracted by the Bray–Kurtz No. 1 method [11] and measured with an UV–VIS spectrophotometer (Model Systronics-117, Systronics India Limited, India) [12]. Available potassium was extracted with 1 mol L^{-1} NH_4Ac and quantified by a flame photometer [13].

2.5. Economics

Net return (INR ha^{-1}) and benefit:cost (B:C) ratio were calculated by considering the sale prices of ricebean and cost of cultivation. The data were analyzed statistically by analysis of variance. The curve estimation of lime levels (kg ha^{-1}) and grain yield (kg ha^{-1}) data was done (Fig. 1) with Microsoft Excel 2007 and the most profitable rate (MPR) was calculated by the regression equation

$$\mathrm{MPR} = \frac{1}{2c}\left(\frac{q}{p} - b\right) \text{or} \frac{\frac{q}{p} - b}{2c}$$

where, q = cost of unit fertilizer applied, p = cost of unit produce obtained, b = coefficient of linear regression of y and x, and c = coefficient of quadratic response (second-degree constant).

Production efficiency and economic efficiency were calculated by the following formulas:

Production efficiency (kg ha^{-1} day^{-1}) = grain yield (kg ha^{-1}) /total duration of cropping (days).

Economic efficiency (INR ha^{-1} day^{-1}) = net return (INR ha^{-1}) / total duration of cropping (days).

2.6. Statistical analysis

A pooled analysis of data (2 years) on growth, yield attributes, yield, economics, quality, and soil physico-chemical properties was performed. Prior to that, Levene's test for homogeneity of variances was performed using SPSS 16.0 (International Business Machines Corporation, Armonk, NY, USA). In all cases, the P-value was greater than 0.05, indicating that the variation in the two years of the study was not significantly different. The analysis of variance (ANOVA) was performed for a split-plot design. Fisher's least significant difference (LSD) was used to test the significance of the differences between various means at $P < 0.05$ [14].

3. Results

3.1. Effect of weather

The meteorological data showed a marked variation in weather conditions during the two years of the experiment (data not shown). Rainfall was higher in 2011–2012 than in 2010–2011. Temperature, particularly in the reproductive phases of both crops, was more conducive to crop performance during the second year. This resulted in slightly better performance of the crops in 2011–2012 than in 2010–2011.

3.2. Effect of lime

Pooled data of 2 years are shown in Table 1, and the results showed that plant height (cm), branches $plant^{-1}$, trifoliate leaves $plant^{-1}$, dry matter $plant^{-1}$ (g), nodules $plant^{-1}$ (at 45 and 60 DAS), root length (mm), root dry weight (g), root volume (mm), crop growth rate (g day^{-1}) and leaf area index were influenced significantly by different levels of lime. Higher values of these growth attributes were recorded with the application of lime at 0.6 t ha^{-1}. Similarly, yield attributes including pods $plant^{-1}$, pod length (cm), grains $plant^{-1}$, filled pods $plant^{-1}$, pod filling (%) and 1000-grain weight (g) were significantly higher with the application of lime at 0.6 t ha^{-1} than in the control, 0.2 t ha^{-1} and 0.4 t ha^{-1} (Table 2).

Among the different levels of lime application (Table 2), liming at 0.6 t ha^{-1} significantly increased grain, straw and biological yields over the other lime levels (control, 0.2 and

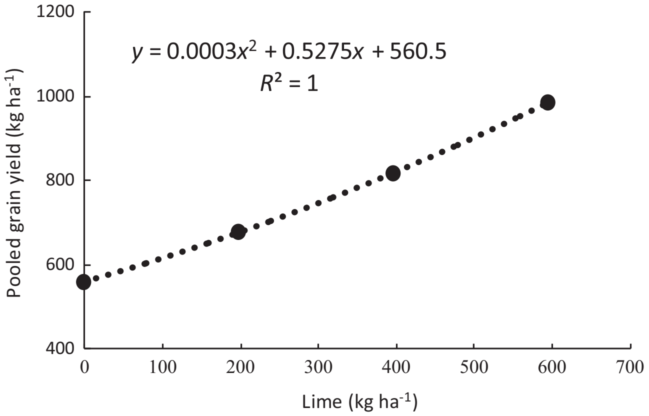

Fig. 1 – Response of ricebean yield to different lime levels.

0.4 t ha^{-1}). The grain, straw and biological yields of ricebean were increased by the application of lime at 0.6 t ha^{-1} by 43.5, 27.9 and 32.4%, respectively, over their values at 0.2 t lime ha^{-1}. The harvest index (%) was the greatest at 0.6 t ha^{-1}, significantly greater than that for the control and 0.2 t ha^{-1} treatments. The application of lime at 0.6 t ha^{-1} resulted in significantly higher protein content and protein yield than for the control, 0.2 and 0.4 t ha^{-1} treatments (Table 2).

