Effects of Different Seed Coating Agents on the Quality of "Grey-matter" Hybrid Rice Seeds

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Abstract [**Objectives**] This study was conducted to select suitable mixed seed coating agents for improving the quality of "grey-matter" hybrid rice seeds. [**Methods**] Three different mixed seed coating agents (A, B, C) were used to coat the seeds of two varieties (Taiyou 390 and Zhenliangyou 8612) of hybrid rice with different "grey-matter" content (5%, 15%, 25%), and the results were investigated and compared. [**Results**] The combinations of treatment B (seed coating agent A + Linong) and treatment C (Manshijin + seed coating agent A) could significantly improve indexes including seed germination potential, germination rate, seed vigor, seedling height, fibrous roots and fresh weight of the two varieties with a "grey-matter" content greater than 15%, but had no significant effects on main root length, dry weight, leaf number and tiller number, and the effects of treatment B was better than those of treatment C. That is to say, mixed seed coating agent B (seed coating agent A + Linong) was suitable for use as a seed coating agent to improve the quality of "grey-matter" seeds. [**Conclusions**] This study provides a reference plan for the safe use of mixed seed batches with "grey-matter" deterioration.

Key words Hybrid rice; Grey-matter seed; Seed coating agent; Seed vigor; Seedling quality

The "grey-matter" of hybrid rice seeds[1-2] refers to the change of the endosperm structure and its components caused by external factors in the process of hybrid rice seed production, which is often manifested as the pulverization of endosperm, the reduction of seed transparency, and the formation of shadows. During the storage process, "grey-matter" seeds require a storage temperature below 16 ℃[4], and their seed quality decreases faster compared with normal rice seeds[3]. Moreover, "grey-matter" seeds not only have a decrease in their own quality, but also produce a large amount of hyphae during the soaking and germination process, which can cause a decrease in the quality of surrounding normal seeds[5], thereby affecting the germination rate and posing a serious threat to agricultural production safety. The use of seed coating agents can improve seed quality, promote seed germination, and improve the prevention and control of pests during the seedling stage[6-7]. China is a major country in rice cultivation, and the application of seed coating agents in rice seed cultivation is still limited. Currently, about 10% of rice seeds are treated with seed coating agents[6-8]. Especially, few studies have been conducted on the impact of mixed seed coating agents on the quality of "grey-matter" seeds. The previous research of our research team showed that mixed seed coating agent A could significantly improve the germination potential and germination rate of "grey-matter" hybrid rice seeds. However, Linong had the best inhibitory effect on the growth of microorganisms related to the germination of "grey-matter" seeds.

Therefore, in this study, in order to explore mixed seed coating agents that can not only improve the germination potential and germination rate of "grey-matter" seeds of hybrid rice, but also improve the seedling percentage and seedling quality, hybrid rice combinations Taiyou 390 and Zhenliangyou 8612 serving as experimental materials were investigated for the seed quality, seedling percentage and seedling quality of seeds with different "grey-matter" contents under different treatments of mixed seed coating agents to screen suitable seed coating agents capable of enhancing the vigor of seeds with "grey-mater" deterioration, providing a reference plan for the safe use of mixed seed batches with "grey-matter" deterioration.

Materials and Methods

Experimental materials

Materials In June 2021, Hunan AVA Seeds Industry Co., Ltd. harvested seeds of Taiyou 390 (Taifeng A × Guanghui 390) and Zhenliangyou 8612 (Longzhen 36S × Huahui 8612) at their Hainan base. After the seeds were dried, they were selected using a 5XFZ-200 duplex selection machine from Sanli Grain Machinery Co., Ltd., and samples were taken for quality testing. The proportion of "grey-matter" seeds in variety Zhenliangyou 8612 was 29%, and the moisture content and purity of the seeds were 11.2% and 99%, respectively; and the proportion of "grey-matter" seeds in variety Taiyou 390 was 32%, and the moisture content and purity of the seeds were 11.6% and 99%, respectively. Through a SORTEX B color sorter from Bühler Group, seeds were optically selected, and normal and "grey-matter" seeds were manually obtained. Finally, 10 kg of normal and 1 kg of "grey-matter" seeds were taken from each variety for later use.

