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Comparative on farm performance of five modern rice varieties with two local cultivars

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ABSTRACT

Different growth and yield contributing parameters of five modern varieties of rice were compared with two local aman rice cultivars at the farmer's field of Satvaiya para, Khagrachari hill district. Modern varieties showed superiority in most of the characters over local cultivars. Results revealed that, highest plant height (131 cm), days to maturity (145) and longest panicle length (25.49 cm) were found with Binadhan-13; earliest flowering and days to maturity (72 days and 100 days) were recorded in Binadhan-16, total number of tillers per hill (19.80) and thousand seed weight (26.03g) were also found to be maximum by Binadhan-16; percent sterility of spikelets was highest in ChakkaPanja cultivar (33.28%); Binnidhan cultivar produced the highest biological yield (24.14t/ha) and BRRIdhan 71 gave the longest root area (21.43 cm^2). In terms of grain yield, highest was obtained from BRRIdhan 71 (6.03 t/ha) followed by Binadhan-17 (5.05 t/ha); Binadhan-16 (4.51 t/ha); Binadhan-7; Binnidhan (4.44 t/ha); ChakkaPanja (4.07 t/ha) and the lowest was recorded in Binadhan-13 (2.77 t/ha). Though local cultivars are low yielded and of more duration but they are cultivated widely in the hilly areas for their quality and taste. To increase the cropping intensity and yield; the short duration high yielding aman rice varieties may be a better option for the farmers.

Key Words: *Aman rice (rainfed), Hill cultivar, Growth characteristics, Duration and Yield*

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I. Introduction

Dominant food crop of Bangladesh is rice, accounting for about 75 percent of agricultural land use and 28 percent of GDP. It is currently the world's sixth largest producer. The cultivation of rice in Bangladesh varies according to seasonal changes in the water supply. More than half of the total production (55.5%) is obtained in Boro season occurring in April-May and second largest production in aman season (37.9%); occurring in November and December (Asia and pacific commission on agricultural statistics, 2016). Potential for increased rice production strongly depends on the ability to integrate a better crop management for the different varieties into the existing cultivation. Variety itself is a genetic factor which contributes a lot in producing yield and yield components of a particular crop (Mahmud et al. 2013). In the year 2015, among aman rice varieties high yielding modern varieties covered 73.08% and de-husked yield was 2.69 t/ha and local varieties covered 20.99% and de-husked yield was 1.65 t/ha (BBS, 2015). It is the farmers who have gradually replaced the local indigenous low yielding rice varieties by high yielding ones and modern varieties of rice developed by Bangladesh Rice Research Institute (BRRI) and Bangladesh Institute of Nuclear Agriculture (BINA) only because of getting 20 to 30% more yield per unit land area (Shahjahan, 2007). Among the three hill tract districts; Khagrachari occupies about one fifth (2,700 m2) of the total area (Ullah et al., 2012). Currently 37.18% of this area is under irrigation and cropping intensity (CI) is 1.56% (BBS, 2015). Due to unavailability of ground water and extreme irrigation limitation rainfed aman rice is the only hope here; as a result 62.54% of total rice is grown and maximum production is obtained in this season (DAE, 2016). Less input requirement, short durated, high