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Effects of Planting Ratio and Planting Distance on Kadaria 1 Hybrid Rice Seed Production

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ABSTRACT

Hybrid rice has the potential to outperform existing inbred rice and was said to have the potential to produce 14-20 % more yield. In response, Malaysia Government has introduced its very own first Hybrid Rice Variety knew as Kadaria 1 developed by MARDI. This is in line with one of the strategies outlined in *Dasar Agromakanan Negara* (DAN) 2011-2020 as an approach to increasing rice productivity within Malaysia. The next step would be developing our hybrid seed rice production system. Therefore, an experiment to determine the planting ratio and planting distance between 0025A (A)-a hybrid with MR283 (R)-inbreed variety was carried out. Planting ratios studied in this study were 2:4, 2:6, 2:8, and 2:10 while planting distance was 14 x 30 cm, 16 x 30 cm, and 18 x 30 cm. Statistical analyses suggested that yield R, yield A, and panicle number A were significantly affected by planting ratios while yield A was significantly affected by an interaction between planting distance and planting ratios. Panicle number A performed significantly higher at planting ratios of 2:4 compared to 2:10. Yield R shows higher significant performance under ratio 2:6 compared to 2:4 and 2:8. Relatively, yield A performed the best under planting distance of 18 x 30 cm. Furthermore, under this particular planting distance, the planting ratio of 2:10 shows the highest significant figure while 2:8 exhibits statistical parity. Both yield R and yield A were significantly affected by planting ratios and have a significant positive association with each other. Therefore, the planting ratio of 2:10 should be the best since it contributed to significantly highest value for yield A while yield R under 2:10 shows statistical parity with 2:6 which was the highest significant value. In conclusion, the combination of 2:10 with a planting distance of 18 x 30 cm was the best since it shows best potential for both yields A and yield R.

Keywords*: Hybrid rice, Planting ratio, Planting distance, Seed production, Yield.*

1. Introduction

Rice (*Oryza sativa* L.) is the most important seed crop in the world as it plays a major role in feeding half of the world's population (Mohanty *et al.*, 2010). One of the strategies outlined in the rice industry stated in National Agrofood Policy is to improve rice productivity and quality (Ministry of Agriculture, 2011). An approach to achieve this target is by utilizing hybrid rice technology. It was found that hybrid rice could increase rice productivity by 20-30% compared to current existing inbred rice varieties in China and India (Virmani, 1994). In response, Malaysia introduced its very own first hybrid rice variety known as Kadaria 1 back in 2020 (Mohd Solihen *et al*., 2020).

To establish sustainable rice production through the use of hybrid rice varieties, the development of hybrid rice seed production standard operating procedure (SOP) must be developed. As described in the document *Spesifikasi Pengeluaran Benih Padi Hybrid* SPJM 2009 – Hybrid by the Department of Agriculture (DOA), the planting ratio between A x R must first be identified since it is influenced by several factors including the variety involved. Some of the ratios recommended by DOA are 2:8, 2:12, and 3:10.

According to Abo-Youssef *et al.*, (2017), the best planting ratio would be 2:8. They discovered that the ratio improved yield by enhancing flag leaf area, panicle length, panicle weight, and panicle exertion. Roy and Vijay (2013) recommended the use of 2:10 or 2:8 for hybrid rice seed production in India. Hasan *et al.*, (2010) discovered that a combination of 2:12 with a planting distance of 15 x 20 cm contributed to the highest yield. Their study also

suggests that the number of effective tillers indicated the highest significant number under the same combination. Other countries may use ratios of 10:3, 6:2, 14:2, 16:2, and 18:6 for mechanized hybrid rice seed production (Virmani *et al.*, 2002). Nevertheless, all of these were based on planting hybrid rice existing outside Malaysia. Therefore, a study to determine the planting ratio and planting distance between 0025A (CMS or A-line) with MR 283 (Restorer (R) line) was carried out in MARDI Seberang Perai as a pioneer in developing Malaysia's hybrid rice seed production.