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Mixed agents A. Duofu + mefenoxam · fludioxonil · azoxystrobin (Beinong (Haili) Zhuozhou Seed Coating Co., Ltd.);

B. Seed coating agent A + Linong (Syngenta (China) Investment Co., Ltd.);

C. Manshijin + seed coating agent A (Syngenta (China) Investment Co., Ltd.);

CK (no treatment).

The ratio of two single agents in each of above three binary mixed seed coating agents A, B, and C was 1∶1.

Main apparatuses and equipment RTOP-268D intelligent artificial climate incubator, produced by Zhejiang Tuopu Instrument Co., Ltd.; SORTEX B color sorter, produced by Bühler (China) Holding Co., Ltd.; 5XFZ-200 type duplex selection machine, produced by Shijiazhuang Sanli Grain Machinery Co., Ltd.

Experimental methods

Mixing of normal seeds and "grey-matter" seeds in three different ratios Normal seeds and "grey-matter" seeds of the two varieties, Taiyou 390 and Zhenliangyou 8612, were mixed in three different ratios of 5%, 15% and 25%. After mixing evenly, seeds with "grey-matter" contents of 5%, 15% and 25% were obtained for the two varieties for later use.

Standard germination test of seeds under different mixing treatments of seed coating agents Seeds of the two varieties with three different "grey-matter" contents were coated with three different seed coating agents (treatments A, B, and C). After coating, the seeds were quickly spread out and air-dried, and the moisture content was measured regularly to ensure that the seed moisture was below 12%.

Seeds of Taiyou 390 and Zhenliangyou 861 with different "grey-matter" contents (5%, 15%, 25%) without coating agent treatments, served as the blank controls (CK), which were compared with the experimental groups with different "grey-matter" contents (5%, 15%, 25%), treated with the three different coating agents. Each treatment had 200 seeds, and was repeated three times. A standard germination test was carried out in a constant-temperature light incubator to measure the seed germination potential on the 3rd day of germination and the seed germination rate and seedling height on the 5th day of germination, and the seed vigor was then calculated.

Determination of seedling percentage and seedling quality during field sowing in different mixing treatments of seed coating agents The experiment was carried out with seeds of Taiyou 390 and Zhenliangyou 8612 containing "grey-matter" seeds at different ratios (5%, 15%, 25%) without coating agent treatment as blank controls (CK) and seeds containing "grey-matter" seeds at different ratios (5%, 15%, 25%) coated with three different coating agents as experimental groups. Each treatment had 1 000 seeds, repeated 3 times. After soaking and inducing germination, seeds were sown at the experimental base of Hunan AVASeeds Co., Ltd. (Ningxiang). At 10 d after sowing, the seedling percentage was calculated. At 25 d after sowing, the seedling quality (number of fibrous roots, tiller number, main root length, plant height, fresh weight, dry weight) was tested, and the experimental data were recorded.

Data processing and analysis Analysis of seed germination-related indexes: The germination potential, seed germination rate and seed vigor were calculated according to formula (1), formula (2), and formula (3), respectively.

$$v = \frac{M1}{M} \times 100 \quad (1)$$

$$G = \frac{M2}{M} \times 100 \quad (2)$$

$$vI = G \times S \quad (3)$$

In the formulas, vI is seed vigor; G is germination rate; v is germination potential; $M1$ is the number of normal germinated seeds in the early stage of germination (the 3rd day); $M2$ is the number of normal germinated seeds in the final stage of germination (the 7th day); and M is the number of test seeds.

