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Development and Experiment of 2ZB-79 Shallow Rice Seedling Transplanter

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Abstract Shallow planting of the rice seedlings is an important factor for getting high yield as it can increase the effective tillers on the low-node of the stem. The 2ZB-79 shallow rice seedling transplanter combined the advantages of shallow planting of the seedling-casting rice transplanter and orderly planting of the traditional rice transplanter. The principle of this kind of machine is firstly to cut the standardization nursery rice seedlings with rug soil into many small pieces, and then to plant the small pieces composed of pot soil and some seedlings on it to the field surface in order, only shallowly planted on the very top part of paddy soil. Not only it can keep the performance of planting shallowly and orderly, but also simplify many mechanisms for transition, separation, and plantation of rice seedlings. It is a new type of rice seedling transplanter called laying-type up to now to get higher efficiency when working and higher yield for rice production. This paper will introduce its developing results and analyze the comparative experiments.

Key words Agricultural machinery, Rice mechanization, Transplanter, Experiment

1 Introduction

Shallow planting is a new type of planting technology extended in the early 1990s in China, and it can increase the low-node effective tiller of rice to get higher yield. Thus, casting seedling technology represented by seedling-casting transplanter developed rapidly. The seedlings are cast disorderly in the field, making the shallow and orderly planting become impossible. Most agriculturists considered that orderly transplanting is good for ventilating and transmitting light and could take full advantage of group cultivation. The machine technique could be improved then to wide row spacing with narrow hole spacing which possesses many more advantages than the square cultivating or disorderly planting. Square planting results easily in radiant individuals, with big leaf angle, weak leaves, strong competition, shade in the low layers, low group quality in later period, poor ventilation and light condition, small green area, little accumulation of dry matters and serious infestation of insects. Casting seedlings is disorderly, causing the poor ventilation and light condition in growth period so that the growth in later period will be influenced badly and making the harvest become more difficult.

2 Main technical characteristics and parameters

The whole mechanism of seedling managing machine is included by working and transitive parts. The former is made up of base powered by paddy solo-wheel, frame of engine, walking wheel, steer wheel, frame of tow, and so on, all of which are applied commonly in China at present. The latter consists of gimbals, assembly to move box, feeding box, seedling float and planting wheel. The main parameters of them are shown in Table 1.

This machine is characterized by many creative features. (i) The core planting wheel adopted integral three-row seedling hands which can take seedlings three times, instead of using traditional planting mechanism (single or double seedling hands) which can only get seedlings one or two times in one cycle, this can increase efficiency and reduce the vibration greatly. (ii) The exchangeable type of machine is researched to adapt different row spacing, so that the user can get 238 mm or 300 mm row spacing through disassembling and assembling to meet the different agronomic standard in different regions of China. (iii) The device to reduce the side accumulation of soil is developed. (iv) The whole ring belt to transmit seedlings is designed to improve the consistence of transmitting seedlings. (v) The adjustable equipment of transmitting seedlings longitudinally is produced to widen the application scope.

3 Working principle of the rice seedling arranging machine

The working principle of the rice seedling-arranging machine is showing in Fig. 1. When the 2ZB-79 shallow rice transplanter works, the rice seedling claw distributing and taking seedlings is driven into the seedling gate by the distributive wheel and the track of the claw is controlled by the cam track. At the moment when the seedling claw goes out the seedling gate with seedlings, the crank wheels run away the cam track simultaneously. Then the spring resets and bumps onto the stop block. This accelerates seedling claw to rotate certain angle to the limited position. It the same time when the seedling claw is rotating, distributing seedling plate speeds up to push rice seedlings. This makes seedlings get off the seedling claw and stay on the earth. Then, the procedure is

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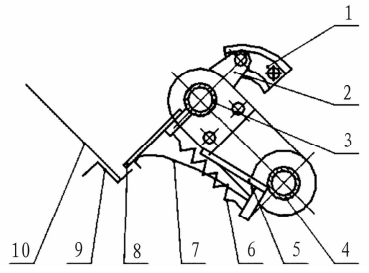
completed. Seedlings get off the seedling claw at certain speed with a series of synthetic effects such as acceleration, push, cast and so on. Thus, seedlings not only can be planted in paddy soil but also be able to stand on soil surface better. The largest difference of the mechanism between transplanting rice seedling machine and the 2ZB-79 shallow rice transplanter is that the seedling claw (detaching pin) must be in soil during transplanting rice seedlings while it needn't be in soil when arranging seedlings. Then the advantage of seedlings laying machine is that it can not only increase rice yield by shallow planting but also reduce the machinery friction caused by entering soil and simplify its structure.

