Growth, Yield and Organoleptic Characteristic of Rice (*Oryza sativa* L.) Varieties in Wet Rice Cultivation Region of Mizoram

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Abstract: The lower rice productivity has been a major concern for Mizoram rice sustainability under the rainfed wet rice cultivation (WRC). Bridging this yield gap, field experiment has been undertaken with 22 rice varieties (Gomati, NLR-1, NLR-2, NLR-3, NLR-4, NLR-5, NLR-9, PB-1121, PB-1718, RCM-9, RCM-10, Shahsarang, PNR 546, Tripura Nirogi, Tripura Sarat, Tripura Chikan, Tripura Hakuchuk, PS-5, PD-13, TRC-2015-7, TRC-2013-11 and Local cultivar) at WRC region of ICAR Kolasib research farm under RBD design for two years (2019 and 2020). The rice *cv* Gomati performed best under the humid subtropical hill region of Mizoram with 152.5% higher grain yield as compared with local cultivar. Gomati recorded high leaf area index, higher productive tillers per hill with medium duration. Apart from rice *cv* Gomati; RCM 9, RCM 10, NLR 1, NLR 9, PNR 546 and TRC 2015-7 recorded nearly double yield than that of local cultivar. However, even with high yield performance of above rice varieties, some of these varieties are not very well adopted by Mizo farmers due to taste requirements of Mizo people. Based on appearance, taste, consistency, aroma and hardness of tested rice varieties, PNR 546, RCM 9 and Tripura Chikan were confirmed at par taste with the local rice cultivar. Most of these varieties matured in about 130-150 days, with very few maturing in about 120-130 days (PNR 546, PS 5 and PD 13) and local cultivar at 159 days. Thus, with adoption of best suitable high-yielding medium duration rice varieties with their preference to taste will enhance rice productivity and narrow down the yield gaps that existed in WRC local rice cultivar of Mizoram.

Keywords: Rice, Mizoram, WRC, Yield, Taste, Crop duration

Rice (*Oryza sativa* L.) is the staple food for a major portion of the world population. In India, it occupied the major area and production with 44.2 million hectares and 116.4 million tonnes, respectively in 2018-19 (Anonymous, 2021a). This comprises 35.1% area and 40.8% production among the total food grains of India. North-East states of India are located in the easternmost part of India comprising Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura. Among them, Mizoram is one of the easternmost states situated in tropical hilly and pre-dominated by tribes called Mizo. These states have rice as a major staple crop with major source of livelihood, food and nutritional security. All these north-eastern states comprised a total rice area of 3.2 million hectares, 7.2 million tonne of production and 2213 kg/ha productivity. Mizoram having 35,210 hectare of rice area with productivity of 1704 kg/ha in 2019-20 (Anonymous 2021b). This total rice area of Mizoram includes upland rice and wet rice cultivation (WRC) area and out of which, WRC area constitutes 17,265 hectares (Mizoram Economic Survey, 2019-20). Most of the agricultural crops including rice (90% of the cultivated crop) in Mizoram are cultivated as rainfed. The area under rice decreased by 35.1% whereas, productivity decreased by 14.8% from 2000-01 to 2019-20 (Mizoram Economic Survey 2019-20). This decrease in area

and productivity of rice in Mizoram is mainly due to the cultivation of lower yielded upland rice under jhum, non-availability of suitable high yielding rice varieties, least mechanization, low adoption of scientific agronomical practices, high cost of cultivation, and replacement of upland rice area with high-valuing horticultural crops, *etc*. Under the WRC system of cultivation, major rice cultivars are of local landraces and other varieties that are being preferred by Mizos due to their taste. However, these varieties are long to extra-long duration having low yield potential, susceptible to lodging during the later growth stages resulting in low yield and poor quality. Therefore, keeping this background in view an experiment has been undertaken to find the most suitable rice varieties for Mizoram having higher yield potential, medium duration with taste acceptability by Mizo people.