yielding and pest resistance varieties have key advantage over local and hybrid. To increase CI and production, there is no alternative for cultivation of short duration variety and adoption of modern agricultural practices. Most of the farmers cultivate BRRI and local varieties; and a few produce Bangladesh Institute of Nuclear Agriculture (BINA) released varieties here. Total area of aman rice cultivation was 28,225 hectare; among them BRRI released varieties were under 22,700 hectare, local cultivars under 5,414 hectare and BINA released varieties were under 111 hectare land. Average production was 4.07, 4.04 and 2.58 t/ha of BRRI, BINA and local varieties respectively (DAE, 2016). Mahmud et al. (2013) concluded that, rice cultivars differed significantly in all growth characters, such as plant height, tillers number, chlorophyll content, dry matter weight of different plant parts, panicle length, filled grain, unfilled grain, filled grain percentage, 1000-grain weight, grain yield and straw yield. Numbers of seedling(s) per hill had remarkable influence on number of total tillers per hill and total dry matter production. The yield of rice depends on its different growth parameters, i.e. leaf area index, dry matter production and its partitioning, tillering, etc. (Shams, 2002). There are several important factors those have tremendous influence on the growth and development, tiller production, grain formation and other yield contributing characters i.e., age of seedling (Islam and Ahmed, 1981), spacing (Miah et al., 1990). A number of reports showed that indigenous rice cultivars possess a wide diversity in ecological, morphological and physiological characteristics (Jahan et al., 2003). The yield contributing characters specially number of effective tillers/hill, number of grains/panicle, grain yield and straw yield were significantly affected when compared to late transplanting. Many of them obtained better results from early transplanting than late transplanting (Oteng-Darko et al. 2013). Most literature suggests that traditional cultivars are of low tillering capacity (Saito and Futakuchi, 2009). Faruk et al. (2009) reported that four week old two seedlings per hill gave high grain yield. Number of seedlings per hill affected all the yield attributes including the number of tillers per hill, grains per panicle, grain yield. Transplanting of 7-21 day old seedlings with single seedling per hill increased plant growth and grain yield of Ciherang rice (Asbur, 2013). Planting less number of seedlings per hill helps to produce healthy tillers which enables normal physiological growth resulting in more panicles with more filled spikelets and thus produces higher grain yield (Rasool et al. 2012). Transplanting with 2 seedlings per hill at a spacing of 20 cm x 20 cm, Hasanuzaman et al. (2009) obtained higher grain yield than planting with 1, 3 or 4 seedlings per hill. First prerequisite for increasing yield is to ensure abundant growth of a particular crop (Mahamud et al. 2012). Production of local cultivars are very low and often affected by biotic and abiotic stresses. So, it is not sufficient to fulfill farmers demand and expectations. So far among modern aman rice varieties BINA has developed 10 (BINA, 2016) and that of BRRI developed 37 (BRKB, 2016). These are mostly suitable for plain lands. All of these may not be suitable for hilly region. Limited or only trail based rice cultivation has been given so far in improving specific rice variety(s) for the hill tracts. Therefore the present investigation was undertaken to compare the