Investigation on seedling percentage and seedling quality:

At 10 d after sowing, the seedling percentage was investigated in each treatment area according to formula (4), and the number of normal seedlings was counted.

Seedling percentage (%) = (Number of normal seedlings/1 000) × 100% (4)

At 25 d after sowing, 10 seedlings were taken from each treatment area in the middle of the diagonal, and the plant height, main root length, number of fibrous roots, fresh weight, dry weight, number of leaves and number of tillers were measured. During the seedling stage, attention should be paid to observe the growth of rice in each treatment area, such as leaf color and seedling condition (strong or weak), and the differences were recorded.

Microsoft Excel 2017 was employed to collate and calculate all data, and the collated data were processed and analyzed using SPSS 23.0 software. Intra-group significance analysis was performed using one-way ANOVA test by the Duncan method ($P < 0.05$). The results in tables were all expressed as mean ± standard deviation, and different lowercase letters following data indicated significant differences.

Results and Analysis

Effects of different treatments of mixed seed coating agents on quality of "grey-matter" seeds

From Table 1, it can be seen that there were no significant differences in germination potential, germination rate, seedling height, and seed vigor among different treatment groups (seed coating agent treatments A, B, C) and the CK when the "grey-matter" content of the seeds of Zhenliangyou 8612 and Taiyou 390 was 5%.

As the "grey-matter" content in seeds increased, the differences in seed germination potential, germination rate, and seed vigor among different treatment groups of mixed agents and the CK group gradually became apparent. When the "grey-matter" content of seeds was 15% – 25%, the germination potential, germination

rate and seed vigor in seeds of variety Zhenliangyou 8612 under seed coating treatment B significantly increased compared with seed coating treatment A, and were significantly higher than the CK treatment group, but there were no significant differences from seed coating treatment C, and the seedling height was not statistically significant among various treatment groups. Similarly, the seed of variety Taiyou 390 had the highest germination potential under the treatment of seed coating agent B, and especially when the "grey-matter" content of the seeds was 15%, the germination potential was as high as 91%, which was significantly higher than that of the CK treatment group, but there were no significant differences in seed germination potential, germination rate, seedling height and seed vigor from the treatments of seed coating agents A and C. However, when the "grey-matter" content of the seeds was 25%, the germination potential, germination rate, seedling height and seed vigor decreased under the treatments of seed coating agents A, B and C, reached (85 ± 0.88)%, (78 ± 0.33a)%, (6.85 ± 0.102) cm, and 534.08 ± 6.85, respectively, but the seed quality of seed coating agent treatment B was still significantly higher than that of seed coating agent treatments A and C. It indicated that when mixed seed coating agents A, B, and C were used to treat different varieties of seeds with different "grey-matter" contents, seed coating agent B had the best effect in improving seed quality.

Table 1 Quality of seeds with different "grey-matter" contents under different mixed agents