2. Materials and Methods

This study was carried out in MARDI Seberang Perai, Penang, Malaysia from June 2019 to July 2020. The experimental design used was a split-plot with 3 replications whereby planting ratio was set as the main plot and planting distance as the subplot. Four planting ratios for A x R and 3 planting distances were evaluated throughout the experiment. The planting ratios were 2:4, 2:6, 2:8 and 2:10 while the planting distances were 14 x 30 cm, 16 x 30 cm and 18 x 30 cm. A total of 36 individual treatment plots were laid out consisting of 5 m x 5 m in size. Parameters evaluated in this study included panicle length, panicle number, spikelet per panicle, percent filled grain, 1000 grain weight, harvest index, and yield for both 0025A (CMS or A-line) and MR 283 (Restorer (R) line). Harvest index was determined by dividing grain yield with biological yield followed by multiplication of 100 (Amanullah and Innamullah, 2016). Data were analyzed using analysis of variance (ANOVA) of SAS 9.4. Mean comparisons were subjected to using Duncan Multiple Range Test if significant.

3. Results and Discussion

3.1. Yield and yield component

The results showed that yield A was significantly affected by an interaction between planting distance and ratios (Table 1). Both yield A and panicle number A were significantly affected by the planting ratio. Interaction between season with planting distance or planting ratio has no significant impact on any of the evaluated parameters.

3.1.1. Panicle number

Panicle number A exhibited the highest significant value under planting ratio 2:4 and shared statistical parity with 2:6. Both 2:8 and 2:10 contributed significantly lower panicle numbers compared to 2:4 (Fig.1).

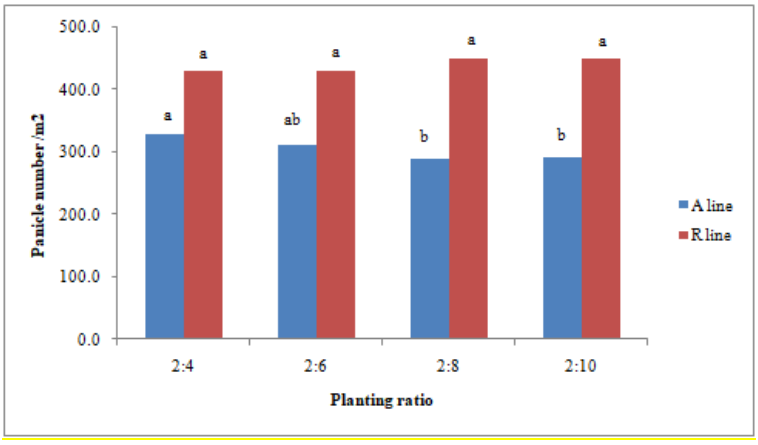

Fig.1. Relationship between planting ratio and panicle number

The difference was at least 12.9%. Hasan *et al.* (2011) reported that panicle number had a significant positive correlation with spikelet sterility, 1000 grain weight, and yield but had a significant negative correlation with the number of days to achieve maturity. Kanfany *et al.*, (2014) discovered that hybrid rice panicle number was significantly affected by cultivars, fertilizer rate, and year of planting. Their study discovered that the control inbred variety Sahel 108 recorded the highest significant panicle numbers while exhibiting a yield that was at par with the hybrid variety. Haque *et al.*, (2015) discovered that the panicle number decreased with the decrease in planting distance whereas Asmamaw (2017) attributed panicle number increment to planting density.

3.1.2. Yield A

Yield A was significantly affected by an interaction between planting ratio and planting distance (Table 1). For all of the planting distances employed in this study, a ratio of 2:10 contributed to the highest significant values (Fig.2). Hasan *et al*., (2010) discovered that row ratio and planting distance of 2:6 with 16 x 30 cm was the best combination respectively in obtaining hybrid rice seeds.

Furthermore, their study also suggests other combinations which contributed to statistical parity which are 2:12 with 20 x 20 cm, 2:14 with 20 x 20 cm, 2:14 with 15 x 20 cm, and 2:14 with 15 x 15 cm. Haqeu *et al*., (2015) found that both biological and grain yield of rice decreased with decreasing plant spacing which their study suggests the use of 25 x 20 cm instead 20 x 15 cm.

Furthermore, Sindhu and Kumar (2003) concluded that both planting distance and row ratio play a major role in hybrid seed production.

