ISSN 1683-5603

International Journal of Statistical Sciences Vol. 20(1), 2020, pp 123-138 © 2020 Dept. of Statistics, Univ. of Rajshahi, Bangladesh

Region Specific BRRI Variety Adoption: A Simple Way of Increasing National Production

Md. Abdul Qayum^{1*}, Md. Ismail Hossain¹, Niaz Md. Farhat Rahman¹, Md. Abdullah Aziz¹, Md. Abdullah Al Mamun¹, Rokib Ahmed¹ and Md. Shahjahan Kabir¹

¹Agricultural Statistics Division, Bangladesh Rice Research Institute, Gazipur-1701, Bangladesh

*Correspondence should be addressed to Md. Abdul Qayum (aqstat.ru@gmail.com)

[Received Jan. 10, 2020; Revised February 13, 2020; Accepted March 3, 2020]

Abstract

'Food security' is the synonym of 'Rice security'. Increasing population, climate vulnerability and decreasing resources appeared as the great challenges to keep the pace of food production in Bangladesh. To overcome that challenges, we have shown a technology in this study namely 'Region Specific BRRI Variety Adoption' that can help to increase the national rice production in Bangladesh. To know the varietal performance at different season and region, replicated trials of randomized complete block (RCB) design with 40, 39 and 9 BRRI varieties have been set up in 10, 9 and 7 regions for Boro, T. Aman and T. Aus seasons respectively in Bangladesh. Bangladesh rice research institute (BRRI) recommended management practices to be followed to conduct the trials. From these trials we find the potential yielded variety with yield, the highest yielded variety with yield, average yield and the lowest yielded variety with yield. To compare the production performance of region specific BRRI variety, secondary data of area and production of rice from BBS were used in this study. We found that, if we adopt the potential yielded variety at the respected season and region then total rice production will be increased by 24.22%, in case of the highest yielded variety it will be increased by 11.03% but for wrong selection of variety (the lowest yielded variety) production will be decreased by more than 50%.

Keywords: Food Security, Region, BRRI Variety, Adoption

AMS Classification: 62Q05, 91B82, 90B30

1. Introduction

Rice security" is synonymous to "Food security" in Bangladesh as in many other rice growing countries (Brolley, 2015). Rice security is not just an economic issue but also an important parameter for determining social and political stability (Nath, 2015). Rice is the main staple food in Bangladesh, which occupies nearly 80% of the total net cropped area of the country. Three major rice crops (namely, Aus, Aman and Boro) constitute 100% of total rice production and grow in three different seasons. Aus is typically planted in March or April and harvested in June or July. Aman is generally sown in July or August and harvested in November or December. Finally, Boro is planted in December or January and harvested in May or June (Islam, 1988; BBS, 2009).

Bangladesh agriculture involves food production for 163.65 million people from merely 8.75 million hectares of agricultural land (Salam et al., 2014). More food will be required in future because of increasing population. Decreasing resources (e.g. land, labour, soil health and water), and increasing climate vulnerability (e.g., drought, salinity, flood, heat and cold) appeared as the great challenges to keep the pace of food production in the background of increasing population. Sufficient rice production is the key to ensure food security in Bangladesh. Population of Bangladesh will reach 215.4 million in 2050, when 44.6 MT of clean rice will be required. In 2014-15, the country acquired a rice surplus of about 2 MT. However, maintaining the current surplus of rice in the coming decades is a great challenge. Authentic estimation of future rice requirement and future resource availability would guide to way forward (Kabir et.al.2015).

Regional variations in agricultural development show that there is scope to boost up the pace of agricultural development and thereby that of economic development in the country with area specific agricultural development programmes and policies (Singh, 1990). There is functional relationship between agricultural productivity of the regions. This relationship should also be taken into consideration so that appropriate development measure can be taken (Anselin, 2003). Different regions or districts of Bangladesh have specialized in growing different crop (Faroque, M.A.A. et al 2011).

Qayum, Hossain, Rahman, Aziz et. al: Region Specific BRRI Variety Adoption ... 125

Development and adaption of high yielding cultivars under wide range of diversified environments is one of the major goals for the plant breeders in crop improvement programme (Boseet.al, 2015). Yield performance of different varieties varies across testing environments and its grain yield performance is a function of genotype (G), environment (E) and genotype \times environment interaction (GEI). The structure of GEI is very important in plant breeding programs because a significant GEI can seriously impair efforts in selection of superior genotypes in relation to new crop introductions and cultivar development programs leads to successful evaluation of stable genotype, which could be used for general cultivation (Yan and Racjan, 2002; Vasgas et al. 2001; Reza et al.2007).So the main objectives of the study are to find out the region specific potential, the highest, average and the lowest yielded varieties and to project the national production of rice in Bangladesh according to that selection.