Variety	Grey-matter content//%	Treatment	Germination potential//%	Germination rate//%	Seedling height//cm	Seed vigor
Zhenliangyou 8612	5	CK	89 ± 1.33 a	86 ± 0.00 a	7.18 ± 0.171 a	612.80 ± 1.74 a
		A	89 ± 0.88 a	86 ± 0.88 a	7.14 ± 0.157 a	610.73 ± 3.88 a
		B	90 ± 1.73 a	88 ± 1.76 a	7.18 ± 0.121 a	628.48 ± 10.27 a
		C	91 ± 0.67 a	87 ± 0.88 a	7.19 ± 0.120 a	625.27 ± 7.83 a
	15	CK	86 ± 0.33 b	83 ± 0.33 b	7.06 ± 0.123 a	577.09 ± 3.50 b
		A	86 ± 0.58 b	83 ± 0.33 b	7.03 ± 0.083 a	580.27 ± 5.80 b
		B	88 ± 0.33 a	85 ± 0.33 a	7.08 ± 0.127 a	602.08 ± 2.38 a
		C	88 ± 0.88 ab	85 ± 1.15 a	7.12 ± 0.134 a	604.03 ± 8.13 a
	25	CK	80 ± 0.58 b	76 ± 0.58 b	6.37 ± 0.123 a	479.28 ± 7.56 c
		A	80 ± 0.67 b	77 ± 0.88 b	6.37 ± 0.097 a	488.86 ± 8.03 bc
		B	84 ± 0.67 a	80 ± 1.00 a	6.41 ± 0.124 a	513.61 ± 7.04 a
		C	83 ± 1.00 a	79 ± 0.67 a	6.48 ± 0.098 a	510.12 ± 5.87 ab
Taiyou 390	5	CK	90 ± 1.76 a	83 ± 2.96 a	7.13 ± 0.098 a	591.93 ± 18.22 a
		A	92 ± 1.20 a	85 ± 2.00 a	7.11 ± 0.129 a	601.99 ± 14.11 a
		B	89 ± 1.67 a	84 ± 0.00 a	7.05 ± 0.134 a	588.96 ± 0.74 a
		C	91 ± 1.00 a	85 ± 0.88 a	7.14 ± 0.080 a	604.92 ± 5.22 a
	15	CK	87 ± 0.88 b	84 ± 1.20 a	7.12 ± 0.112 a	575.23 ± 3.84 a
		A	89 ± 1.20 ab	86 ± 0.88 a	7.11 ± 0.099 a	578.33 ± 10.22 a
		B	91 ± 1.00 a	86 ± 1.53 a	7.12 ± 0.133 a	590.67 ± 6.67 a
		C	89 ± 0.88 ab	85 ± 0.88 a	7.05 ± 0.095 a	589.06 ± 12.43 a
	25	CK	81 ± 1.00 b	73 ± 1.20 b	6.80 ± 0.124 a	496.18 ± 8.45 b
		A	81 ± 1.00 b	74 ± 0.58 b	6.76 ± 0.125 a	499.98 ± 3.06 b
		B	85 ± 0.88 a	78 ± 0.33 a	6.85 ± 0.102 a	534.08 ± 6.85 a
		C	84 ± 0.58 a	78 ± 0.33 a	6.86 ± 0.105 a	533.31 ± 1.98 a

Different letters following data of seeds of the same variety with the same "grey-matter" content in the same column stand for extremely significant differences between the data. The same below.

Effects of different treatments of mixed seed coating agents on quality of seedlings developed from Zhenliangyou 8612 seeds with different "grey-matter" contents

From Table 2, it can be seen that there were no significant differences in seedling height, main root length, number of fibrous roots, fresh weight, dry weight, number of leaves and number of tillers of Zhenliangyou 8612 seedlings under different mixed agent treatments when the "grey-matter" content was 5% and 15%. When the "grey-matter" content was 25%, the seedling height, number of fibrous roots and fresh weight under seed coating agent treatment B were, respectively, about (41.10 ± 0.42) cm, (46.70 ± 3.53) and (15.47 ± 0.18) g, which were all significantly higher than the CK, although there were no significant differences from seed coating agent treatments A and C. However, the seed coating agent treatments A and C were not significantly different from the CK group. Furthermore, there were no significant differences in dry weight, leaf number and tiller number of seedlings among various treatment groups. The above results indicated that seed coating agent treatment B had better effects on the quality of seedlings developed from Zhenliangyou 8612 seeds with different "grey-matter" contents than seed coating agent treatments A and C and the blank control CK.

