Research of precision rice hill-drop drilling technology in China

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1. Introduction

Transplanting and direct-seeding are two basic methods for rice planting. Mechanical rice transplanting includes seedling transplanting, seedling broadcasting, either in order or out of order, and seedling dropping. Manual transplanting includes manual seedling transplanting and manual seedling broadcasting. Both mechanical and manual transplanting requires seedling bed preparation, seeds drilling, seedling management, seedling pulling and transplanting. Water resources, both surface and underground, are shrinking and water has become a limiting factor in rice production (Farooq et al., 2009). Huge water inputs, labour costs and labour requirements for transplanting rice have reduced profit margins.

In recent years, there has been a shift from transplanting to direct-seeding cultivation in several countries of Southeast Asia. This shift should reduce crop water requirements substantially, soil organic-matter turnover, nutrient relations, carbon sequestering, weed biota and greenhouse-gas emissions (Farooq et al., 2011). Manual, mechanical, and air broadcasting are three basic methods for rice direct-seeding. Manual and air broadcasting have some problems, such as higher application rate of rice seeds, out-of-order seedlings, poor ventilation and lighting, easy infection on the part of seedlings by pests and diseases, and lodging of seedlings.

In comparison, rice direct-seeding has obvious advantages, such as lower tillering points, better growth in later phase, and lower cost. To bring out the strengths of rice direct-seeding and overcome the weaknesses of manual and air broadcasting, a precision rice hill-drop drilling technology was invented in China (Wang Z.M. et al., 2010).

2. Material and Methods

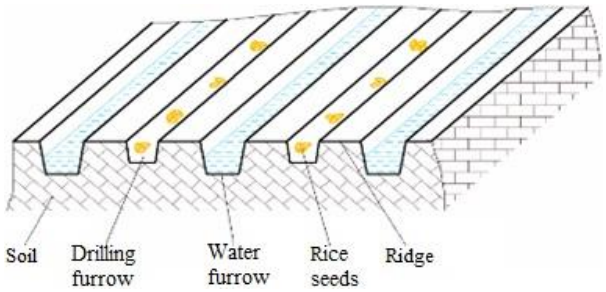

Fig.1 Principle of precision rice hill-drop drilling technology

This research introduces a precision rice hill-drop drilling technology which fits the requirements of rice planting and a machine (Luo X.W. et al., 2008) is developed. In one single pass, it creates a ridge, opens the drilling furrow on the ridge and water furrow between the ridges, and sows pre-germinated rice seeds in the drilling furrow simultaneously based on the requirements of rice planting (Fig.1). The drilling furrow is 5cm in width and 3cm in depth. It keeps the diameter of the seeding cell within 5cm. The drilling furrow increases the depth of rice seedling roots in the soil and reduces lodging which is a big problem of manual broadcasting. The water furrow between the ridges provides water for the growth of the rice seedlings. It is only necessary to keep

some water in the water furrow without the need to irrigate the entire field. This design reduces the evaporation and saves water.

Fig.2 Precision rice hill-drop drilling machine

To meet the requirements of different rice varieties, planting seasons, and soil conditions in China, precision rice hill-drop drilling machine (Fig.2) can be made with different row spacing, including 20cm, 25cm, 30cm and 20+30cm. The hill spacing can be adjusted from 10cm to 25cm. The amount of sowing seeds per drop can be adjusted from 3 to 10 grains. The chassis of an existing riding rice transplanter is used as its chassis. It is four-wheel driven so it can work properly in the deep paddy field. The feeds of the hill-drop drilling machine are driven by the power of the chassis and thus can reduce the slippage of traditional land wheel. The productivity is more than 0.5hm^2/h.

3. Results and Discussion

The field experiment results showed that, compared with precision hill-drop drilling conventional irrigation and transplanting conventional irrigation, precision hill-drop drilling sub irrigation decreased the water amounts by 23.51% and 30.46%. The yield of precision hill-drop drilling was higher than transplanting by 7.75%. Additionally, since there is no water on the ridge, the oxidation-reduction potential of soil is increased and the emission of CH_4 is reduced. The rice seedling grows in row and hill (Fig.3)

Fig.3 Growth trend of rice planted with ditching, ridging and hill-drop drilling simultaneously

Five planting patterns, including precision hill-drop drilling, manual broadcasting, manual seedling broadcasting, mechanical transplanting, and manual transplanting, were tested in the experimental farm of South China Agricultural University during the early rice production season to compare with their yields and related growth parameters. The rice variety was Peizataifeng, a high quality hybrid rice. The results are shown in Table 1.

Table 1. Effects of five planting patterns on yields and related growth parameters

Planting pattern	Yield	effective	grains per	Seed	1000-grain

	(t·hm^{-2})	panicle (×10^4·hm^{-2})	panicle	setting rate (%)	weight (g)
Precision hill-drop drilling	7.170a	310.797ab	157.79a	73.97a	22.18a
Manual broadcasting	5.282b	348.450a	134.64b	62.79b	20.16bc
Manual seedling broadcasting	6.003ab	249.784c	161.14a	74.78a	19.81c
Mechanical transplanting	6.336ab	280.802bc	163.14a	75.61a	19.84c
Manual transplanting	6.086ab	258.129c	161.81a	71.88a	21.06ab

Since 2006, the precision rice hill-drop drilling technology have applied in 26 provinces in China, with different varieties, in different seasons, and on different soil conditions. Yield increases of 10%, 8%, 6%, and 5% were observed over manual broadcasting, manual seedling broadcasting, manual transplanting, and mechanical transplanting, respectively. The rice yield data results with precision hill-drop drilling technology in different region of China are shown in Table 2.

