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Effect of Different Techniques (Staggered Sowing, Planting Ratio and Supplementary Pollination) on Seed yield of Hybrid Rice (PRH-10) in Bihar Condition

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ABSTRACT: The experiments were conducted during Kharif 2017 and 2018 for seed production of hybrid rice PRH-10 at Sabour, Bhagalpur (Bihar) condition. The seed production of hybrid rice is very much dependent on local environmental conditions besides the flowering natures of its parental lines. Based on 50% flowering, the parental line, which includes seed parent Pusa 6A and pollen parent PRR78, had a considerable difference in growth duration and flowering time. The accomplishment of synchronization of seed parent and pollen parent flowering is one of the most important milestones in this process. It was accomplished in the current experiment using the growth duration difference method. Other major variables for increased seed setting percent and hybrid seed output were days to 50% blooming, panicle exertion, and flag leaf angle. Several methods of supplementary pollination under various staggered sowing and planting ratio, had been practiced to find out maximum seed setting percent and hybrid seed yield. It was found that GA3 had a substantial favorable influence on panicle exertion and spikelet opening angle when used alone or in combination with flag leaf trimming, resulting in a high percentage of seed setting and seed yield.

Keywords: Pollen parent, Seed parent, Supplementary Pollination & Hybrid.

INTRODUCTION

Rice (*Oryza sativa* L.) is a globally important crop that plays a vital part in the country's food security. The total area under rice cultivation is roughly 43.78 mha, with hybrid rice covering 2.6 mha. In the year 2019-2020, India's average rice output is roughly 118.43 mt, with a yield of 2705 kg/ha. The entire area under rice production in Bihar is 2.89 mha, with hybrid rice accounting for 15% of the total. Bihar produces roughly 6.05 million tonnes of rice on average, accounting for 5.11 percent of India's total rice production. Rice yield in Bihar for the 2019-2020 season is 1948 kg/ha. (Directorate of Economics and Statistics, 2020). Rice, unlike other crops where hetrosis has been economically exploited, is mostly a self-pollinated crop with little studies on the blooming behaviour and seed setting pattern of parental lines, making hybrid rice seed development a difficult operation. In comparison to inbreed rice varieties, hybrid rice has the potential to boost output by 15-20%. As a result of the increase in rice output attributed to hybrid rice, an estimated 60 million people gain food security each year. (Li *et al.,* 2010) Several hybrids from the public and private sectors have been released and sold in India and other countries since 2003, when they were grown on roughly 1 million acres. To reap the benefits of hybrid rice production technology across all rice-growing agroclimatic areas, it must be developed and implemented successfully. It has been claimed that the provenance has a significant impact on hybrid seed production technique. That is why this technology must be redefined in the environment for better seed parent and pollen parent synchronization in each hybrid. Rice is a self-pollinated crop that requires supplemental pollination to increase out crossing. Furthermore, only the wild abortive (CMS-WA) type of cytoplasm is stable among all the possible cytoplasm sources (Malik *et al.,* 2020). This technology is widely used, and it is the basis for all hybrids released in India.

MATERIALS AND METHODS

The parental lines of hybrid rice PRH 10 was used and sown in the field during kharif season. In parental line were sown in kharif 2017 to know the growth duration difference for synchronization of flowering.

Transplanting was done in planting ratio of 2:6 and 2:8 with following seeding interval of 15, 10, 5 and 0 days between pollen parent and seed parent, in split plot

design during kharif 2018. One seedling per hill was used for transplanting of both parents. It was done in well puddled soil and normal agronomical package and practices were adopted.

Methodology

Rope pulling: Rice is a self-pollinated crop; hence extra pollination is required to improve out crossing. Rope pulling was used in every DOS to accomplish this. At peak anthesis period, between 9.30 a.m. and 11.30 a.m., the male parent was shaken every half hour.

Gibberellic acid (GA_3): GA_3 was sprayed when 5% of the tillers had begun to head, and it was done in the evening. At a rate of 30 gramme per hectare, GA3 (60 ppm) was administered. On the first day, 40% of the GA3 was sprayed, with the remaining 60% sprayed the next day.

Flag leaf clipping: Flag leaf was clipped when primary tillers are at booting stage. This was practiced to improve pollen movement uniformity and pollen grain dissemination, resulting in increased seed set.

Observation:

Plant height (cm): Plant height was measured in centimetres from the ground level to the tip of the plant in both the parents, at grain maturation time.

Days to 50 per cent flowering: The number of days taken from sowing to 50 per cent of the plants in the plot to flower was recorded as days to 50 per cent flowering.