Table 2 Comparison on quality of seedlings developed from Zhenliangyou 8612 seeds with different "grey-matter" contents among different treatments of mixed seed coating agents

Measurement indexes	Treatment	Grey-matter content//%		
		5	15	25
Seedling height//cm	CK	39.30 ±0.89 a	41.39 ±0.49 a	38.11 ±0.99 b
	A	41.79 ±0.63 a	41.78 ±0.41 a	39.88 ±0.57 ab
	B	40.09 ±0.76 a	41.30 ±0.61 a	41.10 ±0.42 a
	C	40.93 ±0.91 a	42.51 ±0.50 a	39.74 ±0.52 ab
Main root length//cm	CK	19.88 ±0.45 a	20.90 ±0.66 a	20.11 ±0.84 a
	A	20.34 ±0.47 a	19.82 ±0.64 a	21.75 ±0.50 a
	B	20.74 ±0.36 a	21.61 ±0.89 a	20.84 ±0.55 a
	C	20.44 ±0.98 a	19.87 ±1.00 a	21.02 ±0.58 a
Number of fibrous roots	CK	40.90 ±3.10 a	39.50 ±2.59 a	37.00 ±1.90 b
	A	46.50 ±4.55 a	36.10 ±2.83 a	39.70 ±2.46 ab
	B	41.10 ±4.03 a	46.70 ±4.57 a	46.70 ±3.53 a
	C	37.40 ±3.28 a	42.80 ±5.75 a	43.20 ±2.69 ab
Fresh weight (B)	CK	14.99 ±0.35 a	15.51 ±0.23 b	14.73 ±0.23 b
	A	15.01 ±0.36 a	15.43 ±0.07 b	15.29 ±0.21 ab
	B	15.37 ±0.31 a	16.21 ±0.17 a	15.47 ±0.18 a
	C	15.92 ±0.25 a	15.85 ±0.22 ab	15.56 ±0.24 a
Dry weight (B)	CK	2.50 ±0.06 a	2.59 ±0.04 a	2.55 ±0.04 a
	A	2.65 ±0.04 a	2.57 ±0.01 a	2.45 ±0.04 a
	B	3.06 ±0.53 a	2.60 ±0.05 a	2.51 ±0.03 a
	C	2.38 ±0.07 a	2.61 ±0.03 a	2.51 ±0.03 a
Leaf number	CK	12.20 ±0.85 a	10.40 ±0.76 a	9.40 ±0.72 a
	A	12.30 ±0.87 a	9.60 ±1.08 a	10.10 ±0.82 a
	B	12.20 ±1.19 a	11.70 ±0.84 a	9.90 ±0.77 a
	C	9.90 ±0.57 a	9.00 ±1.38 a	11.60 ±0.86 a
Tiller number	CK	2.90 ±0.23 a	2.80 ±0.20 a	2.90 ±0.28 a
	A	2.90 ±0.18 a	2.50 ±0.31 a	2.70 ±0.26 a
	B	2.90 ±0.28 a	3.10 ±0.18 a	2.40 ±0.16 a
	C	2.40 ±0.16 a	2.70 ±0.34 a	2.90 ±0.23 a

Effects of different treatments of mixed seed coating agents on quality of seedlings developed from Taiyou 390 seeds with different "grey-matter" contents

From Table 3, it can be seen that the effects of seed coating agents A, B, and C on the quality of seedlings developed from Taiyou 390 seeds with different "grey-matter" contents were consistent with the results of the effects on the quality of seedlings developed from Zhenliangyou 8612 seeds with different "grey-matter" contents. That is to say, there were no significant differences in seedling height, main root length, number of fibrous roots, fresh weight, dry weight, leaf number and tiller number of seedlings among seed coating agents A, B, C and the CK when the "grey matter" content of Taiyou 390 seeds was 5% and 15%. When the "grey-matter" content was 25%, although there were no significant differences in main root length, dry weight, number of leaves and number of tillers among the treatment groups, the seedling height, number of fibrous roots and fresh weight under seed coating agent treatment B were significantly higher than those under seed coating agent treatments A and C and the CK. It indicated that under the three seed coating agents A, B, and C, treatment B had the best effect on the quality of seedlings developed from Taiyou 390 seeds with different "grey-matter" contents.