3.1.3. Yield R

The inbred restorer variety used in this experiment was MR 283. Its yield performance was significantly affected by the row ratio. Planting distance and interaction between planting distance and ratio contributed no significant impact on yield R (Table 1).

Nevertheless, the planting ratio of 2:6 contributed to the highest significant reading while 2:8 was significantly lowest for yield R (Fig.3). The planting ratio of 2:10 exhibited statistical parity with 2:6. Obtaining a higher yield R can benefit yield A seed production. This is because both yields A and yield R have a significant positive correlation with each other (Table 2).

Table 1. Mean square ANOVA on yield and yield components

Source of variance	Parameter													
	Panicle length R	Panicle length A	Panicle number R	Panicle number A	Spikelet per panicle R	Spikelet per panicle A	Percent filled R (%)	Percent filled A (%)	1000 grain weight R (g)	1000 grain weightA (g)	Harvest index R	Harvest index A	Yield R	Yield A
Rep	2.42	4.14	5126.09	9952.29	527.08	2868.14	22.83	27.61	3.34	21.03	0.0056	0.0160	1.77	3.47
Season (S)	39.91	91.07	5781.51	11440.67	115093.50	852.04	138.24	29.82	0.09	199.24	0.1544	0.0380	233.44	4.17
S*Rep	0.70	2.21	2920.34	2515.25	832.78	8536.74	16.97	9.81	0.96	25.81	0.0033	0.0068	6.89	2.41
Ratio (Rt)	0.30	0.65*	3189.70	8367.29*	171.71	1732.28	11.87	9.34	0.02	1.61	0.0036	0.0014	2.10*	7.15*
Rt x Rep	0.51	0.71	4051.32	1877.65	504.07	1199.05	4.03	6.96	1.11	0.92	0.0017	0.0026	0.39	0.75
S x Rt	1.03	0.60	11734.62	4778.81	1597.37	2514.38	0.16	7.38	0.85	3.29	0.0010	0.0009	1.70	0.23
Distance (D)	0.77	0.17	25020.14	2929.59	169.17	5348.04	1.72	1.52	0.30	4.06	0.0003	0.0051	3.98	8.00
S*D	0.78	0.13	4687.64	1617.82	584.40	4052.04	12.10	10.96	0.33	2.97	0.0006	0.0017	0.93	1.19
Rt*D	0.86	0.45	912.29	2741.64	807.46	2080.65	5.81	6.32	0.27	4.17	0.0015	0.0009	0.33	1.33*
S*Rt*D	0.38	1.06	4702.37	2521.25	390.65	2120.54	1.09	2.17	0.35	1.86	0.0028	0.0013	0.28	0.30
Grand mean	26.55	25.7	440.6	305.7	215.7	158.1	88.2	6.8	26.1	20.2	0.54	0.35	7.0	1.6
C.V.(%)	2.75	2.53	13.94	14.49	12.10	27.80	2.06	35.60	2.98	9.33	7.28	11.91	11.89	38.52