2. Materials and Methodology

District wise total area and production of the three different seasons are collected from the yearbook of Agricultural Statistics 2016 which is published in May 2017 and distribute at different specific regions (Table 1) according to the availability of the trial data. Replicated trial in randomized complete block (RCB) design with Bangladesh rice research institute (BRRI) released 40, 38 and 9 varieties set up in 10, 9 and 7 regions (BRRI Headquarter (HQ) and other BRRI regional stations(RSs) at different regions) for Boro, T. Aman and T. Aus seasons respectively. BRRI recommended management practices were followed to conduct the trials. After collecting, data were compiled, tabulated and analyzed according to the objectives of the study. At first we perform Analysis of Variance (ANOVA) for testing the average yield (calculated as ton per hectare(t/ha)) of the regions are equal or not and Duncan multiple range test (DMRT) for specifying the significant different of the average regional yield at all the three seasons. All the analyses were performed by MS excel, and the third generation programming language R.

International Journal of Statistical Sciences, Vol. 20(1), 2020

Season → Region↓	Boro	Aman	Aus	
Region 1 (Rangpur)	Kurigram, Lalmonirhat, Rangpur, Gaibanda, Ponchgor, Takurgaon, Nilfamari, Dinajpur	Kurigram, Lalmonirhat, Rangpur, Gaibanda, Ponchgor, Takurgaon, Nilfamari, Dinajpur	Kurigram, Lalmonirhat, Rangpur, Gaibanda, Ponchgor, Takurgaon, Nilfamari, Dinajpur	
Region 2 (Rajshahi)	Rajshahi, Chapi, Natore, Nogoan, Sirajgonj, Pabna, Joypurhat, Bogra	Rajshahi, Chapi, Natore, Nogoan, Sirajgonj, Pabna, Joypurhat, Bogra	Rajshahi, Chapi, Natore, Nogoan, Sirajgonj, Pabna, Joypurhat, Bogra	
Region 3 (Barisal)	Barisal, Bhola, jhalokati, Potuakhali, Pirojpur, Borguna	Barisal, Bhola, jhalokati, Potuakhali, Pirojpur, Borguna	Barisal, Bhola, jhalokati, Potuakhali, Pirojpur, Borguna,	
Region 4 (Vanga)	Rajbari, Magura, Faridpur, Gopalgonj, Narail, Madaripur, Shariotpur	Rajbari, Magura, Faridpur, Gopalgonj, Narail, Madaripur, Shariotpur	Rajbari, Magura, Faridpur, Gopalgonj, Narail, Madaripur, Shariotpur	
Region 5 (Kustia)	Kustia, Meherpur, Chuadanga, Jhenaidah	(Kustia), Meherpur, Chuadanga, Jhenaidah	Kustia, Meherpur, Chuadanga, Jhenaidah	
Region 6 (Satkhira)	Satkhira, Jessor, Khulna, Bagerhat	Satkhira, Jessor, Khulna, Bagerhat	Satkhira, Jessor, Khulna, Bagerhat	
Region 7 (Sonagazi)	Feni, Noakhali, Laxmipur, Ctg5 dist.	Feni, Noakhali, Laxmipur, Ctg 5dist.	Commilla, B Baria,	
Region 8 (Commilla)	Commilla, B Baria, Chandpur	(Commilla), BBaria, Chandpur, Habigoni	Chandpur, Feni, Noakhali, Laxmipur, Ctg 5dist, Habigoni,	
Region 9 (Habigonj)	Habigonj, Sylhet, Sunamgonj, Moulovibazar	Sylhet, Sunamgonj, Moulovibazar	Sylhet, Sunamgonj, Moulovibazar	
Region 10 (Gazipur)	Gazipur, Dhaka, Manikgonj, Munsigonj, Narayangonj, Narsingdi, Jamalpur, Sherpur, Kishoregonj, Mymenshing, Netrokona, Tangail	Gazipur, Dhaka, Manikgonj, Munsigonj, Narayangonj, Narsingdi, Jamalpur, Sherpur, Kishoregonj, Mymenshing, Netrokona, Tangail	Gazipur, Dhaka, Manikgonj, Munsigonj, Narayangonj, Narsingdi, Jamalpur, Sherpur, Kishoregonj, Mymenshing, Netrokona, Tangail	

Table 1: Season and Region wise district distribution

3. Result and Discussions

Secondary data of Area and Production of Aus, Aman and Boro of different Region are given in the following table (Table 2). Bangladesh Bureau of Statistics (BBS) collect paddy sample at different points using suitable sampling frame and then convert it to clean rice.