MATERIAL AND METHODS

Experimental site: The study was conducted at Research Farm, ICAR RC NEH Region, Mizoram Centre Kolasib, Mizoram, India during *Kharif* 2019 and *Kharif* 2020 to find out the lodging resistance high yielding rice variety suitable for the wet rice cultivation (WRC) region of Mizoram region. The field is located at 24°12'46.03"N latitude and 92°40'37.07"E longitude under the Humid Subtropical Hills

agro-climatic region of Mizoram (as per NARP) and Eastern Himalayan Region (II) agro-climatic region of India (as per Planning Commission).The two-season monthly mean minimum and maximum temperatures during the cropping period were 20.8 and 29.0°C, respectively. The monthly average minimum and maximum relative humidity was 77.5 and 90.5%, respectively having a monthly average bright sunshine hour of 5.1 hrs per day. The average total rainfall during two crop seasons was 2537.8 mm with an average of 16.8 rainy days per month (Fig. 1). The soil belongs to clayey loam with slightly acidic in nature (pH 5.2). The bulk density of the soil is 1.42 Mg m^{-3} and has high organic carbon content (1.3%), low in available nitrogen (251.0 kg/ha), medium in available phosphorus (10.5 kg/ha) and medium in available potassium (289.7 kg/ha).

Experimental details: Rice (*Oryza sativa*) was sown in the experiment under randomized block design with three replications. 22 rice varieties *viz*., Gomati, NLR-1, NLR-2, NLR-3, NLR-4, NLR-5, NLR-9, PB-1121, PB-1718, RCM-9, RCM-10, Shahsarang, PNR 546, Tripura Nirogi, Tripura Sarat, Tripura Chikan, Tripura Hakuchuk, PS-5, PD-13, TRC-2015-7, TRC-2013-11 and Local cultivar were selected as varietal treatments. These varieties were collected from different north-eastern states of India based on its performance and farmers' acceptability. These varieties were raised in the nursery for 24 days during the last week of April months in both the seasons. During the nursery period, the main field was prepared by puddling with power tiller having cage wheel twice and levelled. One seedling per hill was sown at a spacing of 22.5 cm x 15 cm with a net plot size of 12 m^2. During the transplanting time, the field was maintained at the saturated condition with no standing water. All other crop management practices like fertilization, weed and pest management and irrigation was done as per recommended agronomic package of practices.

Crop growth and yield parameters: The plant height (cm) from five tagged plants from each plot was taken at the harvest stage; leaf area (cm^2) was measured from each plot at 60 and 90 DAT. Five plants were pulled out, leaves were detached and fresh leaves were placed in leaf area meter (LI-COR LI-3100C area meter) to record leaf area (cm^2) and leaf area index (LAI) was calculated by formula coined by Yoshida et al (1976).

$$LAI = \frac{\text{Leaf area per plant (cm}^2)}{\text{Spacing (cm}^2)}$$

Crop duration was recorded from date of sowing to the time of harvesting. Yield attributes like productive tillers per hill, number of grains per panicle, test weight (1000 grain weight); grain yield (kg/ha) and biological yield (kg/ha) were recorded at harvest.

Organoleptic analysis: Sixteen (16) best performing rice varieties among 22 varieties under study were evaluated for organoleptic analysis based on appearance, taste, consistency, aroma and hardness. 5.0 g of rice kept in 15 ml of water and soaked for 10 min and cooked. Based on number of variety and panellist, number of samples were cooked and served to 19 taste panellists (Anonymous 2004). Organoleptic evaluation of the samples was done using 5
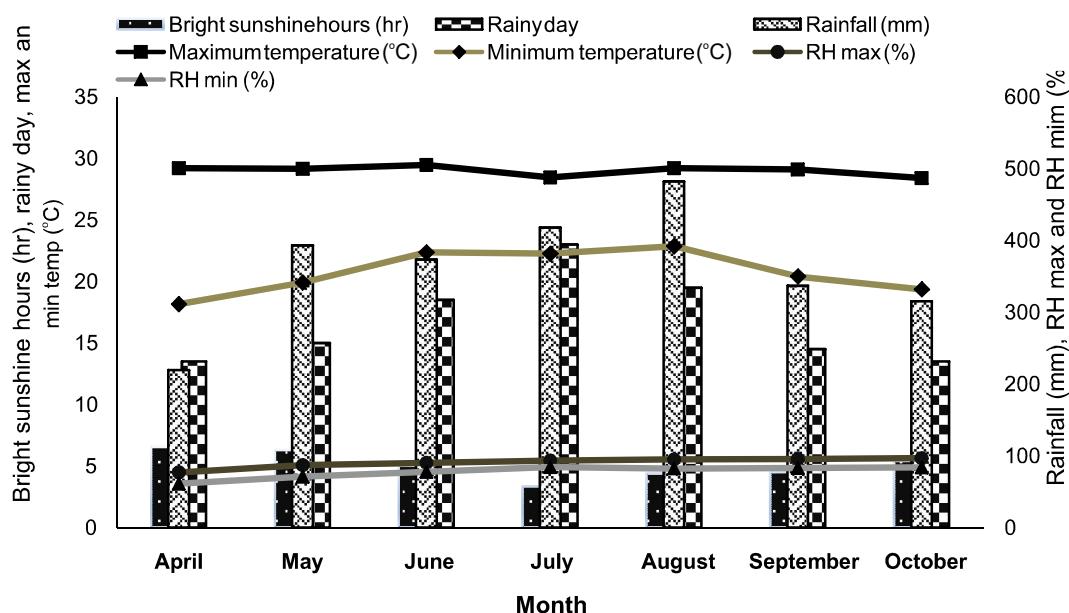