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morphology, relative advantage and performance of some newly released varieties (from research organizations viz. BINA, BRRI) with popular local cultivars.

II. Materials and Methods

The study was conducted at farmer's field of Satvaiya para under Khagrachari Sadar upazila during the period of July 2016 to November 2016. The experimental field was typical rice growing medium high land of clay-loam soil and it is situated in the Agro ecological Zone (AEZ) 29 (FRG, 2012), i.e., Northern and eastern hills. The geographical situation of the experimental field was subtropical climate characterized by moderately high temperature and heavy rainfall during kharif season (March to October) and low rainfall and low temperature during the rabi season (November to February). It was a typical rice growing medium high land of clay-loam with grey colored and moderately acidic in nature. Randomized Complete Block Design (RCBD) with three replications was followed to setup the experiment. Studied field was firstly divided into three equal blocks and each block was further divided into seven unit plots. The size of unit plot was 10 m^2 (4 m × 2.5 m). Total number of plots were twenty one. Block to block distance was 1.0 m and plot to plot was 50 cm. Five modern varieties viz. Binadhan-7, Binadhan-13, Binadhan-16, Binadhan-17, BRRIdhan 71 and two local cultivars viz. ChakkaPanja and Binnidhan were used. Pre germinated seed were sown in the wet seedbed during aman season on 2nd July, 2016. Transplanting was done with three seedlings per hill maintaining 20 cm hill to hill and 20 cm line to line spacing on 2nd August, 2016. The experimental plot was uniformly fertilized (FRG, 2012) with Urea, TSP, MoP, Gypsum and Zinc sulphate @ 130, 50, 80, 44.5 and 2.0 kg/ha respectively. The total TSP, MoP, Gypsum, Zinc sulphate, one third of Urea were applied as basal dose and Furafuran 5G @10 kg/ha was mixed with these fertilizer and applied to the experimental field to control soil borne pest. The rest of the urea was top dressed at two equal split doses at 30 days after transplanting (DAT) and at 50 DAT. Virtako @ 75g/ha was applied with two split doses of urea to prevent stem borer infestation. Rifit 500 EC @ 988mL/ha was applied as pre-emergence weedicide to control weeds. Two hand weeding were done to check weed infestation in the experimental field at 25 DAT and 40 DAT. No major irrigation was applied as aman rice is grown in rainfed condition by farmers. Single irrigation by flood irrigation method was given at dough stage. During the experimentation fungal diseases were controlled by applying Amistar Top @ 500mL/ha and EminentPro @ 790mL/ha. Some insect pest like grass hopper and rice bug were controlled by spraying Syfanon 57 EC @ 988mL/ha. Binadhan-16 was harvested on 9th October, 2016; Binadhan-17 was harvested on 14th October, 2016; Binadhan-7 was harvested on 19th October, 2016; BRRIdhan 71 was harvested on 21st October, 2016; ChakkaPanja was harvested on 9th November, 2016; Binnidhan was harvested on 20th November, 2016 and at last Binadhan-13 was harvested on 23rd November, 2016. Randomly 10 hill were selected from unit plot and plant data were recorded after final harvest on- Plant height (cm), Days to fifty percent flowering, Number of effective tillers/hill, Number of non-effective tillers/hill, Total tillers/hill, Panicle length (cm), Number of filled spikelets/panicle, Number of unfilled spikelets/panicle, Sterility percent, 1000 seed weight(g), Dry straw weight(g), Root length/plant (cm^2), Days to maturity, Grain yield (t/ha), Straw yield (t/ha), Biological yield (Grains yield + straw yield) and Harvest index (HI)% was calculated on the basis of adjusted grain and straw weight provided by Munshi et al. (2016). The collected data were statistically analyzed using "Analysis of variance technique" with the help of computer package program MSTAT and the significance of mean difference was adjudged by Duncan's Multiple Range Test (Russell, 1986) at 5% level of significance.

III. Results and Discussion

Plant height

Highest plant height was observed in Binadhan-13 (131.0 cm) and BRRIdhan 71 (128.9 cm). Binadhan-16 and ChakkaPanja produced statistically similar height (Table 01). Binadhan-17 (109.9 cm) and Binadhan-7 (112.2 cm) had the lowest plant height compared to the other varieties and cultivars. Difference in plant height of the cultivar/varieties were mainly due to varietal variation. Sarkar (2014) also recorded variable plant height due to varietal differences.

Days to 50% flowering

Binadhan-16 took lowest days (72) to 50% flower initiation (Table 01); while it was highest in Binadhan-13 (117.7). Binadhan-16 may had the genetic potentiality to bear early flower; on the other

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Binadhan-13 is a long duration aromatic variety thus it took more days to flower initiation than the all other varieties and cultivars (BINA, 2016). Alam et al. (2014), reported that, days to 50% flowering was positively and significantly correlated with days to maturity.

Panicle Length

Longest panicle length (25.49 cm) was found in Binadhan-13, which was statistically identical to BRRIdhan 71 (25.39 cm), Binadhan-7 (25.32 cm) and Binadhan-16 (24.94 cm). Shortest length (21.11 cm) was observed in ChakkaPanja cultivar (Table 01). Panicle length was longer in modern varieties than the local cultivars. Thus, length of panicle was more in Binadhan-13, BRRIdhan 71, Binadhan-7 and Binadhan-16 and less in ChakkaPanja cultivar. This result is consistent with findings of Sarkar (2014) who reported that panicle length significantly varied among varieties.