Seesan	E	Boro		man	Aus		
Season→	Area	Production	Area	Production	Area	Production	
Region↓	(ha)	(T)	(ha)	(T)	(ha)	(T)	
Region 1	765074	2119560	1026202	2792516	22252	70810	
(Rangpur)	/039/4	5116509	1050502	2785510	52555	/9019	
Region 2	809725	3301627	820324	22338/11	170300	118587	
(Rajshahi)	809723	5501027	829324	2233041	179399	448587	
Region 3	130189	485567	711607	1/1/9/0			
(Barisal)	130107	405507	/1100/	1414940	226876	418346	
Region 4	245777	1071566	269543	595852	220070		
(Vanga)	243111	10/1500	207545	575052			
Region 5	173822	715969	231360	666884	77344	211715	
(Kushtia)	175022	/15/0/	231300	000004	77344	211715	
Region 6	327814	1379025	381127	1005446	33266	84304	
(Satkhira)	527014	1377023	501127	1005440	55200		
Region 7	247589	934233	570099	1441365			
(Sonagazi)	247507	754255	570077	1441505			
Region 8	368373	1/08759			3/1020	776773	
(Cumilla)	500575	1400757	625588	1385590	541727	110113	
Region 9	247406	83/30/	025500	1303370			
(Habigonj)	247400	034304					
Region 10	1159210	4764129	928302	2128620	50515	114069	
(Gazipur)	1137210	4704127	720302	2120020	50515	114007	

Table 2: Area and Production at different season and region in Bangladesh

Note: ha=Hectare, and T=Ton (1000 kg)

3.1 AUS Season

In Aus season 9 different BRRI released Aus variety are used in the trial at seven different locations. But the trial was totally damaged in Barishal region for that reason Aus/ 2016 data present for Barishal region. Location wise potential

(Maximum yield according to replication and variety) variety with yield, the highest (Maximum yield according to replication wise average of the variety) yielded variety with yield, Average yield of all the varieties and the lowest yielded variety with yield are given in table 3. We found the highest potential yielded variety BRRI dhan48 (5.70t/ha) at BRRI HQ and the lowest BRRI dhan65 (3.44 t/ha) in BRRI R/S, Rajshahi. BRRI dhan48 shows the highest yielded variety in all the locations. In case of the lowest yielded variety BRRI dhan27 shows the minimum yield (1.30 t/ha) in BRRI R/S, Rangpur (Table 3).

$\overset{\text{Season}}{\rightarrow}$	Potential Yielded		Hig yield	hest ed	All variety	Lowes	t Yield
Region↓	Variety Name	Yield	Variety Name	Yield	Average Yield	Variety Name	Yield
Cumilla	BRRI dhan42	4.28	BRRI dhan48	3.84	3.12	BRRI dhan27	1.30
Satkhira	BRRI dhan48	5.05	BRRI dhan48	4.30	3.26	BRRI dhan65	2.39
Rajshahi	BRRI dhan65	3.44	BRRI dhan48	3.18	2.63	BR21	2.29
Kushtia	BRRI dhan43	3.76	BRRI dhan48	3.29	2.52	BR26	2.12
Rangpur	BRRI dhan48	5.19	BRRI dhan48	4.88	3.14	BRRI dhan27	1.37
Gazipur	BRRI dhan48	5.70	BRRI dhan48	5.27	4.31	BRRI dhan27	3.07
Barishal	BRRI dhan48	4.25	BRRI dhan48	4.08	3.22	BR 24	2.65

Table 3: Region wise yield performance of BRRI varieties in T. Aus 2017 season

From the ANOVA results of Combined Analysis (Table 4) it is clear that the Locations (Different Region of Bangladesh) have significant yield difference though the same variety and management practice are performed. Also the varieties show the significance difference according to yield performance.

SV	DF	Sum Sq	Mean Sq	F Value
Location	5	48.78	9.756	31.661***
Variety	8	37.26	4.657	15.114 ***
Rep:Location	12	5.68	0.474	1.537
Variety:Location	34	33.28	0.979	3.177***
Residuals	84	25.88	0.308	

Table 4: AVOVA of Combined Analysis for T. Aus 2017 season

Signif.codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

The DMRT result shows the location BRRI HQ, Gazipur have significantly yield difference on other locations with average yield 4.31t/ha also some other location shows significant yield difference to each other (Table 5). According to the yield performance factors the estimated production are shown in Figure 1.

