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Research Article

Determination of seeding interval of most promising parental lines of hybrid rice (*Oryza sativa* L.)

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Abstract: The experiment was carried out at Bangladesh Rice Research Institute (BRRI), Regional Station, Comilla, Bangladesh to determine the seeding interval of most promising parental lines of hybrid rice during boro 2009-10 season. The seeding interval between A (Cytoplasmic genetic male sterile line) and R (Restorer line) lines were determined by growth duration difference (GDD), leaf number difference (LND) and effective accumulated temperature (EAT) method. Five A lines and 12 R lines were used in this experiment. In 5 A lines, the days to 50% flowering ranged from 120 to 135 days and in 12 R lines, it ranged from 127 to 139 days. The leaf number varied from 15.07 to 18.63 and from 17.05 to 19.89 in the A and R lines, respectively. Among the A line, the EAT ranged from 1069 to 1291^{0}C and 1174 to 1351^{0}C in R lines. The growth duration differences between A and R lines varied found from 1 to 19 days. Similarly, the leaf number differences between A and R lines were from 0 to 4.82. The seeding differences between A and R lines in terms of EAT were from 13.5^0 to 282.2^{0}C.

Keywords: Rice, hybrid, parental line, seeding interval and effective accumulated temperature.

INTRODUCTION

Rice (*Oryza sativa* L.) has a special significance in Asia, where about 90% of the rice is produced and consumed as a staple food. Considering the increasing demand, because of population increase on the one hand and decreasing land and water resources available for rice cultivation, on the other hand, it is critical to develop and use rice technologies that will result higher yields [1]. Bangladesh is the fourth-largest producer and consumer of rice in the world with an annual production ranging from 25 to 30 million tons. Rice occupies 77% of total cropped area. At present, rice alone constitutes about 92% of the total food grains produced annually in the country. It provides 75% of the calories and 55% of the proteins in the average daily diet of the people of Bangladesh [2]. Much effort has been given in increasing the rice production to feed the ever-increasing population. Now the yield of modern high yielding varieties has reached to a plateau. Among the different approaches attempted to meet this challenge, hybrid rice technology has already shown its potentiality. Increasing the yield potential of rice is one of the frontier projects of breeding rice. The development and use of hybrid rice is one approach by which rice productivity can be increased.

Hybrid rice technology was successfully developed in China during 1964-75. Since then, it has been used on 50% of the rice area in China and elsewhere it is being developed in about 20 countries worldwide. Bangladesh has started the research and development on hybrid rice since 1997 and first hybrid released in 1999 of course by importing it from abroad. In the crop year 2008-09, about 8% of rice area was planted by different rice hybrids in Bangladesh [3].

The two parents of a hybrid combination differ in their growth duration and therefore flower at different times even when sown at the same date. To produce hybrid seed successfully on a commercial scale, male and female parents planted side by side in a fixed row ratio should flower simultaneously, which is called synchronization [4]. Viraktamath and Ramesha [5] reported that, among the various factors that affect the seed yield levels in hybrid seed production,

synchronization in flowering between the parental lines assumes greater significance as the failure to obtain proper synchronization may result in very poor yield. This is mainly because of the fact that the seed set on the female parent depends on the pollen supplied from the male parent during the flowering period. It can be said that half the success is achieved if one is able to obtain synchronized flowering between the parental lines.

The difference in seeding dates of pollen and seed parents is called as seeding interval. The seeding interval between parental lines may vary from 5 to 20 days. The seeding interval for different hybrid combinations can be determined by three methods viz. growth duration difference (GDD), leaf number difference (LND) and effective accumulated temperature (EAT) method. In growth duration difference method, the seeding interval is determined based on the difference between the parental lines in respect of duration from seeding to initial heading or 50% flowering. Growth duration method is very simple and easy to adopt. Growth duration is highly influenced by temperature and other environmental conditions. Therefore, at those places where temperature fluctuations are very high or the varieties involved in hybrid seed production are sensitive to temperature, this method is not reliable [5].

Unlike growth duration, the leaf number of a given variety is found to be relatively stable over seasons/ years and hence these criteria can be used to determine the seeding interval between the parental lines more accurately. The seeding interval has to be worked out based on the difference in the leaf numbers on the main culm of parental lines. The leaf number of varieties generally very from 10 to 23. In locations where temperature changes are very frequent, the growth duration difference method is not very effective in determining the seeding interval. Under these circumstances, the effective accumulated temperature (EAT) method can be conveniently used. The sum of effective temperature accumulated over the period from seeding to heading is called effective accumulated temperature [5]. Therefore, the experiment was conducted to determine the seeding interval of most promising pollen (R line) and seed (A line) parents of hybrid rice for synchronization in flowering during hybrid seed production.

