Journal of Experimental Biology and Agricultural Sciences, August - 2018; Volume – 6(4) page 684 – 689

Journal of Experimental Biology and Agricultural Sciences

http://www.jebas.org

ISSN No. 2320 – 8694

PRODUCTIVITY OF RAINFED RICE (*Oryza sativa* L.) AS INFLUENCED BY CROP GEOMETRY IN THE CONTEXT OF CLIMATE CHANGE

D. Saveipune[1*], Thomas Abraham[1], Vivek Tripathi[2], Sunil Simon[3]

[1]Department of Agronomy, SHIATS, Allahabad UP-211007
[2]District Project Officer, Satna, MP, SAF-BIN, Caritas, India
[3]South Asia Programme Manager, SAF-BIN, Caritas, India

Received – May 15, 2018; Revision – July 18, 2018; Accepted – July 21, 2018
Available Online – August 10, 2018

DOI: http://dx.doi.org/10.18006/2018.6(4).684.689

KEYWORDS

OFAR

Productivity

Rainfed rice

Crop geometry

Climate change

ABSTRACT

On Farm Adaptive Research experiment was conducted during the *Kharif* season 2013 to assess the effect of crop geomerty in the context of climate change on productivity of rainfed rice (*Oryza sativa* L). Experiment was laid out in Randomized Block Design (RBD) with 3 treatments viz., 20 cm x 20 cm + *Matka khad*; 20 cm x 20 cm + neem and tobacco extract and 20 cm x 15 cm + inorganic fertilizers, conventional practice, each treatment replicated 9 times. Results of study revealed that significantly higher grain yield (7.78 t/ha), straw yield (17.06 t/ha), test weight (24.99 g) panicle length of (21.12 cm) were recorded in the treatment with 20 cm x 20 cm spacing + neem and tobacco extract. Further, this treatment has higher grain yield (15.17%), test weight (2.96%) and panicle length (17.66%) over the 20 cm x 15 cm spacing + inorganic fertilizers. Also this treatment has 12 and 32.65 % higher straw yield as compared to 20 cm x 20 cm spacing + *Matka khad* and 20 cm x 15 cm spacing + inorganic fertilizers respectively. Number of tillers/panicle in treatment containing 20 cm x 20 cm spacing + neem and tobacco extract (17.06) was statistically not different than the 20 cm x 20 cm spacing + *Matka khad* (17.89). The panicle length (20.54 cm) and test weight (24.83 g) at spacing 20 cm x 15 cm + inorganic fertilizers was found to be statistically at par with 20 cm x 20 cm spacing + neem and tobacco extract (24.99 g). Further, highest CGR (7.88 g/m^2/day) and RGR (0.041 g/g/day) were recorded in treatment with 20 cm x 15 cm spacing + inorganic and 20 cm x 20 cm + *Matka khad*. While maximum number of grains/panicle (136.67) was recorded in the treatment having 20 cm x 20 cm spacing + neem and tobacco extract.

* Corresponding author
E-mail: dsaveipune@gmail.com (D. Saveipune)

Peer review under responsibility of Journal of Experimental Biology and Agricultural Sciences.

1 Introduction

Rice (*Oryza sativa* L.) is an important staple crop in Asia, including India. More than half of the world populations are dependent on rice; in India rice crop plays a vital role in ensuring nation's food security and is a means of livelihood for millions of rural households. India has largest area under rice cultivation (44.6 million ha) with a production of about 104 million tons (Chauhan & Mahajan, 2013). An increase in atmospheric CO_2, has a fertilization effect on rice, promoting its growth and productivity. The effect of global warming would have negative influence on rice production due to increased respiration that resulted into shortened vegetative and grain-filling period (Krishnan et al., 2011). Further, increases in temperature might have both positive and negative effects on crop yields, in general, temperature increases have been found to reduce yields and quality of many crops, most importantly cereal and food grains. Increases in precipitation (i.e. level, timing and variability) may benefit semi-arid and other water short areas by increasing soil moisture, but could aggravate problems in regions with excess water, while a reduction in rainfall could have the opposite effect (Reddy & Reddy, 2016).

Rain fed crops are likely to be worse hit by climate change because of the limited mechanisms of coping with variability of precipitation. Thus, adaptation in rain fed rice production can be seen as a promising entry point to buffer the consequences of climate change amongst the poorest of the poor (Wassmann & Dobermann, 2007) and to achieve overall development of agriculture in the country. It is essential to bridge the yield gaps, enhance the productivity and profitability, minimize risk and improve the livelihoods of millions of people dependent on rain fed agriculture (NRAA, 2012).