 Table 5: Mean Comparison with some descriptive statistics for T. Aus 2017 season

Location	Mean Yield with lettering	std	Min	Max
Gazipur	4.31 a	0.74	2.81	5.70
Satkhira	3.26 b	1.06	1.29	5.05
Barishal	3.22 c	0.46	2.37	4.25
Rangpur	3.14 b	1.19	1.03	5.19
Cumilla	3.12 b	0.90	0.86	4.28
Rajshahi	2.63 c	0.50	1.73	3.44
Kushtia	2.52 c	0.55	1.41	3.76



Figure 1: Production at different region for Aus season in Bangladesh

3.2 Aman Season

In Aman season 38 different BRRI released Aman variety are used in the trial at nine different locations in Bangladesh. Location wise potential variety with yield, the highest yielded variety with yield, Average yield of all the varieties and the lowest yielded variety with yield are given in table 6. We found the highest potential yielded variety BRRI dhan46 (6.99 t/ha) at BRRI R/S Sonagazi and the lowest BRRI dhan54 (5.33 t/ha) in BRRI R/S, Rajshahi. In case of the lowest yielded variety BRRI dhan57 shows the minimum yield (0.65 t/ha) in BRRI R/S, Cumilla (Table 6).

From Table 7, the ANOVA results of Combined Analysis, it is clear that the Locations (Different Region of Bangladesh) have significant yield difference though the same variety and management practice are performed. Also the varieties show the significance difference according to yield performance. The DMRT result shows the location BRRI R/S, Sonagazi have significantly yield difference on other locations with average yield 5.39 t/ha also some other location shows significant yield difference to each other (Table 8). For visual convenience the production at different region according to the yield factors are depicted in figure 2.

	Potential Yielded		Highest yielded		All	Lowest Yield	
Season→ Region↓	Variety Name	Yield	Variety Name	Yield	variety Average Yield	Variety Name	Yield
Rangpur	BRRI dhan54	6.64	BRRI dhan54	5.76	3.57	BRRI dhan39	1.33
Rajshahi	BRRI dhan31	5.33	BRRI dhan32	4.84	3.82	BRRI dhan38	2.71
Barisal	BR 22	5.83	BRRI dhan52	5.55	4.12	BRRI Hybrid dhan6	2.23
Bhanga	BRRI dhan54	5.54	BRRI dhan54	5.05	3.11	BRRI dhan44	1.49
Kushtia	BRRI dhan54	5.27	BRRI dhan51	4.95	3.89	BRRI dhan57	2.65
Satkhira	BRRI Hybrid dhan6	6.15	BR 23	5.61	4.50	BRRI dhan34	1.94
Sonagazi	BRRI dhan46	6.99	BRRI Hybrid dhan6	6.76	5.39	BRRI dhan53	3.62
Cumilla	BRRI dhan32	5.80	BRRI dhan32	5.22	3.11	BRRI dhan57	0.65
Gazipur	BR 10	5.21	BR 10	4.64	2.95	BRRI dhan34	1.11

Table 6: Region wise yield performance summary in T. Aman 2017

Table 7: AVOVA of Combined Analysis for T. Aman 2017

SV	DF	Sum Sq	Mean Sq	F Value
Location	8	542.0	67.75	289.134***
Variety	37	195.6	5.29	22.559***
Rep:Location	18	7.9	0.44	1.862*
Variety:Location	294	459.3	1.56	6.667***
Residuals	642	150.4	0.23	

Signif.codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Location	Mean Yield	Lettering	std	Min	Max
Sonagazi	5.39	а	0.89	3.18	6.99
Satkhira	4.50	b	1.00	1.01	6.15
Barishal	4.12	с	0.90	1.90	5.83
Kushtia	3.89	d	0.64	2.22	5.27
Rajshahi	3.82	d	0.71	1.55	5.33
Rangpur	3.57	e	0.87	1.08	6.64
Bhanga	3.11	f	0.93	1.45	5.54
Cumilla	3.11	f	1.07	0.49	5.80
Gazipur	2.95	g	1.07	0.72	5.21

Table 8: Mean Comparison with some descriptive statistics for T. Aman 2017



Figure 2: Production at different region for Aman 2017 in Bangladesh

132

3.3 Boro Season

In Boro season 40 different BRRI released Boro variety are used in the trial at ten different locations in Bangladesh. Location wise potential variety with yield, the highest yielded variety with yield, Average yield of all the varieties and the lowest yielded variety with yield are given in table 9.