*mean followed by * indicate significant difference at 0.05*

*mean followed by ** indicate significant difference at 0.01*

Table 2. Correlation analysis among yield and yield components parameters

	Panicle length R	Panicle length A	Panicle number R	Panicle number A	Spikelet per panicle R	Spikelet per panicle A	Percent filled R (%)	Percent filled A (%)	1000 grain weight R (g)	1000 grain weightA (g)	Harvest index R	Harvest index A	Yield R	Yield A
Panicle length R	1	0.58 **	-0.03 ns	0.25 *	-0.38 **	0.15 ns	-0.45 **	-0.02 ns	-0.01 ns	-0.49 **	0.36 **	-0.40 **	0.58 **	0.18 ns
Panicle length A		1	0.10 ns	0.08 ns	-0.60 **	0.06 ns	-0.53 **	0.12 ns	0.03 ns	-0.35 **	0.57 **	-0.35 **	0.70 **	0.11 ns
Panicle number R			1	0.01 ns	-0.33 **	-0.09 ns	-0.16 ns	0.08 ns	-0.19 ns	-0.23 *	0.25 **	-0.12 ns	0.22 *	0.05 ns
Panicle number A				1	-0.08 ns	-0.28 *	-0.02 ns	0.05 ns	-0.01 ns	-0.18 ns	-0.07 ns	-0.39 **	0.14 ns	-0.08 ns
Spikelet per panicle R					1	-0.10 ns	0.44 **	-0.20 ns	-0.01 ns	0.43 **	-0.60 **	0.24 *	-0.66 **	-0.14 ns
Spikelet per panicle A							-0.14 ns	-0.23 *	0.00 ns	-0.08 ns	0.08 ns	0.07 ns	0.08 ns	0.14 ns
Percent filled R (%)							1	0.07 ns	0.15 ns	0.40 **	-0.22 *	0.34 *	-0.42 **	0.08 ns
Percent filled A (%)								1	0.08 ns	0.03 ns	0.23 *	0.24 **	0.16 ns	0.10 ns
1000 grain weight R (g)									1	0.18 ns	-0.13 ns	0.10 ns	0.00 ns	-0.02 ns
1000 grain weightA (g)										1	-0.31 **	0.60 **	-0.41 **	-0.13 ns
Harvest index R											1	-0.10 ns	0.64 **	0.25 *
Harvest index A												1	-0.28 **	-0.18 ns
Yield R													1	0.20 *
Yield A														1

*Mean followed by * is significant at 0.05*

*Mean followed by ** is significant at 0.01*

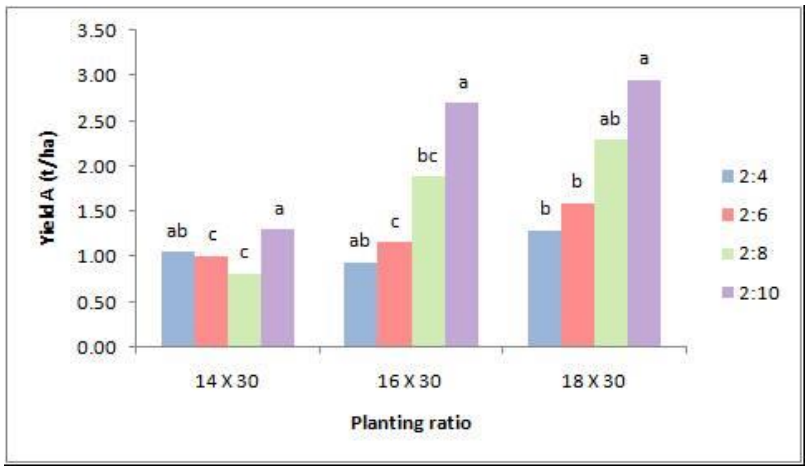

Fig.2. Relationship between planting distance and planting ratio on yield A

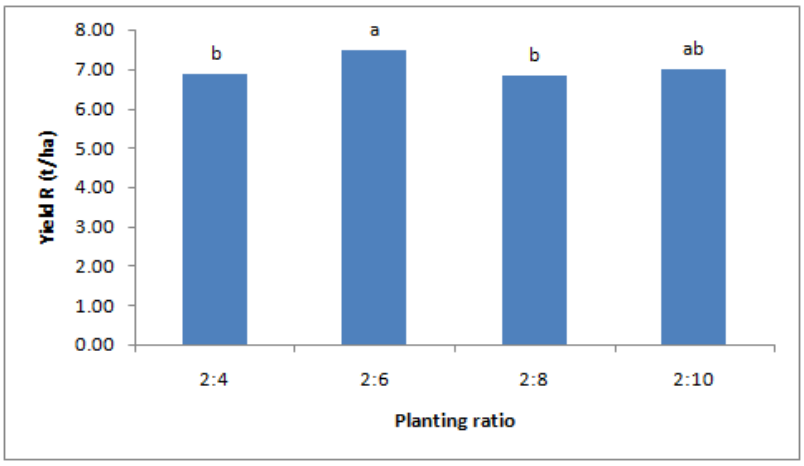

Fig.3. Relationship between planting ratio on yield R

3.2. Correlation among yield and yield component parameters

The yield of A had a significant positive association with the yield of R (Table 2). This may imply that any increment in yield R may contribute to a higher yield of A (hybrid seed). Consequently, other parameters including panicle length R and A, panicle number A and harvest index R had a significant positive association with yield R. Improving the performance of these parameters may benefit both yield R and A.