Effects of different treatments of mixed seed coating agents on seedling percentage of seeds with different "grey-matter" contents

From Table 4, it can be seen that the changes in seedling percentages of seeds of Zhenliangyou 8612 and Taiyou 390 with different "grey-mater" contents, were similar under seed coating agent treatments A, B and C. As the "grey-matter" content increased, the differences in seedling percentage among different treatments increased. When the "grey-matter" content was 5%, there were no significant differences in seedling percentage among seed coating agent treatments A, B and C for the two varieties of seeds. However, when the "grey-matter" content was 15% and 25%, although there was no significant difference in seedling percentage between treatment B and treatment C for the two varieties of seeds, they were significantly higher than the CK and treatment A, and there was no significant difference in seedling percentage between the CK group and treatment A. It indicated that seed coating agent B had the best effect on the seedling percentage of seeds with different "grey-matter" contents.

Table 3 Comparison on quality of seedlings developed from Taiyou 390 seeds with different "grey-matter" contents among different treatments of mixed seed coating agents

Measurement indexes	Treatment	Grey-matter content//%		
		5	15	25
Seedling height//cm	CK	40.52 ±1.18 a	42.18 ±0.82 a	41.70 ±0.65 b
	A	42.98 ±0.75 a	41.85 ±0.92 a	42.58 ±0.86 b
	B	41.72 ±0.96 a	44.13 ±0.51 a	45.87 ±0.64 a
	C	42.67 ±0.63 a	43.47 ±0.66 a	43.47 ±0.97 b
Main root length//cm	CK	19.94 ±0.63 a	19.49 ±0.35 a	19.57 ±0.40 a
	A	19.65 ±0.49 a	18.60 ±0.63 a	20.16 ±0.64 a
	B	20.43 ±0.62 a	19.45 ±0.59 a	21.01 ±0.50 a
	C	19.13 ±0.41 a	18.85 ±0.54 a	19.84 ±0.55 a
Number of fibrous roots	CK	40.80 ±3.13 a	36.50 ±1.45 a	30.20 ±0.92 b
	A	40.70 ±1.73 a	35.10 ±1.86 a	30.40 ±2.33 b
	B	41.20 ±2.95 a	36.80 ±2.13 a	36.90 ±1.29 a
	C	42.00 ±2.18 a	36.90 ±1.94 a	32.50 ±2.04 ab
Fresh weight (B)	CK	15.38 ±0.31 a	15.03 ±0.27 b	14.96 ±0.19 b
	A	15.53 ±0.36 a	15.40 ±0.28 ab	15.72 ±0.29 a
	B	15.75 ±0.23 a	16.04 ±0.17 a	16.38 ±0.24 a
	C	15.57 ±0.21 a	15.75 ±0.26 ab	15.74 ±0.30 a
Dry weight (B)	CK	2.52 ±0.03 a	2.57 ±0.05 a	2.63 ±0.02 a
	A	2.59 ±0.06 a	2.58 ±0.04 a	2.62 ±0.05 a
	B	2.62 ±0.04 a	2.67 ±0.03 a	2.73 ±0.04 a
	C	2.59 ±0.04 a	2.62 ±0.04 a	2.62 ±0.05 a
Leaf number	CK	8.50 ±0.89 a	7.30 ±0.56 a	6.20 ±0.36 a
	A	8.10 ±0.74 a	6.00 ±0.39 a	7.00 ±0.88 a
	B	7.40 ±1.12 a	6.90 ±0.35 a	7.60 ±0.60 a
	C	6.20 ±0.51 a	6.70 ±0.42 a	6.40 ±0.45 a
Tiller number	CK	2.30 ±0.26 a	2.00 ±0.21 a	1.60 ±0.16 a
	A	2.20 ±0.20 a	1.80 ±0.25 a	1.70 ±0.26 a
	B	2.20 ±0.29 a	1.80 ±0.13 a	1.90 ±0.18 a
	C	2.20 ±0.29 a	1.70 ±0.15 a	2.00 ±0.26 a