Number of filled spikelets/panicle

BRRIdhan 71 had significantly maximum number of filled spikelets/panicle (86.16) compared to all other varieties and cultivars (Table 01). Binadhan-16 (67.80), Binadhan-7 (67.37), ChakkaPanja (65.82), Binadhan-17 (61.84) and Binadhan-13 (61.20 cm) gave statistically identical result. Minimum number of filled spikelets/panicle (50.53) was observed in Binnidhan. Variation in grain filling may have occurred due to genetic, environmental or cultural management practices adopted. Dutta et al. (2002) observed that yield was affected by the filled grains/panicle. Kiani and Nematzadeh (2012) observed that filled grains/panicle correlated significantly with grain yield. Roy et al. (2014) reported that the number of spikelets per panicle in indigenous rice is generally lower. Sarkar (2014) reported that number of filled grains/panicle influenced significantly due to variety.

Number of unfilled spikelets/panicle

There were significant differences amongst varieties and cultivars in number of unfilled spikelets/panicle (Table 01). BRRIdhan 71 showed the highest number of unfilled spikelets/panicles (38.15) and Binidhan had the lowest number of unfilled spikelets/panicles (17.18). Though most of the modern varieties have few unfilled grains per panicle but here cultural management and environmental conditons may have effected this character.

Sterile spikelets (%)

Maximum grain sterility (33.28%) was recorded in ChakkaPanja cultivar (Table 01) which was significantly higher than Binnadhan-17 (25.71%), Binnidhan (25.68%), Binadhan-13 (24.09%) and Binadhan-16 (23.46%). Variation in sterility might be due to supply of insufficient food materials, moisture and light for plant in closer spacing. Rice produces 15-20% sterile grains (BRKB, 2016). Sohel et al. (2009) reported that difference in spikelets sterility varied significantly by variety and plant spacing.

Table 01. Growth and yield contributing characters of seven Aman rice varieties/cultivars

Variety	Plant Height (cm)	Days to 50% flowering	Panicle Length (cm)	No. of filled spikelets/ panicle	No. of Unfilled spikelets/ panicle	Sterile spikelets (%)
Binadhan-7	112.2 de	79.00 e	25.32 a	67.37 b	29.71 c	30.48 b
Binadhan-13	131.0 a	117.7 a	25.49 a	61.20 b	19.15 de	24.09 c
Binadhan-16	119.6 b	72.00 g	24.94 a	67.80 b	20.78 d	23.46 c
Binadhan-17	109.9 e	77.00 f	23.73 b	61.84 b	21.30 d	25.71 c
BRRIdhan 71	128.9 a	86.00 d	25.39 a	86.16 a	38.15 a	30.81 ab
ChakkaPanja	116.4 bc	93.00 c	21.11 d	65.82 b	32.81 b	33.28 a
Binnidhan	114.1 cd	108.2 b	22.43 c	50.53 c	17.18 e	25.68 c
LSD (5%)	*3.962*	*1.523*	*0.7521*	*10.18*	*2.273*	*2.604*
CV	*2.86%*	*1.45%*	*2.68%*	*13.28%*	*7.63%*	*8.09%*

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Number of tillers per hill

Significantly higher total number of tillers per hill (Figure 01) were produced by Binadhan-16 (19.8) and Binadhan-7 (17.57); whereas BRRIdhan 71 (7.95) gave the lowest number of tillers per hill. Number of non-effective tillers per hill was lowest in BRRIdhan 71(0.133) which was statistically different to the other cultivar/varieties. On the other hand, highest number of non-effective tillers per hill was produced by Binadhan-7 (2), Binadhan-13 (1.87) and Binadhan-16 (1.57); which were statistically similar. Jisan et al. (2014) concluded that, variation in number of tillers per hill might be due to varietal characters.