Spikelet opening angle: It is the angle between lemma and palea. Five fully opened individual spike1ets were collected randomly for each treatment and kept on a paper. With the help of pointed needle, the points of the opened spikelet were marked. The angle measured using a protector.

Flag leaf angle: Flag leaf angle is the angle between panicle and the flag leaf. It was measured using protector.

Panicle exertion percentage: Panicle exertion percentage was calculated using formula:

Panicle exertion (%) = (Length of exerted panicle/Total length of panicle) × 100.

Seed setting (%): For determining the per cent seed set/row, six panicles were selected randomly from each row of each plot. The filled spikelet was separated from the unfilled spikelet and was counted.

The seed set per cent was calculated by using the following formula and expressed as seed set in percentage.

Seed setting (%) = (Number of filled spikelet/Total number of spikelet) × 100.

Seed yield (kg/ha): Seed harvested from seed parent (A line) was taken and yield was calculated as kg seed per ha.

RESULTS AND DISCUSSION

The mean value for growth duration difference (GDD) based on days to 50% flowering for seed parent (Pusa 6A) and pollen parents (PRR 78) were 81.11 and 90.44, respectively, in a study done during Kharif 2017 to determine seeding interval. The average time delay between 50% flowering of the pollen parent and 50% flowering of the seed parent was 9.33 days (Sushmita *et al.,* 2019). It shows that the pollen parent takes around 10 days longer to blossom than the seed parent. Varma *et al.,* (2018) found similar differences as well. According to Singh and Sahoo (1996), flowering can be synchronized between two parental lines with differing growth duration differences (GDD) by planting both lines on different days.

CMS lines/seed parents based on WA cytoplasm tend to have defective panicle exertion, with parts of the panicle covered by the leaf sheath. There is no pollination or fertilisation of the confined spikelets as a result. Thangapandian *et al.,* (2018) reported that the seed parent Pusa 6A with WA cytoplasm had the similar problem of inadequate panicle exertion. According to Rahman *et al*., (2013) there have been various reports on the use of GA3 and flag leaf trimming to improve panicle exertion.

Gibberellic acid (GA_3) is a diterpenoid carboxylic acid which plays an important role in rice hybrid seed production. It is an effective and efficient growth hormone, which stimulates the cell elongation and thus causes panicle exertion. GA3 alone was ineffective in increasing seed output at maturity, however it was found to be effective when combined with flag leaf trimming and rope pulling. The flag leaf is the final leaf to form and is taller than the panicle that emerges with it. The function of the flag leaf is only necessary at the end of the plant's life cycle. It contributes at least 10 percent of the total yield. Flag leaf trimming improves out crossing rate, which is one of the major variables in increasing seed setting in hybrid rice production. It promotes homogeneous pollen flow and wide pollen grain dissemination, resulting in increased seed set.

Data present in Table 1 shows that the treatment has significant effect on plant height for both the parents, but mean height of pollen parent is still higher than seed parent. Maximum plant height in seed parent (Pusa 6A) were recorded in T_5 (rope pulling + GA_3 + flag leaf clipping) with 89.45 cm followed by T_3 (rope pulling + GA_3) with 87.68 cm. No significant difference was observed between T_1 (control) with 75.78 cm and T_2 (rope pulling) with 75.64 cm. Also, from as presented in Table 3 and 4 spikelet opening angle as well as flag leaf angle was significantly affected by various treatment combinations.

Table 1: Effect of treatments and staggered sowing on plant height of seed parent and pollen parent.

Treatments	Plant Height (cm)									
	Seed Parent (Pusa 6A)					Pollen Parent (PRR 78)				
	S1	S2	S3	S4	Mean	S1	S2	S3	S4	Mean
T1: Control	75.72	76.05	75.72	75.63	**75.78**	99.17	104.18	103.8	101.17	**102.08**
T2: Rope pulling	75.65	75.65	75.65	75.62	**75.64**	101.18	105.18	104.27	102.32	**103.24**
T3: Rope pulling + GA3	87.35	87.30	87.35	88.73	**87.68**	109.92	110.85	114.68	114.03	**112.37**
T4: Rope pulling + Flag leaf clipping	77.10	77.15	77.12	77.11	**77.12**	104.12	104.52	104.52	102.52	**103.92**
T5: Rope pulling + GA3 + Flag leaf clipping	89.48	89.00	89.50	89.82	**89.45**	112.28	115.02	116.02	114.2	**114.38**
Mean	**81.06**	**81.02**	**81.07**	**81.38**		**105.33**	**107.95**	**108.66**	**106.85**	
CD (P = 0.05)										
T	1.44					1.85				
S	NS					1.71				
T × S	NS					NS				

S: Staggered Sowing; T: Treatment (Supplementry Pollination); S_1: 15 days seeding interval between Pollen parent & Seed Parent; S_2: 10 days seeding interval between Pollen parent & Seed Parent; S_3: 5 days seeding interval between Pollen parent & Seed Parent S_4: 0 days seeding interval between Pollen parent & Seed Parent.