Agriculture in Madhya Pradesh, especially for small and marginal farmers in rain fed areas is perceived to be increasingly unviable owing to yield and price risk and lack of risk mitigation mechanism. Only about 50% of the 90 lakh operational land holdings have been covered with credit and the per hectare agricultural credit is lower than that of many states, pointing at the need for concerted efforts of the banks in improving farm credit scenario in the State. Marginal & small farmers account for more than two thirds (71%) and hold around one third (34%) of total area. This restricts farm mechanization and affects production and productivity (NABARD, 2014).

Adaptive research is designed to adjust technology to the specific needs of a particular set of environmental conditions by taking into account the different bio-physical and socio-economic circumstances of the farmers. The concept of "On Farm Adaptive Research" (OFAR) entails full farmers' participation, by direct contact between researchers and farmers and concerted multi-disciplinary investigation of farmers' situations (Adeola et al., 2014). According to Mahapatra & Behera (2011), the strategy for OFAR has to be a "bottom-up" approach, which was certainly implemented and evident during the course of trial in Satna District of Madhya Pradesh. During the process of base line and secondary review of SHF collective through interactive sessions, most of the farmers' revealed that they raised rice crop without any consistent spacing and mostly preferred closer spacing. However, closer plant spacing reduces the number of effective tillers and increases the tiller mortality. Rasool et al. (2013) reported that the plant spacing of 20 ×20 cm significantly recorded higher panicle length, panicle weight more spikelets/panicle, grain/ panicle as compared to 15 × 20 cm and 15 × 15 cm spacing. The wider spacing adopted appears to be an advantageous factor for better development of panicles, hence more panicle length, panicle weight, spikelets number and filled grains panicle. Wider spacing coupled with higher number of seedlings/hill accumulate maximum amount of dry matter as productivity of tillers as well as dry matter yield will be lower with closer spacing (Hasanuzzama et al., 2009), number of tillers/m^2 was significantly higher in wider spacing with 20 cm × 20 cm as compared to other planting geometry (Rajput et al., 2016). According to Gautam et al. (2008), proper planting geometry have more advantages such as, to maximize light utilization efficiency, improves aeration within crop canopy, enhances soil respiration and provides better weed control thereby higher crop yields.

Soil organic matter content (2.1%) was maintained in FYM containing treatments (2.15–2.17%), while declining with inorganic treatments (Paul et al., 2013). Adopting organic fertilization (compost, animal, and green manure) is widely found to have positive effects on the yields (Branca et al., 2013). According to Abraham & Lal (2002) application of biological and organic manures not only supplies a balanced amount of micronutrients but also improve the physico-chemical and biological properties of soil. Agronomic management is the most important input for getting potential yield and high net returns in any crop. Therefore, the study was undertaken to find out the effect of different agronomic management practices (proper plant spacing, organic component and agronomic analysis) for enhanced productivity of rice on the farmers' fields with the objectives of finding out the effect of climate change on rice productivity; effect of crop geometry on rain fed rice and effect of cultural practices on growth and yield of rice.

2 Materials and Methods

The field experiment was carried out as an On Farm Adaptive Research during *kharif* season 2013 in 9 villages of Satna district of Madhya Pradesh. The district physiographic aspect of the area was Latitude 23° 58' to 25° 12' N, Longitude 80° 21' to 81° 23' E, Altitude 313 m. The soil was sandy clay loam (Bouyoucos hydrometer method proposed by Bouyoucos, 1927) with pH 7.51 (Glass electrode pH meter by Jackson, 1973). Study area soil was moderately fertile with medium organic carbon (0.41%) (Walkley and Black method proposed by Jackson, 1973). Further, presence of medium nitrogen (190.00 kg/ha), P (9.42 kg/ha) and K (299.00 kg/ha) was estimated by alkaline permanganate method (Subbiah & Asija, 1956), Olsen method (Olsen et al., 1954) and Flame Photometer method (Toth & Prince, 1949) respectively.

The average maximum and minimum temperature during the experimentation period was recorded in June (34.90 ^{o}C) and November (10.74 ^{o}C) respectively. The highest relative humidity was 92.29% in October while it was reported 39.25% in November and total rainfall of 1367.10 mm was obtained in 80 rainy days, major part of which was received in the month of August during experimentation.