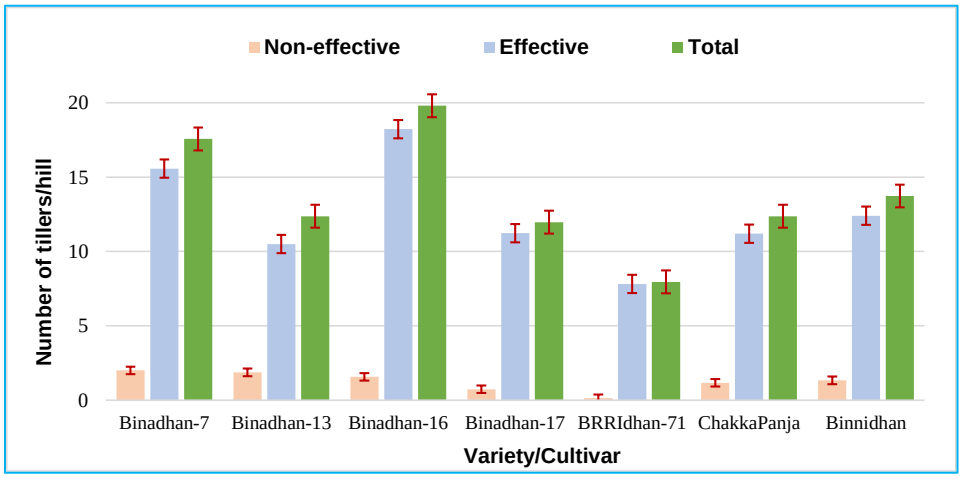

Figure 01. Number of tillers per hill of different variety/cultivars.

1000 grain wt. (g)

Highest 1000 grain weight was recorded in Binadhan-16 (26.03 g); and lowest was in Binadhan-13 (13.67 g) (Table 02). Highest 1000 grain weight of Binadhan-16 was may be due to long and fine grain and lowest weight of Binadhan-13 may be due to small sized grain, round shape and aromatic. Roy et al. (2014) studied on 12 rice varieties and found difference in thousand weight of grains due to morphological and varietal variation. Mondal et al. (2005) stated that 1000-grain weight differed significantly among the 17 aman cultivars studied.

Dry Straw weight (g/hill)

Varieties differed significantly in their dry straw weight (Table 02). The highest straw weight was recorded in Binnidhan (78.80 g/hill) followed by Binadhan-13 (51.50 g/hill). The lowest straw weight was observed in ChakkaPanja (24.90 g/hill) followed by BRRIdhan 71(27.60 g/hill) and Binadhan-17 (30.30 g/hill). Delayed maturity and long duration may have caused in higher straw weight per hill in Binnidhan and Binadhan-13. Medium plant height, short duration and high yield may be the reason of low straw weight in ChakkaPanja, BRRIdhan 71 and Binadhan-17. The result are in accordance with the findings of Hossain (2002). Pheloung and Siddique (1991), reported that straw yield could be assigned to plant height. Sarkar (2014), reported that, straw weight differed significantly due to varieties.

Root length (cm^2)

Rooting depth of BRRIdhan 71 (21.43 cm^2) was significantly higher than all other varieties and cultivars. ChakkaPanja (7.30 cm^2) had the minimum rooting depth (Table 02). Higher rooting depth indicates more nutrient and moisture uptake. So, BRRIdhan 71 had the ultimate higher yield than ChakkaPanja cultivar. Islam et al. (2009) reported that higher rooting depth might be due to thinner roots and it differs among varieties.

Harvest Index (HI) (%)

BRRIdhan 71 had significantly highest HI (%) (46.73). Binnidhan and Binadhan-13 gave significantly lowest harvest index (18.25 and 17.69 respectively) (Table 02) which were statistically identical. Dry matter partitioning to economic yield was superior in BRRIdhan 71 compared to the other varieties/cultivars such as- Binnidhan and Binadhan-13. Harvest index is a vital character having physiological importance. It reflects translocation on alternatively dry matter partitioning of a given genotype to the economic parts. Kusutani et al. (2000) highlighted the contribution of high harvest

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index to yields. High yield is determined by physiological process leading to a high net accumulation of photosynthates and their partitioning (Miah et al. 1990). Jisan et al. (2014) and Tyeb et al. (2013) reported that variety has significant influence on harvest index.