Table 2: Effect of supplementary pollination along with treatment combination on days to 50% flowering of seed parent and pollen parent.

Treatments	Days to 50% flowering									
	Seed Parent (Pusa 6A)					Pollen Parent (PRR 78)				
	S1	S2	S3	S4	Mean	S1	S2	S3	S4	Mean
T_1: Control	83.17	82.50	82.17	80.17	**82.00**	90.83	90.33	91.67	90.00	**90.71**
T_2: Rope pulling	82.33	81.50	83.17	82.67	**82.42**	90.50	89.33	90.50	89.67	**90.00**
T_3: Rope pulling + GA_3	79.00	80.83	79.50	80.00	**79.83**	90.33	89.17	87.50	88.83	**88.96**
T_4: Rope pulling + Flag leaf clipping	82.50	81.83	80.00	81.33	**81.42**	90.17	90.67	88.50	89.33	**89.67**
T_5: Rope pulling + GA_3 + Flag leaf clipping	80.17	79.33	79.33	80.83	**79.92**	89.67	89.83	86.83	89.33	**88.92**
Mean	**81.43**	**81.20**	**80.83**	**81.00**		**90.30**	**89.87**	**89.00**	**89.43**	
CD (P = 0.05)										
T	1.08					0.71				
S	NS					0.63				
T × S	NS					1.41				

S: Staggered Sowing; T: Treatment (Supplementry Pollination)**;** S_1: 15 days seeding interval between Pollen parent & Seed Parent; S_2: 10 days seeding interval between Pollen parent & Seed Parent; S3: 5 days seeding interval between Pollen parent & Seed Parent S_4: 0 days seeding interval between Pollen parent & Seed Parent**.**

Table 3: Effect of supplementary pollination along with treatment combination on spikelet opening angle of seed parent and pollen parent.

Treatments	Spikelet Opening Angle (°)									
	Seed Parent (Pusa 6A)					Pollen Parent (PRR 78)				
	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean
T_1: Control	18.05	18.43	18.47	17.97	**18.23**	17.00	15.35	14.87	15.25	**15.62**
T_2: Rope pulling	18.30	19.90	19.27	19.21	**19.21**	16.87	16.28	15.07	16.38	**16.15**
T_3: Rope pulling + GA_3	21.08	21.53	21.62	21.53	**21.53**	23.08	22.13	22.00	19.58	**21.70**
T_4: Rope pulling + Flag leaf clipping	17.70	18.25	19.12	18.47	**18.47**	16.63	15.48	15.76	16.70	**16.14**
T_5: Rope pulling + GA_3 + Flag leaf clipping	21.55	21.85	22.25	21.93	**21.93**	24.22	22.15	23.07	18.95	**22.09**
Mean	**19.34**	**19.99**	**20.14**	**20.02**		**19.56**	**18.28**	**18.15**	**17.37**	
CD (P = 0.05)										
T	1.14					1.13				
S	NS					0.86				
T × S	NS					2.26				

S: Staggered Sowing; T: Treatment (Supplementry Pollination)**;** S_1: 15 days seeding interval between Pollen parent & Seed Parent; S_2: 10 days seeding interval between Pollen parent & Seed Parent; S3: 5 days seeding interval between Pollen parent & Seed Parent S_4: 0 days seeding interval between Pollen parent & Seed Parent.

Table 4: Effect of treatments and staggered sowing on flag leaf angle of seed parent and pollen parent.