The experiment was laid out in randomized block design with 3 treatments and 9 replications. Different treatments of transplanted rice were 20 cm x 20 cm spacing + *Matka khad*, 20 cm x 20 cm spacing + neem and tobacco extract and 20 cm x 15 cm spacing + inorganic fertilizers, conventional practice. The *Matka khad* was prepared by mixing 2 kg neem (*Azadirachta indica*) leaves + 2 kg akaua (*Calotropis gigantea*) leaves + 1 litre cow urine + 2 kg cow dung + 250g jaggery. Final combination of *Matka khad* (5%) was prepared by adding 500 ml prepared and filtered solution in 10 liters of water, and applied as foliar spray 3 times at fortnightly intervals. Treatment neem and tobacco extract was prepared by mixing 1 kg neem (*A. indica*) leaves and 1 kg tobacco (*Nicotiana tabacum*) leaves. Rest preparation and application procedure was similar to the *Matka khad*. The inorganic fertilizers, conventional practice treatment containing 108.69 kg DAP/ha and 175.00 kg urea/ha. Half of the phosphorus was applied as basal along with supplement of nitrogen within 3-5 days after transplanting. The remaining amount of phosphorus was applied in two equal split at fortnightly intervals. The remaining amount of nitrogen was applied as top dressing at fortnightly intervals, as per the prevailing practice of the farmers' in the region. FYM 10 t/ha was applied 7 days before transplanting in all the treatments. All the observations were taken from the four tagged hills which tagged randomly in each plot. The crop was harvested separately from two random quadratic area of 2.0 m^2 in each plot ensuring exclude the border rows and sampling rows. The net plots were harvested, tied, tagged and left in the field to dry for 2–3 days. Threshing was done manually after recording the weight of the total produce of an individual plot. After proper cleaning and winnowing, the grain weight of each plot at 14% moisture was recorded. All the data pertaining to growth, yield attributes and yield were recorded. The data related to each parameter of the experiment were statistically analyzed as per procedure of analysis of variance using F-test.

3 Results and Discussion

3.1 Growth parameters

The plant height in treatment having 20 cm x 20 cm spacing + neem and tobacco extract (101.21 cm) was recorded significantly over treatment with 20 cm × 20 cm spacing + *Matka khad* (90.09 cm) and 20 cm × 15 cm spacing + inorganic fertilizers, conventional practice (89.75 cm) (Table 1). The highest plant height was recorded with plant spacing 20 cm × 20 cm it might be because of optimum condition for light reception, photosynthesis, water and nutrient consumption and less competition (Roshan et al., 2011). Further, According to Ogbodo et al. (2010) wider spacing produced plants with more vigorous growth and larger plant size which normally increases photosynthetic efficiency, increased availability of nutrients utilization and greater accessibility of nutrients for plant.

Table 1 Productivity of rainfed rice as influence by crop geomerty on growth parameters

Treatment	Growth Parameters			
	90 DAT		75-90 DAT intervals	
	Plant height (cm)	No.of tillers/ hill	CGR (g/m^2/day)	RGR (g/g/day)
20 cm × 20 cm + *Matka khad*	90.09	17.89[a]	6.90	0.046
20 cm x 20 cm + neem + tobacco extract	101.21[a]	17.06[a]	5.57	0.014
20 cm x 15 cm + inorganic fertilizers + conventional practice	89.75	13.28	7.88	0.031
F-Test	S	S	NS	NS
SEm±	1.32	0.54	0.28	0.001
CD (P=0.05)	8.42	3.46	-	-
CV (%)	8.91	21.47	144.32	248.88

Data are mean of nine replicates; Values with superscript letters differ significantly