Fig. 1. Mean monthly weather condition (*Kharif* 2019 and 2020)

point hedonic scale (5 – Very good to 1 – Poor; Amerine et al 1965).

Statistical analysis: Data were analysed using OPSTAT software with the link http://14.139.232.166/opstat /default.asp. The response of treatments was similar during both the years and followed the homogeneity test.

RESULTS AND DISCUSSION

Crop growth and yield parameters: Crop growth and yield parameters of rice varieties varied under the same growing conditions. Significant variations in leaf area index (LAI) were observed at 60 and 90DAT, respectively. The significant higher LAI at 60 DAT was recorded in Gomati variety (3.06) that was at par with NLR-4,5,9, TRC-2015-7 and TRC-2013-11 whereas lowest was in PD-13 (2.03). Similarly at 90DAT, significantly higher LAI was observed under Gomati variety (4.28) at par with NLR 1,2,3,4,5,9, RCM 9, 10, local, TRC-2015-7 and TRC-2013-11. The significant lowest LAI was observed in PB-1718 (2.80) (Table 1). This might be due to genetic makeup of rice varieties having different ability to accumulate the photosynthates supplemented with conductive climatic condition. These results were also supported by finding of Kumar et al (2017). Among the 22 rice varieties evaluated for Mizoram, days to maturity varied from 124 days (PD 13) to 159 days (local rice) (Table 1). It was observed that local rice cultivar recorded significantly longest crop duration (159 days) followed by NLR 2 and Tripura Sarat whereas, significantly shortest crop duration was observed under PD 13 (124 days). Days to maturity varies with rice varieties due to genetic traits of cultivars with conductive climatic condition (Ojha 2013).

At maturity stage of rice, tallest plant was recorded in local rice cultivar (183.0 cm) followed by TRC 2013-11 while PD 13 with shortest plant height (Table 2). Number of tillers per hill is an important yield attributing parameter and significantly higher number of productive tillers per hill was recorded in Gomati (15.8 statistically at par with RCM 9 and least was

observed in PS 5 (6.0). The number of grains per panicle was significantly higher in TRC 2015-7 (118.6) and was followed by Tripura Hakuchuk and significantly least in PD 13 (41.6). This might be due to varietal genetic characteristics combined with congenial environment conditions favouring healthier plant, more productive tillers per hill and higher

Table 1. Leaf area index of different rice varieties at humid sub tropical hills region of Mizoram

Variety	Leaf area index		Crop duration (days)
	60 DAT	90 DAT	
Gomati	3.06	4.28	148.7±0.7
NLR 1	2.55	3.92	142.3±2.0
NRL 2	2.49	3.84	151.0±0.6
NRL 3	2.72	3.95	145.7±3.4
NLR 4	2.89	4.17	145.7±0.9
NLR 5	2.91	4.16	149.3±0.7
NLR 9	2.97	4.07	148.7±0.3
PB 1121	2.06	2.85	149.3±0.7
PB 1718	2.21	2.80	149.3±0.7
RCM 9	2.65	3.89	148.7±0.3
RCM 10	2.50	4.21	148.7±0.7
Shahsarang	2.54	3.12	149.3±0.7
PNR 546	2.66	3.18	129.3±1.8
Tripura Nirogi	2.69	2.97	133.0±3.8
Tripura Saarat	2.25	2.91	151.0±0.6
Tripura Chikan	2.49	3.28	141.7±2.2
Tripura Hakuchuk	2.18	3.02	131.0±2.6
PS 5	2.54	3.13	125.0±0.6
PD 13	2.03	2.81	123.7±1.9
TRC 2015-7	2.98	3.68	143.3±2.2
TRC 2013-11	2.86	3.67	143.3±2.2
Local	2.66	3.89	159±0.67
LSD (p=0.05)	0.22	0.71	4.0