Treatments	Flag Leaf Angle (°)									
	Seed Parent (Pusa 6A)					Pollen Parent (PRR 78)				
	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean
T_1: Control	23.08	22.57	23.70	22.40	**22.94**	22.00	21.15	23.88	22.12	**22.29**
T_2: Rope pulling	24.67	25.88	25.18	24.90	**25.16**	22.58	23.90	23.87	22.25	**23.15**
T_3: Rope pulling + GA_3	30.48	32.35	31.80	30.82	**31.36**	30.30	31.25	32.07	33.35	**31.74**
T_4: Rope pulling + Flag leaf clipping	23.95	24.47	23.92	23.58	**23.98**	21.73	23.35	24.80	22.70	**23.15**
T_5: Rope pulling + GA_3 + Flag leaf clipping	29.58	31.37	31.48	30.68	**30.78**	33.50	31.97	33.68	30.02	**32.29**
Mean	**26.35**	**27.33**	**27.22**	**26.48**		**26.02**	**26.32**	**27.66**	**26.09**	
CD (P = 0.05)										
T	1.14					1.19				
S	NS					1.24				
T × S	NS					NS				

S: Staggered Sowing; T: Treatment (Supplementary Pollination)**;** S_1: 15 days seeding interval between Pollen parent & Seed Parent; S_2: 10 days seeding interval between Pollen parent & Seed Parent; S3: 5 days seeding interval between Pollen parent & Seed Parent S_4: 0 days seeding interval between Pollen parent & Seed Parent.

Data presented in Table 5 revealed the significant and positive effect of GA_3 application and flag leaf clipping on panicle exertion in seed parent. The panicle exertion was significantly highest in T_5 (93.45 %) followed by T_3 (92.97 %) and T_4 (82.80 %) than control T_1 (79.12 %). Riaz *et al.,* (2019) stated that application of gibberellic acid of concentration 200 ppm shows significant increase in hybrid rice seed production (0.3-1 tonne per hectare). Similarly, Suralta and Robles (2003) showed that GA_3 application at 150 g/ha in two split doses at the beginning of 5-10 per cent panicle initiation of the female parent population, results in increased percentage of panicle exertion from the flag leaf sheath by a maximum of around 80 per cent. Seed setting percentage is one of the most yield attributing characters. In present experiment, we have found that seed setting percent was significantly highest in T_5 (18.96%) followed by T_3 (13.13%), T_4 (12.75%), T_2 (9.25%) than control (4.21%).

Significant effect of staggering of pollen parent was observed on its days to 50% flowering. It was observed that when staggered sowing and transplanting of pollen parent of various seedling aged i.e. 36 day old seedling, 31 days old seedling, 26 days old seedling and 21 days old seedling; in crossing block with 21 days old seedling of seed parent, the range of difference in days to 50 percent flowering were 8.67, 8.17, 8.44 and 8.53 days, similar observations were reported by Bishwas *et al*., (2020) and Madhukeshwara *et al*., (2019). The highest hybrid seed yield was reported in T_5 (1113.49 kg/ha) followed by T_3 (774.64 kg/ha), T_3 (752.23 kg/ha), T_2 (554.04 kg/ha) than control (226.74 kg/ha). Similarly, Ponnuswamy *et al*., (1998) suggested that application of GA_3 (125 g/ha) at the 15-20 per cent panicle exertion stage increased plant height, panicle exertion, flag leaf angle, seed setting percentage and seed yield.

Table 5: Effect of supplementary pollination along with treatment combination on panicle exertion of seed parent.

Treatments	Panicle Exertion (%)				
	S_1	S_2	S_3	S_4	Mean
T_1: Control	78.88	79.05	79.52	79.03	**79.12**
T_2: Rope pulling	79.28	78.95	80.83	80.35	**79.85**
T_3: Rope pulling + GA_3	92.63	93.45	92.9	92.90	**92.97**
T_4: Rope pulling + Flag leaf clipping	82.48	82.48	82.48	83.75	**82.80**
T_5: Rope pulling + GA_3 + Flag leaf clipping	93.97	93.13	93.10	93.58	**93.45**
Mean	**85.45**	**85.41**	**85.77**	**85.92**	
CD (P = 0.05)					
T	1.33				
S	NS				
T × S	NS				

S: Staggered Sowing; T: Treatment (Supplementary Pollination)**;** S_1: 15 days seeding interval between Pollen parent & Seed Parent; S_2: 10 days seeding interval between Pollen parent & Seed Parent; S3: 5 days seeding interval between Pollen parent & Seed Parent S_4: 0 days seeding interval between Pollen parent & Seed Paren.

Table 6: Effect of supplementary pollination along with treatment combination on yield of hybrid seed production.