Table 02. Seed, straw, root and harvesting index characteristics of the studied variety/cultivars

Variety	1000 grain wt. (g)	Dry Straw weight (g/hill)	Root length (cm^2)	HI (%)
Binadhan-7	22.30 c	39.73 c	12.73 c	30.33 c
Binadhan-13	13.67 e	51.50 b	9.17 d	17.69 d
Binadhan-16	26.03 a	39.45 c	17.40 b	31.52 c
Binadhan-17	24.00 b	30.30 d	18.65 b	39.86 b
BRRIdhan 71	22.00 c	27.60 de	21.43 a	46.73 a
ChakkaPanja	15.02 d	24.90 e	7.30 e	39.53 b
Binnidhan	24.00 b	78.80 a	18.50 b	18.25 d
LSD (5%)	*0.4644*	*3.535*	*1.200*	*4.496*
CV	*1.90%*	*7.27%*	*6.86%*	*12.07%*

In a column figures having same letter (s) do not differ significantly at $P \leq 0.05$

Days to maturity

Binadhan-13 required maximum days (145) to maturity followed by Binnidhan (143) and Chakkapanja (131). Contrary, Binadhan-16 took the minimum days (100) to mature (Figure 02). Traditional cultivars are generally of long duration and thus Binnidhan had the longest maturity days. But, Binadhan-13 matures within 138-142 days (BINA, 2016). Therefore cultural management, soil and climatic conditions (adaphic factors) may have effected in the duration of maturity. Awal et al. (2007) reported that, conventional varieties required 133-150 days for maturity. Ghosh et al. (2015) recorded variation of days to maturity due to different varieties. Haque et al. (2016) who reported wide genotypic variation in phenological events among 14 aus cultivars. Ahmed et al. (2015) demonstrated significant differences in attaining phenological stages due not only to varieties but also to variable management practices.

Yield

Among the seven varieties/cultivar studied BRRIdhan 71 yielded (6.03 t/ha) significantly higher than others (Figure 03). Binadhan-13 had the minimum yield (2.77 t/ha) which was significantly lowest than rest of the varieties/cultivars. More number of grains per panicle, less number of non-effective tillers and higher root length of BRRIdhan 71 may have resulted in higher yield. Poor tillering, less number of grains per panicle, lodging tendency and more straw yield may be the reasons for such lower yield in Binadhan-13. Varietal differences of grain yield were reported by Biswas et al. (1998). The genotypes, which produced higher number of effective tillers per hill and higher number of grains per panicle also showed higher grain yield in rice (Dutta et al. 2002). Yield differences due to varieties were recorded by Islam et al. (2014) who observed variable grain yield among varieties.

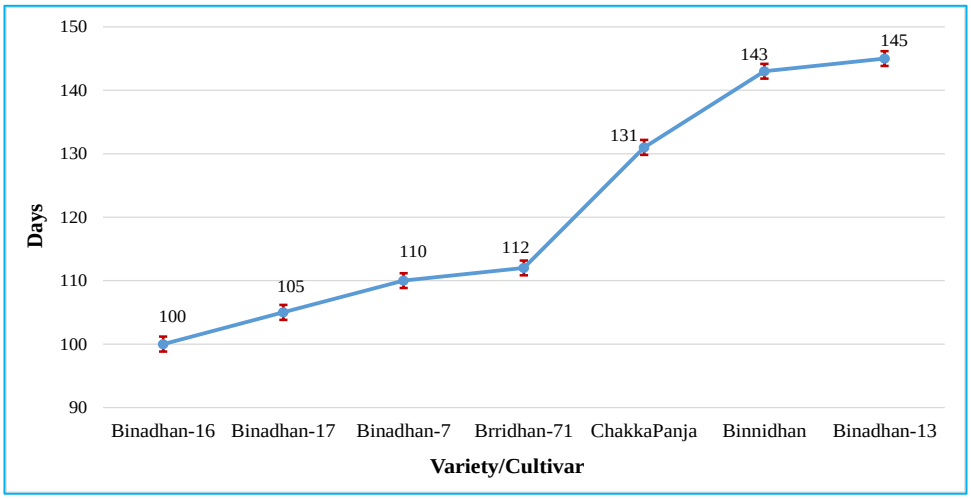

Figure 02. Maturity days of different varieties/cultivars.