Fig. 2. Rice panicle of selected rice variety under study

grain per panicle and also, the differential life span of the varieties. Longer the duration of rice varieties produced better yield components than shorter duration varieties (Chaudhary et al 2008, Mandal et al 2018). The 1000 grain weight of rice varieties under study was in the range of 20.5 to 33.7 g. The significantly higher 1000 grain weight was recorded in NLR 9 (33.7 g) followed by Gomati whereas least weight was recorded in PS 5 (20.5g). The variation in 1000 grain weight between the varieties was mainly due to grains boldness, fineness and length. It is also affected by climatic conditions associated with different rice variety's duration.

Grain yield was significantly higher in Gomati (3884 kg/ha) and was statistically at par with RCM 10 and NLR 9 and significantly least grain yield was obtained in PB 1121 (1060 kg/ha) (Table 2, Fig. 2). The best performing varieties *viz*., Gomati and RCM 10 was out yielded 152.5 and 139.9%, respectively from local cultivar. The higher yield of above varieties are due to higher values of one or more yield attributes of rice *viz*., number of effective tillers per plant, number of grains per panicle and 1000 grain weight *etc*. Similar finding was reported by Kitilu et al (2019). However, the significantly higher biological yield was obtained in NLR 4 (15454 kg/ha) at par with Gomati, NLR 9, RCM 10, Shahsarang, Local and Tripura Chikan. The lowest biological

yield was observed in PB 1718 (5638 kg/ha). The rice biological yield is the combined weight of rice grain yield and straw yield. However, when comparison has been made among different varieties under same ecological condition, it was found that sometime higher vegetative growth of one variety does not yielded more grain yield, this might be due to poor translocation of photosynthate from source to sink, genetic makeup and weather condition prevailing to that region. Therefore, even higher biological yield of some of rice varieties doesn't reflect higher grain yield. These results are in line with finding of Baishya et al (2015) and Mandal et al (2018). Harvest index (HI) is the depiction of ratio between grain yields to biological yield. TRC 2015-7 recorded significantly higher HI (0.39) statistically at par with PNR 546, Tripura Hakuchuk, RCM 9, NLR 1, TRC 2013-11, Tripura Nirogi, NLR 5 and PS 5 while lowest HI (0.16) were observed under NLR 4, PB 1121 and Local cultivar (Table 2). The higher HI was due to good partitioning efficiency of plants and process of translocating more photosynthates from source to sink that reflected higher HI (Kitilu et al 2019).

Organoleptic analysis: The overall mean scores for the organoleptic analysis based on appearance, taste, texture, aroma, hardness, and overall acceptability showed significant differences. Overall organoleptic mean scores of

Table 2. Yield attributes and yields of different rice varieties at humid subtropical hills region of Mizoram (Mean±SD)

