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Iron Powder "Kona-Bijin™" for Iron Coating Direct Seeded Rice†

1. Introduction

The wet direct seeding technique, which aims to realize labor saving in paddy rice cultivation, has continued to gain popularity in recent years. Unlike the traditional transplantation method, in which young rice plants are first grown and then transplanted to a paddy field, wet direct seeding is a technique in which the seed rice is sown directly in a rice paddy, where it germinates and establishes, and the rice is harvested from the same paddy. Because the work of raising and transplanting seedlings can be omitted, wet direct seeding can make an important contribution to labor saving in farm work.

This technique was developed in 2004 by National Agriculture and Food Research Organization (NARO)[1,2]. The seed rice is coated with iron powder, which increases its weight so that the seeds settle easily in water, and forms a tough coating that preventing birds from eating the seeds. JFE Steel began development of iron powder for use in coating seeds for wet direct seeding in 2011 and has commercialized products based on reducing iron powder.

The properties required in iron powder for seed coating are coatability, coating strength, germination rate, etc. In this research, the particle size of the iron powder was refined and a new iron powder (S91) with excellent coating performance was developed. A product in which this improved iron powder is pre-mixed with gypsum, which is used as a binder during coating, was also commercialized under the trade-name "Kona-Bijin™." This new product simplifies the coating work by the user.

This report introduces the advantages of the developed Kona-Bijin and compares its features with those of the past products.

2. Iron Coating Direct Seeding Technique

2.1 Iron Coating

The seed rice (seeds) for coating is soaked in water in advance to enable easy germination after planting. The seeds are removed from the water immediately before coating, dried, and then supplied to the coating process.

Ordinary coating is performed at a ratio of 10 kg of iron powder and 1 kg of gypsum to 20 kg of dry seeds[3]. Of these materials, the gypsum functions as a binder with the iron powder and is mixed prior to coating. Conventionally, this work was done manually. Because this pre-mixing was a troublesome step in the coating work, improvement had been desired.

Coating is performed by sprinkling the above-mentioned mixture of iron powder and gypsum on the seeds while shaking the seeds on the coating machine. A coating layer is formed by adhesion of the iron powder on the seed surface by spraying water, with the gypsum acting as a binder. In the final stage of the coating process, additional gypsum is added and mixed to form an overcoat layer on the seeds.

After coating, a tough rust layer is formed on the seed surface by drying the moisture content and oxidizing the iron, which enables curing under a uniform condition. Because the seeds adhere to each other after curing, forming an aggregate, iron coating seeds for planting are obtained by crushing this aggregate.

During crushing, part of the coating layer drops off in a phenomenon called shedding. Since rusted iron powder and the gypsum binder peel off, deterioration of the working environment had been an issue. Peeling is caused by the size of the iron powder particles; that is, iron powder with a large particle size is more prone to shedding. Shedding is also undesirable because the shed material causes clogging of various types of seeding machines. In Japan, it is generally said that coated and dried seeds can be stored for 1 year.

2.2 Iron Powder for Iron Coating (S91)

The particle size of iron powder has a large effect on the quality of iron powder-coated seeds. If the particle size is too large, uneven coating will be a problem, and shedding of the iron powder particles will occur after drying and oxidation, even assuming the coating is uniform.

As iron powders for iron coating rice seeds manufactured by JFE Steel, **Fig. 1** shows the particle size distributions of F55, which was developed in FY2012, and S91, which was developed in FY2014. In comparison with F55, the particle size of S91 is finer.

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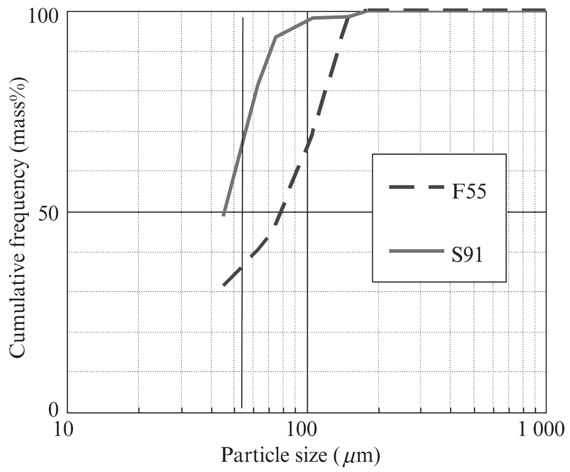

Fig. 1 Particle size distribution of iron powders for iron coating rice seed

In S91, the content of particle sizes of 53 μm and smaller exceeds 50%. However, because fire does not catch and spread in the small gas flame ignition test (The Fire Services Act; the fire laws, Dangerous object Category No. 2), this product is classified as a non-hazardous substance. The coating layer, in which this iron powder is coated together with gypsum, is extremely uniform and is virtually free from peeling after drying. Moreover, because the effect of the moisture content at the time of coating is also slight, variations in the quality of the iron coating seeds can be reduced to a very low level.

3. Kona-Bijin™ (S91 Premix)

3.1 Features of Kona-Bijin™ (S91 Premix)

Using S91 with improved particle size distribution, as described in Chapter 2, JFE Steel commercialized a product in which the gypsum used during coating is premixed with the iron powder, and began sales of this product under the trade-name Kona-Bijin™ (S91 Premix) in FY2014.