MATERIALS AND METHODS

The experiment was conducted at the research farm of the Bangladesh Rice Research Institute in Comilla, Bangladesh. Five A lines viz. IR73328A, BRRI 3A, PMS 8A, Jin 23A and IR68888A and 12 R lines viz. Wan 3R, M.H. 77R, BR7011-37-1-2R, HP-4R, BR736R, IR73004-107-3-3-2R, Gui 99R, BR6723-1-1-2R, IR40750R, BR168R, Ajaya R and BR6839-41-5-1R were used in this experiment.

The seeding interval between A and R lines were determined by the following methods:

- Growth duration difference (GDD) method: Seeding interval was determined by the difference in days to 50% flowering of parental lines.
- Leaf number difference (LND) method: Seeding interval was determined by the difference in leaf number of parental lines.
- Effective accumulated temperature (EAT) method: Seeding interval was determined by the difference in EAT of parental lines. The EAT of parental lines were calculated by the following formula [14]:
  $EAT = \sum(T - H - L)$

Where,
T = Daily mean temperature (^oC)
H = The temperature over upper limit ($T - 27\ ^oC$)
L = The temperature of lower limit ($12\ ^oC$)

The pre-germinated seeds of all A and R lines were sown separately in ideal seedbed to produce uniform seedling. Thirty days old 10 selected seedlings of each parental line were transplanted in the main field with hill to hill distance 20cm in a single row. Between two parental lines the distance was 40cm. On the basis of initial soil test report nitrogen, phosphorous, potassium, sulfur and zinc were applied at the rate of 168, 33, 80, 21 and 1.3 kg/ha as urea, triple super phosphate, muriate of potash, gypsum and zinc sulfate heptahydrate respectively following fertilizer recommendation guide-2005 [6]. After transplanting 3 – 5 cm water depth was maintained in the experimental field by irrigation. Insects, diseases and weeds were controlled as and when necessary to avoid any interference on crop growth.

Days to 50% flowering was recorded for determining seeding interval by growth duration difference method and leaf numbers were counted following 3 division method [7] in 3 days interval by marking with permanent marker until the opening of the flag leaf for leaf number difference method. For calculating effective accumulated temperature (EAT) of parental lines, the mean daily temperature was recorded from seeding to 50% flowering. The mean value of 10 hills and effective accumulated temperature of each parental line at 50% flowering was calculated using Microsoft Excel 2003 program.

RESULTS AND DISCUSSION

Days to fifty percent flowering

In five A lines, the days to 50% flowering ranged from 120 to 135 days and in 12 R lines, it ranged from 127 to 139 days (Table 1). Nevertheless, Krishnamurthy *et al*. [8] and Viraktamath *et al*. [9] reported the 50% flowering ranged from 90.0 – 98.0 days and 92.6 – 126.0 days among the different parental lines, respectively. Results revealed that among the A lines,

the early flowering genotype was IR68888A (120 days) followed by Jin 23A (125 days), IR73328A (131 days), BRRI 3A (133 days) and PMS 8A (135 days). Similarly, among the R lines, the early flowering genotype was M.H. 77R (127 days) and late flowering genotype was BR736R (139 days).

Table-1: Days to fifty percent flowering, leaf number and effective accumulated temperature of some promising parental lines of hybrid rice

Parental lines	Days to 50% flowering (no.)	Leaf number	Effective accumulated temperature (EAT) at 50% flowering
A line			
IR73328A	131	17.85	1232
BRRI 3A	133	18.05	1261
PMS 8A	135	18.63	1291
Jin 23A	125	16.79	1144
IR68888A	120	15.07	1069
R line			
Wan 3R	128	17.09	1189
M.H. 77R	127	17.05	1174
BR7011-37-1-2R	134	18.56	1276
HP-4R	132	18.05	1247
BR736R	139	19.89	1351
IR73004-107-3-3-2R	137	18.85	1321
Gui 99R	134	18.54	1276
BR6723-1-1-2R	128	17.70	1189
IR40750R	137	18.85	1321
BR168R	134	19.15	1321
Ajaya R	138	19.55	1336
BR6839-41-5-1R	136	18.66	1306

Leaf number

The leaf number varied from 15.07 to 18.63 and from 17.05 to 19.89 among the A and R lines until flowering, respectively (Table 1). Viraktamath and Ramesha [5] also reported that the leaf number of rice varieties generally vary from 10 to 23. However, Krishnamurthy *et al*. [8] found 15.0 – 16.0 and Viraktamath *et al*. (1998) observed 15.3 – 18.5 leaf number in parental lines of hybrid rice in India, the difference might be due to genetic reason. Among the A lines, the highest leaf number was observed in PMS 8A (18.63) and lowest in IR68888A (15.07). On the other hand, among the R lines, the highest leaf number was found in BR736R (19.89) and lowest in M.H. 77R (17.05).

Effective accumulated temperature (EAT)

Among the A lines, the highest EAT was 1291^0C in PMS 8A and lowest was 1069^0C in IR68888A (Table 1). In case of R lines, the highest EAT was 1351^0C in BR736R and lowest was 1174^0C in M.R. 77R. Yuan and Fu (1995) reported the EAT of IR24 and Zhen-Shan 97A were 1133 and 791^0C, respectively and difference might be due to genetic reason.