	Potential Yielded		Highest yielded		All variety	Lowest Yield	
Season→ Region↓	Variety Name	Yield	Variety Name	Yield	Average Yield	Variety Name	Yield
Rangpur	BRRI Hybrid dhan3	7.21	BRRI Hybrid dhan3	6.97	5.61	BR 17	3.71
Rajshahi	BR 19	7.02	BRRI Hybrid dhan3	6.50	5.69	BRRI dhan36	3.22
Barishal	BR 9	6.21	BRRI Hybrid dhan3	5.44	4.25	BR 17	2.41
Bhanga	BR 15	7.72	BRRI Hybrid dhan2	7.39	5.72	BRRI dhan45	4.15
Kustia	BRRI Hybrid dhan5	8.80	BRRI Hybrid dhan5	8.79	6.47	BRRI dhan27	4.62
Satkhira	BRRI dhan61	8.68	BRRI Hybrid dhan5	8.01	6.55	BR 6	5.24
Sonagazi	BRRI dhan29	7.11	BRRI dhan29	6.91	4.76	BRRI dhan27	3.07
Cumilla	BRRI Hybrid dhan5	10.14	BRRI Hybrid dhan5	9.11	6.28	BR 17	3.12
Habiganj	BRRI Hybrid dhan2	8.50	BRRI Hybrid dhan2	8.21	5.56	BR 17	2.75
Gazipur	BRRI Hybrid dhan3	9.36	BRRI dhan61	8.11	6.22	BR 17	3.06

Table 9: Region wise varietal yield performance summary in Boro 2017-18

We found the highest potential yielded variety BRRI hybrid dhan5 (10.14 t/ha) at BRRI R/S, Cumilla and the lowest BR 9 (6.21 t/ha) in BRRI R/S, Barishal. BRRI hybrid dhan shows the best performance in most of the location. In case of the lowest yielded variety BR 17shows the minimum yield (2.41 t/ha) in BRRI R/S, Barishal (Table 9).

DF	Sum Sq	Mean Sq	F Value
9	547.9	60.88	201.929***
39	349.2	8.95	29.701***
20	21.7	1.08	3.597***
321	425.4	1.33	4.396***
720	217.1	0.30	
	DF 9 39 20 321 720	DFSum Sq9547.939349.22021.7321425.4720217.1	DFSum SqMean Sq9547.960.8839349.28.952021.71.08321425.41.33720217.10.30

 Table 10: AVOVA of Combined Analysis for Boro 2017-18

Signif.codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Table 11: Mean Comparison with some descriptive statistics for Boro 2017-1

Location	Mean Yield	Lettering	std	Min	Max
Satkhira	6.55	а	0.81	4.84	8.68
Kushtia	6.47	а	0.94	4.55	8.80
Cumilla	6.28	b	1.32	1.89	10.14
Gazipur	6.22	b	1.10	2.37	9.36
Bhanga	5.72	С	0.96	4.05	7.72
Rajshahi	5.69	cd	0.70	3.10	7.02
Rangpur	5.61	cd	0.80	2.69	7.21
Habiganj	5.56	d	1.06	2.16	8.50
Sonagazi	4.76	e	0.86	2.94	7.11
Barishal	4.25	f	0.87	1.65	6.21

In Table 10, the ANOVA results of Combined Analysis shows that the Locations (Different Region of Bangladesh) have significant yield difference though the same variety and management practice are performed. Also the varieties show the significance difference according to yield performance. The DMRT result (Table 11) shows the location BRRI R/S, Satkhira have significantly yield difference on other locations with average yield 6.55 t/ha, also some other location shows

Qayum, Hossain, Rahman, Aziz et. al: Region Specific BRRI Variety Adoption ... 135

significant yield difference to each other. For visual convenience the production at different region according to the yield factors are depicted in figure 3.



Figure 3: Production at different region for Boro 2017-18 in Bangladesh

3.4 Total of Aus, Aman and Boro

According to the yield of the experimental data at different region of Bangladesh the total production at different seasons were calculated. From this paddy production we convert it in clean rice production using the average milling outturn 71% (Annual Report of GQN Division, BRRI) (Table 12). For visual convenience the comparison of experimental production and BBS Collected production is depicted in figure 4.