In Kona-Bijin, gypsum is added and mixed with the iron powder (S91) at a weight ratio of 10: 100. Considering workability in the coating process, Kona-Bijin is packed in bags weighing 11 kg/bag (Iron powder: 10 kg, Gypsum: 1 kg). This means one bag of Kona-Bijin can be used directly with one 20 kg bag of dry seeds without weighing. This allows the user to omit both weighing and mixing work, contributing to higher efficiency and improved workability in coating work.

3.2 Performance of Kona-Bijin™ (S91 Premix)

3.2.1 Evaluation method

The performance of Kona-Bijin™ was compared with that of the conventional product, F55. The coating conditions are shown in **Table 1**. Coating was performed with different amounts of water between 12% and 18% so as to understand the effect of the water content. A pre-mixed material, which consisted of 50 g of iron powder and 5 g of gypsum, and 2.5 g of gypsum for overcoating were prepared for 100 g of dry seeds. After soaking the dry seeds in water for 5 min, the seeds were dried, and the water content was adjusted at this time. In coating, the mixture of iron powder and gypsum and the proper amount of water were added at a known number of rotations, while rotating all of the water-adjusted seeds at 30 min^{-1} in a pan type granulator. After coating, all of the material was spread on a tray, the weight was measured, and the material was then cured in a thermostatic and humidifying chamber for 12 hours at a temperature of 25°C and relative humidity of 95%. This was followed by drying for 36 hours at 25°C and 30% of relative humidity.

Table 1 Raw materials for coating

Rice seed	Iron powder or pre-mixed powder	Gypsum for binder	Gypsum for finishing coat
Kusa-no-hoshi: 100 g	F55: 50 g	5 g	2.5 g
	F55-Premix: 55 g	0 g	
	S91: 50 g	5 g	
	S91-Premix: 55 g	0 g	

After observing the external appearance and measuring the total weight of the dried coated seeds, the entire amount was screen with a mesh of 2 mm. The weight of the material under the screen was measured, and the peel-off rate was obtained. The adhesion weight was obtained by measuring the weights of 100 grains each of dry seeds and coated seeds and calculating the difference.

3.2.2 Evaluation results

The appearance of the rice seeds which were coated using Kona-Bijin™ (S91 Premix) is shown in **Photo 1**. A uniform, satisfactory appearance without unevenness can be observed. **Figure 2** shows the adhesion weight. The adhesion weight of the F55 Premix is higher than that of F55, while S91 showed a further increase, and the adhesion weight of Kona-Bijin (S91 Premix) was the highest among the samples.

Figure 3 shows the difference in the peel-off rate depending on the water content. It can be understood that F55 shows the largest peel-off rate when the water content is small. In contrast, the peel-off rate of S91 is low independent of the water content. This is considered to be the result of refinement of the iron powder particle size.

Photo 1 Rice seed coated by "Kona-Bijin[TM]" (S91 Premix)

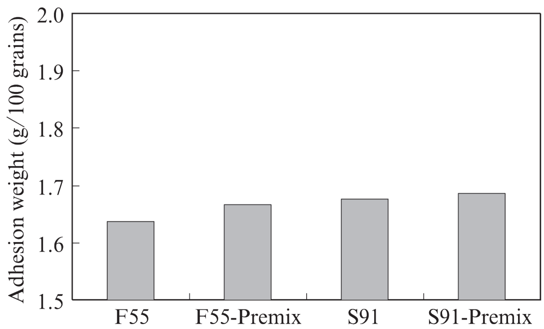

Fig. 2 Adhesion weight coated iron on 100 rice grains

4. Conclusion

Iron powder S91 for iron coating rice seeds for wet direct seeding, and Kona-Bijin[TM] (S91 Premix), in which the gypsum binder is pre-mixed with S91, were developed and sales have begun. The aims of the iron coating direct seeding technique are to improve efficiency and realize labor saving in agriculture. Kona-Bijin contributes to improved coating performance and labor saving. In the future, JFE Steel will continue to develop new products which make further contributions to the progress of agriculture.

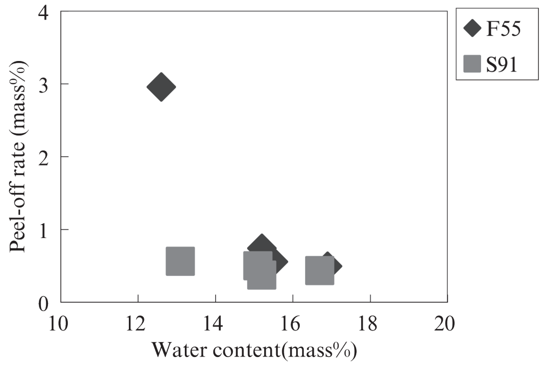

Fig. 3 Influence of water content on peal-off rate

References

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3) National Federation of Agricultural Cooperative Associations. "Fukyu · Eino-Shidoinnotameno Tetsu-Coating-Shushiwo Mochiita Suitono Chokuhan-Saibai-Manual." 2014.

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