The pooled data in Table 3 showed that maximum gross return (INR 39,098 ha^{-1}), net return (INR 27,228 ha^{-1}), B:C ratio (2.29), production efficiency (11.12 kg ha^{-1} day^{-1}) and economic efficiency (INR 328.38 ha^{-1} day^{-1}) were realized with 0.6 t lime ha^{-1}.

The level of lime had a significant influence on pH, soil organic carbon (SOC), and available soil N, P and K (Table 3). Application of lime at 0.6 t ha^{-1} significantly increased pH, SOC, and available soil N, P and K over lower rates of lime (0, 0.2 and 4.0 t ha^{-1}).

3.3. *Effect of ricebean cultivars*

Cultivar RBS-53 had significantly greater plant height, branches plant^{-1}, trifoliate leaves plant^{-1}, dry matter plant^{-1}, root length, root dry weight, root volume, crop growth rate and leaf area index than did RCRB-4, RBS-16 and PRR-2 (Table 1). Similarly, pooled data showed that yield attributes including pods plant^{-1}, pod length, grains plant^{-1}, filled pods plant^{-1}, pod filling (%) and 1000-grain weight were significantly greater for RBS-53 than other cultivars. Cultivars RCRB-4 and RBS-16 were similar in terms of yield attributes and were significantly higher than PRR-2. Among the cultivars, RBS-53 produced significantly higher grain, straw and biological yields than did RCRB-4, RBS-16 and PRR-2. Cultivar RBS-53 produced 23.2%, 14.1% and 18.6% higher grain, straw and biological yield, respectively than PRR-2. Similarly, cultivar RBS-53 had significantly higher protein content and protein yield than the other cultivars (Table 2).

The maximum gross return (INR 33,639 ha^{-1}), net return (INR 23,869 ha^{-1}) and B:C (2.36) were observed for RBS-53 (Table 3). The lowest gross return (INR 27,690 ha^{-1}), net return (INR 17,920 ha^{-1}) and B:C ratio (1.86) were observed for PRR-2. Production efficiency and economic efficiency were also significantly greater for RBS 53 than for the other cultivars (Table 3).

3.4. *Interaction effect*

The pooled data showed that the interaction effect of levels of lime and ricebean cultivars on seed yield was significant (Table 4). The maximum (1.21 t ha^{-1}) seed yield was recorded at 0.6 t ha^{-1} for RBS-53.

3.5. *Curve fitting, regression, and most profitable rate*

A quadratic relationship between lime application and grain yield was fitted. The relationship between lime and grain yield could be expressed by high coefficient of determination ($R^2 = 1$) (Fig. 1). From the regression equation, the most profitable rate of lime application was estimated to be 0.556 t ha^{-1} to achieve the maximum grain yield.

Table 1 – Growth attributes of ricebean cultivars at harvest as affected by levels of lime application (pooled data of 2 years).

Treatment	Plant height (cm)	No. of branches plant^{-1}	No. of trifoliate leaves plant^{-1}	Dry matter plant^{-1} (g)	No. of nodules at 45 DAS	No. of nodules at 60 DAS	Root length (cm)	Root weight (g)	Root volume (mm)	Crop growth rate (g day^{-1})	Leaf area index (45 DAS)
Lime application (t ha^{-1})											
Control	92.69	3.03	17.92	23.74	14.77	18.14	18.70	1.01	3.71	3.59	5.07
0.2	97.96	3.44	19.31	25.90	17.72	21.00	19.60	1.11	3.95	4.00	5.40
0.4	103.08	3.68	20.63	27.88	20.65	24.01	20.63	1.19	4.16	4.35	5.64
0.6	108.71	3.92	22.09	29.54	22.26	25.54	21.85	1.28	4.47	4.67	5.88
LSD ($P = 0.05$)	4.77	0.21	1.02	1.66	1.02	0.66	0.85	0.07	0.20	0.30	0.23
Cultivar											
RBS-16	99.50	3.36	19.74	25.72	17.53	20.88	19.75	1.08	3.91	4.06	5.30
RBS-53	104.42	3.82	21.15	28.53	21.02	24.40	21.27	1.28	4.42	4.47	5.85
PRR-2	97.52	3.29	18.78	25.54	17.04	20.37	19.53	1.05	3.82	3.89	5.25
RCRB-4	101.00	3.61	20.30	27.26	19.81	23.04	20.22	1.17	4.14	4.20	5.59
LSD ($P = 0.05$)	2.13	0.12	0.53	1.02	0.72	0.44	0.59	0.04	0.16	0.19	0.15

Table 2 – Yield attributes and yields of ricebean cultivars as affected by different levels of lime application (pooled data of 2 years).