Rice variety	Plant height (cm)	No of productive tillers per hill	No of grains per panicle	1000 grain weight (g)	Grain yield (kg/ha)	Biological yield (kg/ha)	Harvest index
Gomati	149.0±0.3	15.8±0.3	86.0±4.9	30.3±0.5	3884±245	14854±381	0.26±0.02
NLR 1	142.0±4.7	9.5±0.4	98.7±4.9	27.0±0.3	3143±265	10330±1110	0.31±0.02
NRL 2	154.5±3.3	8.6±0.9	58.8±0.7	26.3±0.3	2190±323	9985±2111	0.23±0.03
NRL 3	149.9±1.1	7.4±0.9	94.5±9.3	27.5±0.7	2310±136	10312±202	0.22±0.01
NLR 4	149.3±0.4	7.1±0.2	94.6±6.0	28.4±0.6	2312±279	15454±1647	0.16±0.04
NLR 5	144.4±4.3	8.7±0.4	96.1±4.7	28.5±0.3	2963±50	10521±262	0.28±0.00
NLR 9	135.4±0.7	11.6±0.9	88.2±2.5	33.7±0.6	3496±203	14087±1417	0.26±0.04
PB 1121	134.9±0.4	11.3±1.1	65.5±8.9	24.3±0.1	1060±166	6831±937	0.16±0.01
PB 1718	147.7±0.1	10.4±0.2	67.1±7.7	25.2±0.1	1119±184	5638±1452	0.21±0.03
RCM 9	132.7±2.6	13.6±0.2	65.2±1.6	25.5±0.2	3345±164	10293±526	0.33±0.03
RCM 10	156.0±8.4	12.7±0.7	87.1±3.4	26.2±0.1	3690±214	13979±130	0.26±0.01
Shahsarang	137.8±0.4	9.2±0.1	79.7±5.9	25.2±0.6	2892±107	13167±1662	0.23±0.04
PNR 546	131.3±7.6	11.1±0.1	92.0±3.8	28.6±0.5	3075±209	8390±225	0.37±0.03
Tripura Nirogi	143.5±0.2	7.2±0.1	67.2±5.1	26.0±0.0	2833±180	9863±701	0.29±0.01
Tripura Saarat	158.6±2.4	9.4±1.4	50.0±0.8	28.1±0.2	1199±161	6895±1980	0.19±0.03
Tripura Chikan	132.3±2.1	10.1±1.4	73.7±2.1	30.2±0.8	2223±240	12094±2196	0.20±0.05
Tripura Hakuchuk	147.7±0.4	7.5±0.6	110.2±4.4	24.3±0.1	2630±44	7523±375	0.35±0.01
PS 5	121.3±3.6	6.0±0.2	96.3±6.3	20.5±0.3	2665±47	9714±1150	0.28±0.03
PD 13	77.7±0.7	8.4±0.9	41.6±3.8	21.0±0.6	1451±43	6149±77	0.24±0.01
TRC 2015-7	135.3±2.5	10.2±0.1	118.6±5.1	22.4±0.2	3267±251	9014±1258	0.39±0.09
TRC 2013-11	172.9±2.9	10.6±0.7	47.1±8.2	24.9±0.4	2238±38	8834±1474	0.29±0.05
Local	183.0±4.1	7.7±0.3	67.6±4.3	23.3±0.1	1538±115	12409±3231	0.16±0.06
LSD (p=0.05)	9.1	2.9	7.8	1.2	463	4030	0.12

Table 3. Organoleptic score in hedonic scale of different rice varieties

Rice variety	Organoleptic score in 5 points hedonic scale (5-very good to 1-Poor)
Gomati	3.4±0.15
NLR 1	3.2±0.13
NLR 4	3.4±0.21
NLR 5	3.1±0.15
NLR 9	3.1±0.17
RCM 9	4.1±0.17
RCM 10	3.4±0.15
Shahsarang	3.4±0.16
PNR 546	4.4±0.14
Tripura Nirogi	4.0±0.20
Tripura Chikan	3.1±0.15
Tripura Hakuchuk	3.1±0.24
PS 5	3.6±0.15
TRC 2015-7	2.9±0.23
TRC 2013-11	3.3±0.15
Local	4.1±0.12
LSD (p=0.05)	0.4

range 2.9-4.4 (Table 3). The significant highest rating of overall organoleptic characters was seen in rice *cv* PNR 546 (4.4) followed by local cultivar, RCM 9 and Tripura Chikan. Whereas, least rating was given to TRC 2015-7 (2.9) at par with NLR1, 5, 9, Tripura Chikan, Tripura Hakuchuk. The highest organoleptic score of PNR 546 was due to its promising aromatic rice quality, attractive long and its fine grains (Singh et al 2000).

CONCLUSION

Among all 22 varieties under study, significant difference was observed among all the parameters in a WRC region of Mizoram. There is enough scope for improving rice productivity by introduction of high yielding medium-duration rice varieties like Gomati, RCM 10 and NLR 9 suitable for the WRC region of Mizoram India. Out of 22 varieties studied, except PD 13, Tripura Saarat, PB 1718 and PB 1121; all other 17 rice varieties out-yielded by 42.3 to 152.5% when compared with local cultivar. PNR 546 and RCM 9 scored organoleptically equal with local cultivar with 99.8 and 117.4% higher grain yield, respectively than local cultivar. However, more varieties from different regions should be tested to identify short to medium duration, high yielding verities suitable for the region with local taste preference so that rice fallow period can be used for growing *Rabi* crop under residual moisture.

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