Table-2: Growth duration difference between A and R lines in days

R lines	A lines				
	IR73328A	BRRI 3A	PMS 8A	Jin 23A	IR68888A
Wan 3R	3	5	7	-3	-8
M.H. 77R	4	6	8	-2	-7
BR7011-37-1-2R	-3	-1	1	-9	-14
HP-4R	-1	1	3	-7	-12
BR736R	-8	-6	-4	-14	-19
IR73004-107-3-3-2R	-6	-4	-2	-12	-17
Gui 99R	-3	-1	1	-9	-14
BR6723-1-1-2R	3	5	7	-3	-8
IR40750R	-6	-4	-2	-12	-17
BR168R	-6	-4	-2	-12	-17
Ajaya R	-7	-5	-3	-13	-18
BR6839-41-5-1R	-5	-3	-1	-11	-16

Positive value means higher than corresponding R line and negative value means lower than corresponding R line

Seeding difference

The seeding differences between A and R lines in growth duration are presented in Table 2. The results revealed that the growth duration differences between A and R lines varied from 1 to 19 days. Viraktamath and Ramesha [9] also reported that the seeding interval between parental lines vary from 5 to 20 days. Similarly, the leaf number differences between A and R lines were from 0 to 4.82 (Table 3). However, Krishnamurthy *et al*. [8] found the leaf number difference between IR58025A and KMR-3 was 1.0; the difference might be due to genetic reason. It was also observed that the seeding differences between A and R lines in terms of EAT were from 13.5 to 282.2^{0}C (Table 4).

Table-3: Leaf number difference between A and R lines

R lines	A lines				
	IR73328A	BRRI 3A	PMS 8A	Jin 23A	IR68888A
Wan 3R	0.76	0.96	1.54	-0.30	-2.02
M.H. 77R	0.80	1.00	1.58	-0.26	-1.98
BR7011-37-1-2R	-0.71	-0.51	0.07	-1.77	-3.49
HP-4R	-0.20	0.00	0.58	-1.26	-2.98
BR736R	-2.04	-1.84	-1.26	-3.10	-4.82
IR73004-107-3-3-2R	-1.00	-0.80	-0.22	-2.06	-3.78
Gui 99R	-0.69	-0.49	0.09	-1.75	-3.47
BR6723-1-1-2R	0.15	0.35	0.93	-0.91	-2.63
IR40750R	-1.00	-0.80	-0.22	-2.06	-3.78
BR168R	-1.30	-1.10	-0.52	-2.36	-4.08
Ajaya R	-1.70	-1.50	-0.92	-2.76	-4.48
BR6839-41-5-1R	-0.81	-0.61	-0.03	-1.87	-3.59

Positive value means higher than corresponding R line and negative value means lower than corresponding R line

Table-4: Effective accumulated temperature difference between A and R lines

R lines	A lines				
	IR73328A	BRRI 3A	PMS 8A	Jin 23A	IR68888A
Wan 3R	43.7	72.2	102.2	-45.0	-120.0
M.H. 77R	58.7	87.2	117.2	-30.0	-105.0
BR7011-37-1-2R	-43.5	-15.0	15.0	-132.2	-207.2
HP-4R	-15.0	13.5	43.5	-103.7	-178.7
BR736R	-118.5	-90.0	-60.0	-207.2	-282.2
IR73004-107-3-3-2R	-88.5	-60.0	-30.0	-177.2	-252.2
Gui 99R	-43.5	-15.0	15.0	-132.2	-207.2
BR6723-1-1-2R	43.7	72.2	102.2	-45.0	-120.0
IR40750R	-88.5	-60.0	-30.0	-177.2	-252.2
BR168R	-88.5	-60.0	-30.0	-177.2	-252.2
Ajaya R	-103.5	-75.0	-45.0	-192.2	-267.2
BR6839-41-5-1R	-73.5	-45.0	-15.0	-162.2	-237.2

Positive value means higher than corresponding R line and negative value means lower than corresponding R line

CONCLUSION

In 5 A lines, the days to 50% flowering ranged from 120 to 135 days and in 12 R lines, it ranged from 127 to 139 days. The leaf number varied from 15.07 to 18.63 and from 17.05 to 19.89 in the A and R lines, respectively. Among the A line, the EAT ranged from 1069 to 1291^{0}C and 1174 to 1351^{0}C in R lines. The growth duration differences between A and R lines varied found from 1 to 19 days. Similarly, the leaf number differences between A and R lines were from 0 to 4.82. The seeding differences between A and R lines in terms of EAT were from 13.5^0 to 282.2^{0}C. Among the 5 A and 12 R lines, the seeding interval for days to 50% flowering, leaf number and effective accumulated temperature were found from 1 to 19 days, from 0 to 4.82 and from 13.5 to 282.2^{0}C, respectively and these might be used in hybrid seed production for optimum synchronization in flowering between 5 seed and 12 pollen parents.

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