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Significantly highest biological yield was obtained from Binnidhan cultivar (24.14 t/ha) and lowest was found in Binadhan-17 (12.63 t/ha) and BRRIdhan 71 (12.94 t/ha); which were statistically identical (Figure 03). Variation in maturity and duration may be the reason for differences in biological yield. As a result, Binnidhan and Binadhan-13 gave more biological yield and Binadhan-17 and BRRIdhan 71 had low yield. Munshi (2005) reported that grain yield was positively correlated with biological yield in rice. Sarkar et al. (2016) reported varied biological yield among different rice varieties.

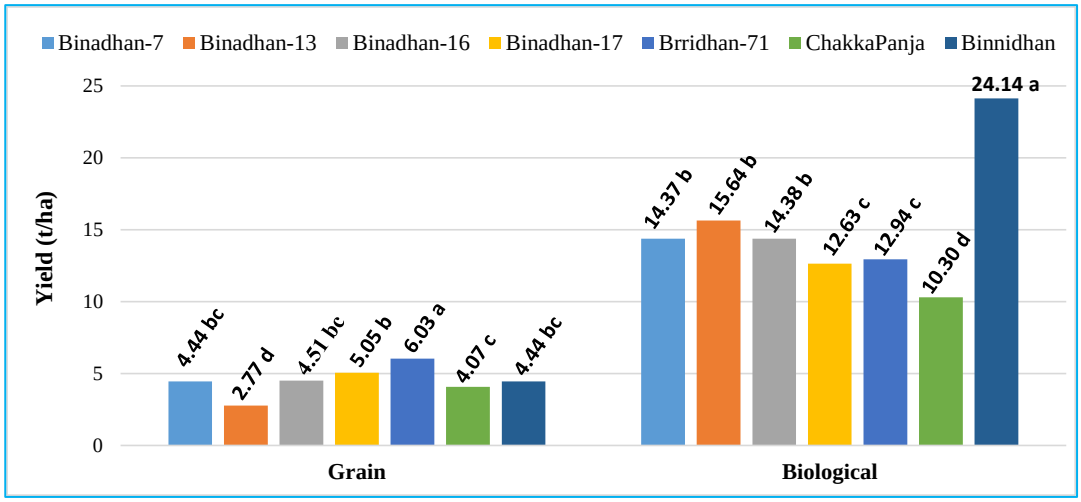

Figure 03. Yield of different aman rice varieties/cultivars.

IV. Conclusion

Modern varieties and local cultivars showed wide variation in respect of agronomic parameters and crop duration. Maximum grain yield was obtained from BRRIdhan 71 (6.03 t/ha) with crop duration of 112 days followed by Binadhan-17 (5.05 t/ha) with crop duration of 105 days; While locally cultivated Binnidhan and ChakkaPanja yielded 4.44 t/ha and 4.07 t/ha with duration of 143 and 131 days respectively. Local cultivars ChakkaPanja and Binnidhan were highly preferred by the farmers due to its wide adaptability and good taste. Considering above facts necessary steps should be undertaken to reduce the crop duration of this two local cultivars.

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Figure 04. Plant height of Binadhan-7 (A), Binadhan-13 (B), Binadhan-16 (C), Binadhan-17 (D), BRRIdhan 71 (E), ChakkaPanja (F) and Binnidhan (G).