Treatment with 20 cm × 20 cm spacing + *Matka khad* (17.89 no. of tillers/hill) recorded significantly higher tillers/hill (34.71%) over 20 cm × 15 cm + inorganic fertilizers, conventional practice (13.28/hill). However, 20 cm × 20 cm spacing + neem and tobacco extract (17.06/hill) was found statistically similar with the 20 cm × 20 cm spacing + *Matka khad*. The more vigorous plants with particularly higher tillering ability produce more photosynthate than less vigorous plants of the closer spacing (Ogbodo et al., 2010). Transplanting of rice at a wider spacing produced a significantly higher number of tillers/hill as compared to closer spacing which may be due to increase in available nitrogen levels (Gautam et al., 2008; Bezbaruha et al., 2011; Mohaddesi et al., 2011). According to Rajput et al. (2016) number of tillers/m^2 was significantly higher in wider spacing with 20 cm × 20 cm as compared to other planting geometry. Wider spacing resulted in the production of more tillers per stand than closer spacing (Moro et al., 2016). Highest CGR was observed at spacing 20 cm x 15 cm + inorganic fertilizers, conventional practice (7.88 g/m^2/day), and RGR at spacing 20 cm × 20 cm + neem and tobacco extract (Table 1). However, it was found to be non significant. Biomass production in a plant community is positively correlated with crop growth rate and wider spacing recorded more CGR as observed by Rao et al. (1998) in sorghum. The increase in LAR in the rice grown at 30/24°C as reported by Nagai & Makino (2009) may have led to an increase in RGR.

3.2 Yield Parameters

The panicle length in the treatment with 20 cm × 20 cm spacing + neem and tobacco extract (21.12 cm) recorded significant and 17.66% higher over 20 cm × 15 cm spacing + inorganic fertilizers conventional practice (17.97cm). However, 20 cm × 20 cm spacing + *Matka khad* (20.54 cm) found statistically at par with spacing 20 cm × 20 cm + neem and tobacco extract. The wider spacing adopted appears to be an advantageous factor for better development of panicles, hence more panicle length and it might be because of filled grains/panicle (Bezbaruha et al., 2011; Rasool et al., 2013). The yield attributes *viz*., panicles/m^2, panicle length and filled grains/panicle was significantly influenced by spacing and nutrient management practices (Damodaran et al., 2012). The treatment at spacing 20 cm × 20 cm + neem and tobacco extract (136.67/panicle) recorded maximum number of grains/panicle and this was followed by 20 cm × 20 cm + *Matka khad* and lowest was recorded at spacing 20 cm × 15 cm + inorganic fertilizers conventional practice (125.70/panicle) (Table 2). However, the number of grains per panicle was found to be non-significant. Fertility of grains and development of grains depend on environmental factors such as nutrition, moisture and light. Wider spacing possibly facilitated the supply of more food materials, moisture and light for the plant and ultimately for development of grain as compared to closer spacing (Tyeb et al., 2013), leading to maximum number of filled grains/panicle and lowest sterile per cent (Gorgy, 2010). Treatment with 20 cm × 20 cm spacing + neem and tobacco extract registered significant and 2.96% higher test weight over 20 cm × 15 cm + inorganic fertilizers, conventional practice. However, treatment with 20 cm × 20 cm spacing + *Matka khad* was statistically at par with 20 cm × 20 cm spacing + neem and tobacco extract. Adoption of wider spacing for rice transplanting may have resulted in higher grain weight than at closer spacing (Gautam et al., 2008), and due to nutrient management practices (Bezbaruha et al., 2011). The tendency of increasing 1000 grain weight with increased spacing was also observed by Rashid & Khan (2006). Treatment with 20 cm x 20 cm spacing + neem and tobacco extract (7.78 t/ha) recorded significantly higher grain yield over treatment at spacing 20 cm x 20 cm + *Matka khad* (6.93 t/ha) and 20 cm x 15 cm + inorganic fertilizers, conventional practice (6.69 t/ha) and 20 cm x 20 cm +

Table 2 Productivity of rainfed rice as influence by agronomic practices on yield parameters

Treatment	Yield Parameters					
	Panicle Length (cm)	No. of grains/ Panicle	Test weight (g)	Grain Yield (t/ha)	Straw Yield (t/ha)	Harvest Index
20 cm × 20 cm + *Matka khad*	20.54[a]	133.81	24.83[a]	6.93	15.11	30.35
20 cm x 20 cm + neem + tobacco extract	21.12[a]	136.67	24.99[a]	7.78[a]	17.06[a]	31.42
20 cm x 15 cm + inorganic fertilizers + conventional practice	17.95	125.7	24.27	6.69	12.86	34.81
F-Test	S	NS	S	S	S	NS
SEm±	1.63	1.49	.03	.001	.011	0.72
CD (P=0.05)	3.09	-	0.48	0.07	0.19	-
CV (%)	15.98	21.59	1.95	10.19	12.83	13.12