Table 4 Comparison on seedling percentage of Taiyou 390 seeds with different "grey-matter" contents among different treatments of mixed seed coating agents

Variety	"Grey-matter" content//%	Seedling percentage//%			
		CK	A	B	C
Zhenliangyou 8612	5	84 ±0.33 a	85 ±0.58 a	86 ±0.33 a	85 ±0.33 a
	15	82 ±0.58 b	82 ±0.33 b	85 ±0.00 a	86 ±0.58 a
	25	76 ±0.33 b	75 ±0.58 b	80 ±0.33 a	80 ±0.33 a
Taiyou 390	5	87 ±0.33 a	87 ±0.33 a	88 ±0.33 a	88 ±0.67 a
	15	84 ±0.33 b	85 ±0.33 b	87 ±0.00 a	86 ±0.33 a
	25	77 ±0.33 b	78 ±0.33 b	81 ±0.00 a	81 ±0.33 a

Conclusions and Discussion

Discussion

The experimental results of the effects of different seed coating agents on the germination rate, seedling quality and seedling percentage of seeds with different "grey-matter" contents showed that for different varieties, as the content of "grey-matter" seeds increased, their germination rate, seedling quality and seedling percentage decreased, which is consistent with the previous results of our research team, that is, as the proportion of "grey-matter" seeds increased, their germination potential and germination rate both decreased[2]. However, in this study, after being treated with three different seed coating agents, the germination rate, germination potential and seed vigor were all improved, especially for the treatment with B (seed coating agent A + Linnong), which had the best effect. It might be because that the mixed seed coating agent B had the best remediation effect on the damaged "grey-matter" structure of seeds[9-10], and it inhibited microbial activity during the seed germination process, thereby achieving antibacterial and disease prevention effects.

Moreover, in this study, the seedling percentage of some seeds was higher than the germination rate. For example, when the

"grey-matter" content of Zhenliangyou 8612 was 25%, the seedling percentages after treatment with mixed seed coating agents A, B, and C were, respectively, (75 ± 0.58)%, (80 ± 0.33)% and (80 ± 0.33)%, which were higher than their corresponding germination rates of (74 ± 0.58)%, (78 ± 0.33)% and (78 ± 0.33)%. It might be due to the formation of a large amount of hyphae during the soaking and germination stage of "grey-matter" seeds, which affected other seeds and led to the production of abnormal seedlings; and during the field seedling cultivation process, the hyphae could not affect other normal seeds, so the seedling percentage of seeds with a "grey-matter" content greater than 15% was greater than the germination rate.

No yield-related measurement was carried out in this study, because previous studies showed that the impact of "grey-matter" of hybrid rice seeds on rice seeds was mainly manifested in the stage of seed soaking and germination. The activities of microorganisms related to "grey-matter" led to the generation of abnormal seedlings, which affected the germination rate, thus affecting the seed quality. Whether "grey-matter" affected the yield remains to be further explored and studied.

Conclusions

In this study, the seeds of two different varieties, Zhenliangyou 8612 and Taiyou 390, with different "grey-matter" contents, were treated with different mixed seeding coating agents, to explore the effects of different combinations on germination rate, seedling quality and seedling percentage. The main conclusions were described as below.

(1) The combinations of treatment B (seed coating agent A + Linong) and treatment C (Manshijin + seed coating agent A) could significantly improve the seed quality of the two varieties with a "grey-matter" content greater than 15%.

(2) The combinations of treatment B (seed coating agent A + Linong) and treatment C (Manshijin + seed coating agent A) could significantly improve indexes including seedling height, fibrous roots and fresh weight of the two varieties, but there were no significant effects on the main root length, dry weight, leaf number, and tiller number.

(3) When the "grey-matter" content was lower than 15%, the seed quality and field seedling quality were in a good state.

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