Treatment	No. of pods plant^{-1}	Pod length (cm)	No. of seeds pod^{-1}	No. of seeds plant^{-1}	No. of filled pods plant^{-1}	Pod filling (%)	1000-grain weight (g)	Seed yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)	Protein content (%)	Protein yield (kg ha^{-1})
Lime application (t ha^{-1})													
Control	27.46	8.22	5.07	96.25	22.61	81.97	63.40	0.57	0.65	1.22	46.49	17.81	102.24
0.2	29.98	8.80	5.40	99.87	25.87	85.96	67.69	0.69	0.73	1.42	49.41	19.56	135.81
0.4	34.11	9.29	5.64	102.90	30.55	89.41	71.79	0.82	0.80	1.62	50.75	20.98	172.36
0.6	36.63	9.92	5.88	106.05	33.92	92.43	75.45	0.99	0.89	1.88	52.25	22.69	228.02
LSD (P = 0.05)	2.58	0.42	0.23	2.12	2.39	0.91	3.19	0.04	0.06	0.11	1.80	1.33	13.64
Cultivar													
RBS-16	31.31	8.79	5.30	97.76	27.55	87.46	68.59	0.74	0.76	1.50	49.54	19.81	150.22
RBS-53	35.46	9.67	5.85	105.69	32.03	89.50	72.65	0.85	0.81	1.66	50.30	21.56	191.05
PRR-2	28.89	8.56	5.25	97.36	24.67	84.91	66.68	0.69	0.71	1.40	48.90	19.15	133.06
RCRB-4	32.52	9.22	5.59	104.26	28.70	87.90	70.42	0.79	0.78	1.57	50.16	20.54	164.09
LSD (P = 0.05)	1.50	0.31	0.15	1.35	1.41	0.75	2.46	0.03	0.03	0.06	1.59	0.83	10.25

Table 3 – Economics and soil health of ricebean cultivars as affected by levels of lime application (pooled data of 2 years).

Treatment	Gross return (INR ha^{-1})	Net return (INR ha^{-1})	B:C ratio	Production efficiency (kg ha^{-1} day^{-1})	Economic efficiency (INR ha^{-1} day^{-1})	pH	Soil organic carbon (%)	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})
Lime application (t ha^{-1})										
Control	23,064	15,321	2.01	6.36	172.38	5.38	0.95	235.85	9.61	136.14
0.2	27,790	18,502	2.06	7.76	205.00	5.76	1.02	243.51	10.52	139.87
0.4	32,698	22,228	2.12	9.22	252.99	6.13	1.09	256.17	11.92	146.98
0.6	39,098	27,228	2.29	11.12	328.38	6.53	1.18	270.44	13.56	154.33
LSD (P = 0.05)	1935	1293	0.13	0.54	14.44	0.31	0.07	10.93	1.25	6.49
Cultivar										
RBS-16	29,774	19,713	2.02	8.34	231.05	5.90	1.05	250.55	11.08	144.01
RBS-53	33,639	23,869	2.36	9.50	271.69	6.05	1.09	253.83	12.04	145.26
PRR-2	27,690	17,920	1.86	7.74	204.26	5.86	1.04	250.39	11.13	143.69
RCRB-4	31,548	21,778	2.25	8.88	251.75	5.99	1.06	251.20	11.36	144.35
LSD (P = 0.05)	1302	901	0.10	0.37	10.55	NS	NS	NS	NS	NS

4. Discussion

4.1. Lime application influencing growth attributes

The application of lime at up to 0.6 t ha^{-1} produced significantly higher growth traits in the present study. This result could be attributed to higher photosynthesis and better translocation to the fruiting sink due to liming. The increase in vegetative growth with liming may result from better availability of nutrients due to moderation of soil reaction [15]. It may also be due to increased biological N fixation. A sufficient Ca^{2+} supply in the soil has been shown to mitigate N_2 fixation limitations of leguminous plants such as *Phaseolus vulgaris* [16]. Application of lime at the levels from 0 to 250 kg ha^{-1} significantly increased leaf area index, number of leaves $plant^{-1}$, plant height, and number of branches $plant^{-1}$. The favorable influence of liming on growth of legumes is due to the indirect effect of increasing the nitrogen availability to the plants through increased nitrification by moderating the pH in acid soils [17–19]. A positive influence of liming on legume growth has been reported [20]. Plant height was significantly increased by the application of lime. Reduced height may be attributed to the toxic effect of soil acidity, which may lead to stunting of plants growing in lime-untreated soil [21].