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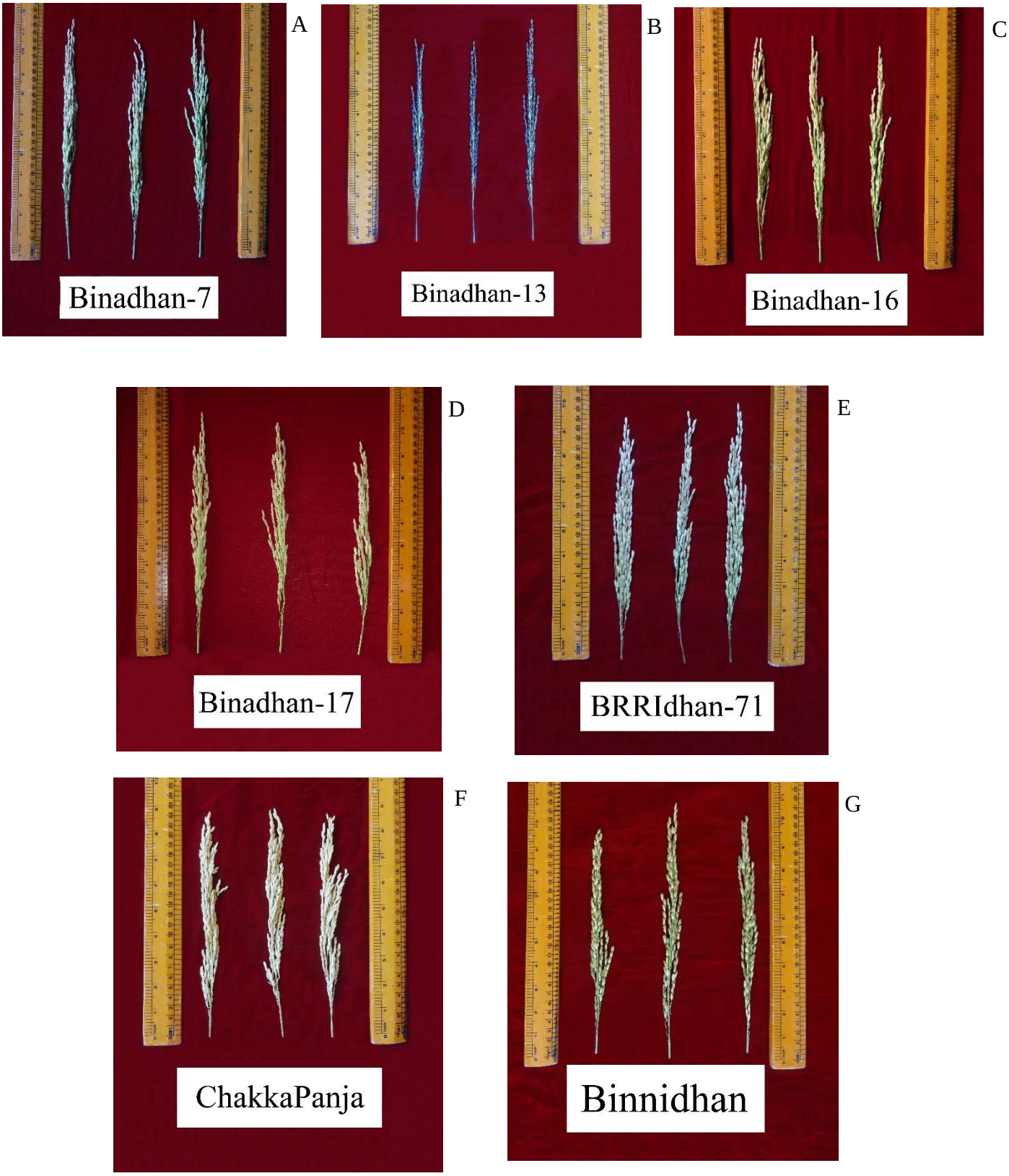

Figure 05. Panicle length of Binadhan-7 (A), Binadhan-13 (B), Binadhan-16 (C), Binadhan-17(D), BRRIdhan 71 (E), ChakkaPanja (F) and Binnidhan (G).

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Figure 06. Grain morphology of Binadhan-7 (A), Binadhan-13 (B), Binadhan-16 (C), Binadhan-17 (D), BRRIdhan 71 (E), ChakkaPanja (F) and Binnidhan (G).

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