Data are mean of nine replicates; Values with superscript letters differ significantly neem and tobacco extract was 15.17% higher in value than 20 cm x 15 cm + inorganic fertilizers in grain yield. The higher value in grain yield at spacing 20 cm x 20 cm + *Matka khad* and 20 cm x 20 cm + neem and tobacco extract may be due to the wider spacing. Wider spacing facilitates maximum light interception and better soil aeration (Bezbaruha et al., 2011) and more area of land around them to draw the nutrition and more solar radiation to absorb for better photosynthetic process and hence performed better as individual plant (Mohaddesi et al., 2011) and leading to more dry matter production ultimately resulting in yield enhancement. Moro et al. (2016) reported that wider spacing of 25 cm x 20 cm and 20 cm x 20 cm, produced 8.06 and 7.56 t ha^{-1} more grain over the closer spacing of 30 cm x 10 cm and 15 cm x 15 cm. Straw yield of treatment with spacing 20 cm x 20 cm + neem and tobacco extract (17.06 t/ha) was significantly higher over treatment at spacing 20 cm x 20 cm + *Matka khad* (15.11 t/ha) and 20 cm x 15 cm + inorganic fertilizers, conventional practice (86 t/ha). The treatment at spacing 20 cm x 20 cm + neem and tobacco extract was 12% and 32.65% higher in value than treatment at spacing 20 cm x 20 cm + *Matka khad* and 20 cm × 15 cm + inorganic fertilizers conventional practice in straw yield. DMP is the product of the influence of growth characters like plant height, number of tillers, LAI and efficiencies of the crop to capture available resources (Damodaran et al., 2012**)**. However, it was found non-significant in all the treatments. The harvest index of treatment at spacing 20 cm × 15 cm + inorganic fertilizers conventional practice) (34.18%) was recorded highest, but found non-significant in all the treatments.

Conclusion

It may be concluded that treatments at spacing 20 cm × 20 cm + neem and tobacco extract and 20 cm × 20 cm + *Matka khad* were regarded as best in growth, yield attributes and dry matter production. The findings of OFAR through agronomic practices has evinced the stakeholder farmers' that this possess better soil health and productivity which is feasible and acceptable. Therefore, this plant spacing enable appropriate agronomic expression.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this research paper

References

Abraham T, Lal RB (2002) Sustainable enhancement of yield potential of mustard (*Brassica juncea* L. Czern. Coss.) through integrated nutrient NM) in a legume based cropping system for the inceptisols. Cruciferae Newsletter Nr.24 July Eucarpia Ed. INRA Rennes, France Pp 99-100.

Adeola RG, Tijani EH, Fakunle AO (2014). Assessment of farmers' participation in on-farm adaptive research in south-western, Nigeria. International Journal of Innovation and Applied Studies 9:1155-1160.

Bezbaruha R, Sharma RC, Banik P (2011) Effect of nutrient management and planting geometry on productivity of hybrid rice (*Oryza sativa* L.) Cultivars. American Journal of Plant Sciences 2: 297-302.

Bouyoucos GJ (1927) The hydrometer as a new method for the mechanical analysis of soils. Soil Science 23: 343-353.

Branca G, Lipper L, Nancy M, Jolejole MC (2013) Food security, climate change, and sustainable land management. A review. Agronomy for Sustainable Development 33:635-650.

Chauhan BS, Mahajan G (2013) Strategies for boosting rice yield in the face of climate change in India. International Rice Research Institute 1:105

Damodaran V, Saren BK, Ravisankar N, Bommayasamy N (2012) Influence of time of planting, spacing, seedling number and nitrogen management practices on productivity, profitability and energetics of rice (*Oryza sativa*) in island ecosystem. Madras Agricultural Journal 99: 538-544.

Gautam AK, Kumar D, Shivay YS, Mishra BN (2008) Influence of nitrogen levels and plant spacing on growth, productivity and quality of two inbred varieties and a hybrid of aromatic rice. Archives of Agronomy and Soil Science 54:515–532.

Gorgy RN (2010) Effect of transplanting spacing and nitrogen level on growth, yield and nitrogen used efficiency of some promising rice varieties. Journal of Agricultural Research Kafer El-Shiekh University 36:123-144.

Hasanuzzaman M, Nahar K, Roy TS, Rahman ML, Hozzain MZ, Ahmed JU (2009) Tiller dynamics and dry matter production of transplanted rice as affected by plant spacing and number of seedlings per hill. Academic Journal of Plant Science 2:162-168.