4.2. Lime application influencing yield attributes

Similarly, yield attributes of ricebean increased with increasing levels of lime. This increase may be due to improvement of soil pH and other physico-chemical properties of soil that increases the plant availability of soil nutrients [22,23]. The grain and straw yields of ricebean realized with application of lime at 0.6 t ha^{-1} were 76.4, 77.2 and 39.1, 38.5% greater than those of the control. The increase in yield may be due in part to the neutralization of exchangeable Al^{3+} ions and an increase in available Ca^{2+}, which, in turn, resulted in excellent grain filling. The better uptake of nutrients facilitated by liming increased vegetative growth and resulted in increased dry matter production and ultimately seed yield of ricebean [23]. Application of gypsum and lime neutralized exchangeable Al^{3+}, improving the uptake and concentration of P in soybean [24–26]. Common bean genotypes showed higher yield and yield components when grown in lime treated soil than lime-untreated soil, which led to an average yield reduction of 26% due to the soil acidity effect [27]. This improvement may be ascribed to the optimization by liming of nutrient availability and utilization, reduction of levels of available Al and Mn, enhancement of N_2 fixation in legumes, and improvement in the microbial-aided process of organic matter breakdown [28]. All treatments improved the harvest index compared to the control, indicating that the treatments promoted better partitioning of food reserves to sinks via effective photosynthetic activity performed by the sources (photosynthetic parts of plant).

Table 4 – Interaction effect of lime levels on seed yield of ricebean cultivars.

Cultivar	Lime level (t ha^{-1})			
	0	0.2	0.4	0.6
RBS-16	0.54	0.66	0.84	0.95
RBS-53	0.58	0.73	0.87	1.21
PRR-2	0.50	0.69	0.71	0.85
RCRB-4	0.65	0.67	0.87	0.95

LSD (*P* = 0.05) for lime on the same varieties = 0.06 and varieties at the same or different lime levels = 0.07.

4.3. Lime application influencing soil health

The addition of lime increased soil pH, an effect that may have accelerated the process of mineralization of nitrogen, leading to higher protein content and protein yield of ricebean cultivars. The increase in availability of nitrogen in the soil following liming may have resulted from an increase in soil pH that accelerated the rate of decomposition and mineralization of organic matter. Nitrogen fixation may be also increased by increasing microbial activity under a favorable soil environment. Increased phosphorus availability due to liming may be due to dissolution of complex Fe and Al phosphates, making phosphate available in the form of monocalcium phosphate [26,29]. The interaction of lime and SOC is complex. At lower rates of lime application, pH increases, increasing surface negative charges so that repulsive forces dominate [30]. However, at higher rates of lime application, Ca^{2+} concentration and ionic strength in the soil solution increase, resulting in the compression of the diffuse double layer of soil colloids followed by flocculation of clay micelles [30]. Moreover, liming induces the precipitation of Al^{3+} complexes in soil that may act as binding agents. Thus, with enhancement in soil aggregation induced by repeated liming (for a second year, as in the present experiment) SOC increased. Liming increases K availability, owing to the displacement of exchangeable K by Ca [30]. Yield benefits from liming can be ascribed to the lime-induced increasing of nutrient availability under acid conditions and reduction of Al toxicity [31]. In a field experiment of maize, liming at 300 kg ha^{-1} (furrow application) led to 32% yield increase over the control under an acidic Alfisol (pH 4.6) of Meghalaya, northeastern India [32]. In another experiment, application of lime at 500 kg ha^{-1} in the furrow produced higher yield attributes and yield of groundnut at mid-hill altitudes in Meghalaya, India [33].

4.4. Lime application influencing ricebean cultivars and economics

Although the growth characters of ricebean differed among cultivars, the maximum values were recorded for RBS-53 in both years of the study. However, RCRB-4 and RBS-16 were found to be statistically equivalent, and significantly superior to PRR-2, with respect to growth attributes. Similarly, higher yield attributes were observed for RBS-53. Cultivars RCRB-4 and RBS-16 were statistically equivalent, and significantly superior to PRR-2, with respect to grain and straw yields in both years. Higher vegetative growth in RBS-16 may have resulted from more efficient extraction of nutrients resulting in higher dry matter production than achieved by other cultivars. Economics of production is a very important aspect for adjusting the efficiency of different production systems based on practicability and its commercial viability, when economics, cost of cultivation, gross returns, net returns, and B:C ratio are taken into consideration. Maximum gross and net returns and B:C ratio were found for RBS-53. This finding may be due to the higher yield of this cultivar than of the other cultivars.

5. Conclusion

Soil acidity problems for ricebean production can be overcome by growing genotypes that are adapted to acid soil conditions in circumstances where soil amendment strategies are not practical. Although some genotypes showed outstanding grain yield, soil fertility improvement by liming is still very important for economical ricebean production in areas with acid soil, such as the onsite used in this study. We conclude that application of lime at 0.6 t ha^{-1} and the use of ricebean cultivar RBS-53 improved productivity, quality (protein content), and soil health for ricebean cultivation in acidic soils of foothills in northeastern India.

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