Season	Production (Ton) BBS	Production (Ton) Exp. Potential	Production (Ton) Exp. Maximum	Production (Ton) Exp. Average	Production (Ton) Exp. Minimum
Aus	2133613	2811221	2577834	2053207	1348597
Aman	13656054	23398997	21302665	14916873	7431959
Boro	18013748	26083050	23983354	18611355	10962813
Total	33803415	52293267	47863853	35581436	19743370

Table 12: Total clean rice production at different seasons in Bangladesh



Figure 4: Comparison of Productions at different seasons in Bangladesh

Kabiret. all (2015) showed that the yield gap between farmers field and the experimental field is 20.7%. To consider this yield gap the total production of clean rice was converted by that yield gap percentage (Table 13). The total production of clean rice in Bangladesh with and without yield gap is shown in figure 5.

Table 13: Considering yield gap total clean	ean rice production at different seasons in	1
Banglad	ladesh	

Season	Production (Ton) BBS	Production (Ton) Exp. Potential	Production (Ton) Exp. Maximum	Production (Ton) Exp. Average	Production (Ton) Exp. Minimum
Aus	2133613	2257410	2070001	1648725	1082923
Aman	13656054	18789394	17106040	11978249	5967863
Boro	18013748	20944689	19258633	14944918	8803139
Total	33803415	41991494	38434674	28571893	15853926





136

Qayum, Hossain, Rahman, Aziz et. al: Region Specific BRRI Variety Adoption ... 137

That means if we adopt the potential yielded variety at the respected season and region than total clean rice production reached at 41991494 Ton, In case of the highest yielded variety it reached at 38434674 Ton, for average variety selection estimated production is 28571893 but for wrong selection of variety (the lowest yielded variety) production goes down to 15853926 (Less than half of present production).

4. Conclusion

To increase national production of rice we adopt the potential yielded variety at the respected season and region with the best crop management practice (BRRI Recommended) then the total clean rice production increased by 24.22% from the present production. , in case of the highest yielded variety it increased by 11.03% but for wrong selection of variety (the lowest yielded variety) production decrease more than 50%.

Acknowledgments: Our gratitude goes to the authority of Bangladesh Rice Research Institute (BRRI), Ministry of Agriculture, Government of the People's Republic of Bangladesh for allowing to conduct this study and all the personnel of regional station of BRRI for helping to setup the experiments.

Reference

- [1] M. S. Kabir, M. U. Salam, A. Chowdhury, N. M. F. Rahman, K. M. Iftekharuddaula, M. S. Rahman, M. H. Rashid, S. SDipti, A. Islam, M. A. Latif, A. K. M. S. Islam, M. M. Hossain, B. Nessa, T. H. Ansari, M. A. Ali and Biswas, J. K. (2015). Rice Vision for Bangladesh: 2050 and Beyond, Bangladesh Rice J. 19(2): 1-18.
- [2] BBS (Bangladesh Bureau of Statistics) (2009). Statistical Yearbook Bangladesh, Ministry of Planning, Government of the People's Republic of Bangladesh.
- [3] Singh, V. (1990). Regional Disparities in Agricultural Development, Deep and Deep Publications, New Delhi, India, 13pp.
- [4] Gomez, K. W. and Gomez, A. A. (1984). Statistical procedure for agricultural research, John Wiley & Sons.

- [5] BRRI (2016). Adhunik Dhaner Chas, 18th ed., Gazipur-1701.
- [6] BRRI (2015a). Annual Report 2014-15, Bangladesh Rice Research Institute, Gazipur-1701, Bangladesh.
- [7] Brolley, M. (2015). Rice security is food security for much of the world, Rice Today, International Rice Research Institute (IRRI), DAPO Box 7777, Metro Manila, Philippines, PP. 30-32.
- [8] Nath, N. C. (2015). Food security in Bangladesh: Status, challenges and strategic policy options. Paper presented at 19th Biennial Conference of the Bangladesh Economic Association (BAE), held on 8-10 January, 2015, Dhaka, Bangladesh.
- [9] Salam, M. U., S. M. A. Hossain, J. K. Biswas, and Mridha, A. J. (2014). Managing the unmanageable: rice variety technology for future challenging food security in Bangladesh. Extended abstract in the "Agronomic visions in challenging future", the proceedings of the 13thconference of the Bangladesh Society of Agronomy, 20 September 2014, Bangladesh Rice Research Institute (BRRI), Gazipur, Bangladesh.