Jackson KL (1973) Soil chemical analysis. Prentice hall of india. Pvt. Ltd. New Delhi. pp. 38-43.

Krishnan P, Ramakrishnan B, Reddy KR, Reddy VR (2011) High temperature effect of rice growth, yield and grain quality. Advance in Agronomy 111: 87-190.

Mahapatra IC, Behera JK (2011) Rice (*Oryza sativa*)- based farming system for livelihood improvement of Indian farmers. Indian Journal of Agronomy 56: 1-19.

Mohaddasi A, Abbasian A, Bakhshipour S, Aminpanah H (2011) Effect of different level of nitrogen and plant spacing on yield, yield components and physiological indices in high-yield Rice. American-Eurasian Journal of Agricultural & Environmental Sciences 10: 893-900.

Moro BM, Nuhu IR, Martin EA (2016) Effect of spacing on grain yield and yield attributes of three rice (*oryza sativa* l.) varieties grown in rain-fed lowland ecosystem in Ghana. International Journal of Plant & Soil Science 9: 1-10

NABARD (2014) Status focus paper 2014-2015 Madhya pradesh. Available on http://www.dif.mp.gov.in/circulars%5CNABARD_StateFocusPaper2014_15 29 January.

Nagai T, Makino A (2009) Differences between rice and wheat in temperature responses of photosynthesis and plant growth. Oxford Journal of Plant and Physiology 50:744-755.

NRAA (2012) Prioritization of rainfed Area in India, Study report 4, NRAA, New Delhi. India Pp.100.

Ogbodo EN, Ekpe II, Utobo EB, Ogah EO (2010) Effect of plant spacing and N rates on the growth and yields of rice at abakaliki ebonyi State, Southeast. Research Journal of Agriculture and Biological Sciences 6*:* 653-658.

Olsen SR, Cole CV, Watanable FS, Dean LA (1954) Estimation of available phosphorus in soils by extraction with sodium bicarbonate. Department of Agriculture, United States, circular 939.

Paul T, Bisht PS, Pandey PC, Singh Dk, Roy S (2013) Rice productivity and soil fertility as influenced by nutrient management in rice (*Oryza sativa*), wheat (*Triticum aestivum*) cropping system. Indian Journal of Agronomy 58:495-99.

Rajput A, Sharma S, Rajput SS, Jha G (2016) Impact of different crop geometries and depths of planting on growth and yield of rice in system of rice intensification. Bioscience Biotechnology Research Communications 9: 512-516

Rao SS, Rao MH, Khrishnan, Rana BS (1998) Characteristcs of sorghum hybrids and varieties for growth parameters, biomass accumulation and yield potential in rainy season. Indian Journal of Plant Physiology 3:269-273.

Rashid MH, Khan AH (2006**)** Tillering dynamics and productivity of BRRI dhan 44 as influenced by spacing and nitrogen management technique. Journal of Agriculture and Rural Development 4:47-52

Rasool FU, Habib R, Bhat MI (2013) Agronomic evaluation of rice (*Oryza sativa* L.) for plant spacings and seedlings per hill under temperate conditions. African Journal of Agricultural Research 8: 4650-4653.

Reddy N, Reddy S (2016) Impact of climate change on rainfed agriculture: a study of its impact on the socio-economic life of farmers in Rayalaseema region of Andhra Pradesh. International Journal of Current Innovation Research 2:451-457

Roshan AM, Ebrahim A, Maradi M (2011) Study of yield and yield components of rice in different plant spacings and number of seedlings per hill. Middle- East Journal of Scientific Research **7**:136-140.

Subbiah BV, Asija CL (1956) A rapid procedure for the estimation of available Nitrogen in soil. Soil Science 25: 328.

Toth SJ, Prince AL (1949) Estimation of cation exchange capacity and exchangeable Ca, K and Na content of soil by flame photometer technique. Soil Science 67:439-445.

Tyeb A, Paul SK, Samad MA (2013) Performance of variety and spacing on the yield and yield contributing characters of transplanted Aman rice. Journal of Agroforestry and Environment 7: 57-60

Wassmann R, Dobermann A (2007) Climate change adaptation through rice production in regions with high poverty levels. SAT eJournal/ejournal.icrisat.org/4:1-2.