Treatments	Seed Setting (%)					Hybrid Seed Yield (kg/ha)				
	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean
T_1: Control	4.333	6.333	4.500	1.667	**4.208**	234.447	337.700	250.648	84.167	**226.740**
T_2: Rope pulling	10.000	12.833	10.167	4.000	**9.250**	591.837	755.260	600.295	228.803	**544.049**
T_3: Rope pulling + GA_3	13.333	17.167	14.500	7.500	**13.125**	790.022	1,006.982	861.455	440.107	**774.641**
T_4: Rope pulling + Flag leaf clipping	15.667	15.833	13.000	6.500	**12.750**	925.188	940.733	761.668	381.357	**752.237**
T_5: Rope pulling + GA_3 + Flag leaf clipping	21.500	23.833	21.333	9.167	**18.958**	1,263.860	1,397.607	1,254.497	538.025	**1,113.497**
Mean	**12.967**	**15.200**	**12.700**	**5.767**		**761.071**	**887.656**	**745.713**	**334.492**	
CD (P = 0.05)										
T	0.483					28.001				
S	0.454					24.476				
T × S	0.966					56.002				

S: Staggered Sowing; T: Treatment (Supplementry Pollination) S_1: 15 days seeding interval between Pollen parent & Seed Parent; S_2: 10 days seeding interval between Pollen parent & Seed Parent; S3: 5 days seeding interval between Pollen parent & Seed Parent S_4: 0 days seeding interval between Pollen parent & Seed Parent.

Table 7: Effect of treatments on planting ratio on hybrid seed setting percent and yield.

Treatment	Seed Setting (%)			Hybrid Seed Yield (kg/ha)		
	P_1	P_2	Mean	P_1	P_2	Mean
T_1: Control	4.417	4.000	**4.208**	250.453	203.028	**226.740**
T_2: Rope pulling	9.333	9.167	**9.250**	525.240	562.858	**544.049**
T_3: Rope pulling + GA_3	13.417	12.833	**13.125**	750.938	798.344	**774.641**
T_4: Rope pulling + Flag leaf clipping	13.250	12.250	**12.750**	742.688	761.786	**752.237**
T_5: Rope pulling + GA_3 + Flag leaf clipping	19.583	18.333	**18.958**	1,092.616	1,134.378	**1,113.497**
Mean	**12.000**	**11.317**		**672.387**	**692.079**	
CD (P = 0.05)						
T	0.483			28.001		
P	0.306			17.709		
T × P	NS			39.600		

S: Staggered Sowing; P: Planting Ratio; T: Treatment (Supplementry Pollination) T1: Control; T_2: Rope pulling; T_3: Rope pulling plus application of GA_3; T_4: flag leaf cutting along with Rope pulling; T_4: flag leaf cutting along with Rope pulling plus application of GA_3; P_1: Planting ratio 6:2 (Female: male); P_2: Planting ratio 8:2 (Female: male).

CONCLUSION

According to the findings of the preceding investigations, successful production of hybrid rice PRH 10 in Sabour (Bihar) conditions is required. GA3 application at the 5% flowering stage increased panicle effort dramatically and positively, either alone or in combination with flag leaf cutting. Seed setting percentage was increased by 5.04 percent (9.25; 554.04 kg/ha) over control (4.21; 226.74 kg/ha) with supplemental pollination by rope pulling alone. GA3 was determined to be the optimum treatment for hybrid seed yield and its contributing features such as panicle length, panicle exertion %, and spikelet opening when combined with flag leaf cutting and rope pulling.The effect of planting ratio was also found significant. Seed setting percent were significantly higher in planting ratio 2:6, while increasing the planting ratio, percentage seed setting decreases. However, total seed yield per ha were recorded highest in planting ratio 2:8.

FUTURE SCOPE

Hybrid rice seed production is currently centered in Telangana and Andhra Pradesh's Karimnagar, Warangal, Kurnool, and Nandyal districts, Karnataka's Mandaya & Mysore district, Maharastra's Kolhapur district, and Tamilnadu's Erode & Bhawanisagar district. The cool and dry agroclimatic conditions in these places favours good seed setting of hybrid seed. The hot and humid weather conditions result in poor opening of flower and pollen loss due to monsoon rain, are a major factor affecting seed production of hybrid rice in Bihar. In eastern regions like Bihar, Jharkhand, and West Bengal, high seed costs and a lack of understanding among farmers are also significant barriers to hybrid seed production. On the other hand, hybrid paddy acreage in eastern states is fast increasing, and there is a large market demand. If hybrid seed production technology were standardized according to local environmental conditions, hybrid seed costs would be reduced, and local hybrid seed entrepreneurship among youngsters would flourish.

Abbreviations: Staggered Sowing; **T_0**: control**; T_1**: rope pulling; **T_2**: rope pulling along with GA_3 application; **T_3**: rope pulling along with flag leaf clipping **T_4**: rope pulling along with GA_3 application as well as flag leaf clipping

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