4. Conclusions

This study reveals that seed production (yield A) was significantly affected by the interaction between planting ratio and planting distance. Furthermore, both yield A and yield R shares a significant positive correlation. Hence, steps should be taken to improve the performance of the evaluated parameter such as harvest index R since it has a significant positive correlation with yield A. Ideally, the best combination to achieve the highest seed production (yield A) is by implementing a planting ratio of 2:10 with 18 x 30 cm.

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Declarations

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Competing Interests Statement

The authors declare no competing financial, professional and personal interests.

Ethical Approval

Based on institutional guidelines.

Consent for publication

Authors declare that they consented for the publication of this research work.

Availability of data and material

Authors are willing to share the data and material according to relevant needs.

Authors' Contributions

All authors equally contributed in data collection, research, and paper drafting.

References

[1] Abo-Youssef, M., Sabagh, A.E.L., Abo-Gendy, G. and Mohamed, A. (2017). Enhancing seed yield of hybrid rice by maintaining row ratio and dosages of gibberellic acid. Cercetari Agronomice in Moldova, 1(69): 31–45.

[2] Amanullah and Inamullah (2016). Dry matter partitioning and harvest index difer in rice genotypes with variable rates of phosphorus and zinc nutrition. Rice Science, 23(2): 78–87.

[3] Asmamaw, B.A. (2017). Effect of planting density on growth, yield and yield attributes of rice (*Oryza sativa* L.). African Journal of Agricultural Research, 12(35): 2713–2721.

[4] Haque, M.A., Razzaque, A.H.M., Haque, A.N.A. and Ullah, M.A. (2015). Effect of plant spacing and nitrogen yield of transplant Aman rice var. BRRI dhan 52. Journal of Bioscience and Agriculture Research, 4(2): 52–59.

[5] Hasan, M.J., Kulsum, M.U., Akter, A., Masuduzzaman, A.S.M. and Ramesha, M.S. (2011). Genetic variability and character association for agronomic traits in hybrid rice (*Oryza sativa* L.). Bangladesh Journal of Plant Breeding and Genetics, 24(1): 45–51.

[6] Hasan, M.J., Ullilah, M.Z., Rahman, A.H.M.A., Rahman, M.S. and Nasseem, S.B. (2010). Determination of suitable row ratio and spacing for F1 seed production of commercial rice hybrid. International Journal of Biological Research, (2): 74–78.

[7] Kanfany, G., El-Namaky, R., Ndiaye, K., Traore, K. and Ortiz, R. (2014). Assessment of rice inbred lines and hybrids under low fertilizer levels in Senegal. Sustainability, 6: 1153–1162.

[8] Ministry of Agriculture and Agro Based Industry (MOA) (2011). *Dasar Agromakanan Negara 2011-2020*, Chapter 3: Memperkukuhkan Industri Padi dan Beras. pp. 46–51.

[9] Mohanty, S., Narcis, O.J., Valera, H.G., Molina, I., and Matriz, J.M. (2010). Global wheat markets in turmoil: what does this mean for rice ?. Rice today, 9 (4): 47–48.

[10] Mohd Solihen, J., Elixon, S., Asfaliza, R., Rahiniza, K., et al. (2020). Kadaria 1 – Varieti padi hibrid pertama MARDI (Kadaria 1 – MARDI's first hybrid rice variety). Buletin Teknologi MARDI Vol. 22 (2020), 1–11.

[11] Roy, B. and Vijay, D. (2013). Chapter 6: Hybrid Rice in Tropical Countries. In: Breeding, Biotechnology and Seed Production of Field Crops. Ed: Roy, *B.*, New India Publishing Agency. pp. 155–201.

[12] Sindhu, J.S. and Kumar, I. (2003). Quality seed production in hybrid rice. In : Sustainable rice production for food security: Proceedings of 20th Session of International Rice Commission, Bangkok, Thailand, 23-26 July 2002. pp. 1–6.

[13] Virmani, S.S., Mao, C.X., Toledo, R.S., Hossain, M. and Jannaiah, A. (2002). Hybrid rice seed production technology and its impact on seed industries and rural employment opportunities in Asia. International Rice Research Institute, Metro Manila, Philippine.