Table 2. Results of Production Tests

Place	Planting time	Variety	Yield (kg·hm^{-2})	Yield increase from Manual broadcasting
Songjiang, Shanghai	Middle rice in 2015	Conventional rice	10371	15.2%
Songjiang, Shanghai	Middle rice in 2014	Conventional rice	9525	9.5%
Songjiang, Shanghai	Middle rice in 2013	Conventional rice	9375	7.8%
Chongming, Shanghai	Middle rice in 2011	Conventional rice	10507.5	11.7%
Shayang, Hubei	Middle rice in 2011	Conventional rice	8265	4.4%
Wuhan, Hubei	Middle rice in 2009	Hybrid rice	9418.5	14.4%
Xiaonan, Hubei	Late rice in 2009	Conventional rice	10005	10.8%
Wuhan, Hubei	Middle rice in 2008	Hybrid rice	8560.5	14.91%
Ningxiang, Hunan	Middle rice in 2008	Conventional rice	8708.4	12.90%
Nanling, Anhui	Middle rice in 2008	Hybrid rice	9496.5	28.89%
Jiujiang, Jiangxi	Middle rice in 2007	Glutinous rice	8613	10.5%
Pinghu, Zhejiang	Middle rice in 2008	Hybrid rice	9600	14.29%
Leizhou, Guangdong	Early rice in 2008	Conventional rice	8478.45	17.1%
Hetian, Xinjiang	Middle rice in 2015	Conventional rice	10549.5	40%
Wensu, Xinjiang	Middle rice in 2011	Conventional rice	12250.5	31.6%

4. Conclusion

A precision rice hill-drop drilling technology is presented and the machine is developed. In one single pass, it creates a ridge, opens the drilling furrow on the ridge and water furrow between the ridges, and sows rice seeds in the drilling furrow simultaneously based on the requirements of rice planting. The results show that precision hill-drop drilling sub irrigation can decrease the water amounts more than 20%. Since 2006, the precision rice

hill-drop drilling technology have applied in more than 26 provinces in China. The rice yield increased by more than 10%, 8%, 6% and 5%, compared with the manual broadcasting, manual seedling broadcasting, manual transplanting, and mechanical transplanting, respectively. The production cost can be saved more than 1500 Chinese Yuan per hectare，compared with manual seedling broadcasting, manual transplanting, and mechanical transplanting.

The precision rice hill-drop drilling technology provides an advanced light-simplified cultivation technique for Chinese rice mechanization production, its economic and social effectiveness are remarkable, leading the development of Chinese rice mechanization technology for rice direct-seeding.

References

Farooq, M., Wahid, A., Lee, D.-J., Ito, O., & Siddique, K.H.M. (2009). Advances in drought resistance of rice. Crit. Rev. Plant Sci. , 28, 199－217.

Farooq, M., Siddique, Kadambot H.M., Rehman, H., Aziz, T., Lee, Dong-Jin, & Wahid, A. (2011). Rice direct seeding: Experiences, challenges and opportunities. Soil & Tillage Research, 111, 87－98.

Gaikwad, B.B., Sirohi, N.P.S. (2008). Design of a low-cost pneumatic seeder for nursery plug trays. Biosystems Engineering, 99, 322－329.

Karayel, D., Barut, Z.B., & Ozmerzi, A. (2004). Mathematical Modelling of Vacuum Pressure on a Precision Seeder. Biosystems Engineering, 87 (4) , 437－444.

Kumara, G.V. P., Srivastavaa, B., & Nageshb, D.S. (2009). Modeling and optimization of parameters of flow rate of paddy rice grains through the horizontal rotating cylindrical drum of drum seeder. Computers and electronics in agriculture, 65, 26－35.

Luo, X.W., Jiang, E.C., Wang, Z.M., Tang, X.R., Li, J.H., & Chen, W.T. (2008). Precision rice hill-drop drilling machine. Transactions of the CSAE, 24(12), 52－56.

Saha, M.S.K., Rautaray, K.P. , Singh, S.K., & V.V. (2006). Development and evaluation of self-propelled rice ridge seeder for pre-germinated seeding. International Agricultural Engineering Journal, 15(2-3), 79－89.

Singh, R.C.，Singh, G.，& Saraswat, D.C. (2005). Optimisation of Design and Operational Parameters of a Pneumatic Seed Metering Device for Planting Cottonseeds. Biosystems Engineering, 92 (4) , 429－438.

Yadav, Sudhir, Gill, M.S., & Kukal, S.S. (2007). Performance of direct-seeded basmati rice in loamy sand in semi-arid sub-tropical India. Soil & Tillage Research, 97, 229－238.

Yazgi, Arzu., Degirmencioglu, Adnan. (2007). Optimisation of the seed spacing uniformity performance of a vacuum-type precision seeder using response surface methodology. Biosystems Engineering, 97(7) , 347－356.

Zheng, T.X., Tang, X.R., Luo, X.W., et al. (2010). Effects of different irrigation methods on production of precision hill-direct-seeding super rice. Transactions of the CSAE, 26(8),52－55.

Wang Z.M., Luo X.W., Tang, X.R., et al. (2010). Precision Rice Hill-Direct-Seeding Technology and Machine Based on the Combination of Agricultural Machinery and Agronomic Technology. Journal of South China Agricultural University, 31(1),91－95.