Table 1 Main parameters of 2ZB-79 shallow rice transplanter

Parameter	2ZB-79
Size (length × width × height) // mm	2 489 × 2 410 × 1 272
Engine	Diesel cooled by air for Model 170F
Walking part	Solo-wheel driving, float shape simulation
Working part	Integral seedling managing mechanism
Row number // row	9
Row spacing// mm	238
Hole spacing //mm	100 – 120
Frequency //cycle/min	281
Velocity on paddy //km/h	1.7, 2.07
Velocity on the road //km/h	8.9
Efficiency//ha/h	0.2 – 0.34
Width of gate//mm	20
Max. depth of taking seedling //mm	≤25
Latitudinal width of taking seedling //mm	19.4
Length of longitudinal belt for sending rice seedling // mm	15/25
Diameter of the driving wheel (iron wheel/ rubber wheel) // mm	700/705
Maximum steer angle // degree	60

4 Experiment of the 2ZB-79 shallow rice transplanter

It takes six years to make productive replicate to test the performance of the laying machine on single crop of rice, first crop of double rice of crop rotation, second crop of double rice of crop rotation in 10 regions of Jiangsu Province, Zhejiang Province, *etc.* The performance of the machine is listed in Table 2. The comparison of growth and output is listed in Table 3 through Table 5.



Note: 1. cam track, 2. crank, 3. row of seedling claw, 4. distributing seedling axle, 5. stop block, 6. reset spring, 7. seedling releaser, 8. seedling claw, 9. seedling gate, 10. feeding box.

Fig.1 Structure of distributing seedling device

4.1 Performance of the 2ZB-79 shallow rice transplanter

Any performance of the 2ZB-79 shallow rice transplanter meets the needs of local agronomy. There is little increase in yield using seedlings laying machine than using transplanting seedling machine or planting manually. The reason of high yield lies in advantages of more effective low-node tilling, faster tiller rate and more ears, etc, after rooting of seedling in field. The contrast test between planting manually, transplanting rice seedlings using machine, casting seedlings using machine and laying seedling indicates that the average rice yield of using seedlings laying machine is 5.35%, 6.14%, and 0.27% higher than using manual transplant, rice transplanter and cast seedling machine respectively.

4.2 Analyses of performance The rate of damaged seedlings is very low, with the minimum rate of 0.12%, which would contribute to the growth of seedlings in late period. The rate of leaving out seedlings is also low, with the minimum rate of 1% and average rate of 2.89%. The 2ZB-79 shallow rice transplanter runs evenly and steadily, its maximum evenness degree is 98.1%, and average relative evenness degree is as high as 106.4%. The 2ZB-79 shallow rice transplanter has higher efficiency. Its average productivity of pure working hour is 0.34 ha/h, while the productivity of the rice transplanter for the 2ZT-78 is 0.2 ha/h. The row spacing is constant and coefficient of variation is less than 5%.

Table 2 Test results of the 2ZB-79 shallow rice transplanter

Region		Lujia village, Fuyang, Zhejiang	Yuexi, Suzhou, Jiangsu	Jingdu, Yangzhou, Jiangsu	Yellow Sea Farm, Jiangsu
Experiment condition	Area //ha	0.16	0.1	0.53	0.27
	seedling breeding ways	Breeding in drought carpet pattern	Carpet pattern	Carpet pattern in plastic plate	Breeding in water carpet pattern
	Row spacing//mm	238	238	238	238
	Height of seedling//mm	97.13	130.3	158.6	142
	Qualified rate of evenness degree before transplanting//%	84	75	85	86
	Empty rate//%	4	4	3.6	2
	Depth of soil//mm	15.4	15.16	23.6	19.2
	Density of seedlings with soil//plant/cm^2	1.704	1.4	1.75	1.71

(To be continued)

(Continued)

Region		Lujia village, Fuyang, Zhejiang	Yuexi, Suzhou, Jiangsu	Jingdu, Yangzhou, Jiangsu	Yellow Sea Farm, Jiangsu
	Damaged seedlings rate before transplanting //%	0	0	0	0
	Soil compaction //cm	10.8	8.3	/	12.2
Performance quality	Average amount of seedlings // plant	5.75	6.24	3.7	4.6
	Average depth of arranging //mm	4.5	0.92	0.46	0.3
	Actual arranging holes //10^4/ha	42.108	26.013	34.05	34.44
	Rate of leave out arranging //%	3	1.08	4.7	4.8
	Rate of falling seedlings //%	4	1.6	3.9	2.6
	Rate of damaged seedlings //%	0.12	0.16	3.2	2.1
	Qualified range of evenness degree // hole	3 – 9	3 – 9	2 – 7	2 – 7
	Qualified rate of evenness degree //%	84.33	84	88	90
	Relative evenness degree//%	10^4	112	103.5	106
	Coefficient of variation of row spacing //%	<5	<5	3.2	4.69
	Productivity during pure work hour //ha/h	0.32	0.33	0.39	0.45

Table 3 Grain structure of ear and yield for different planting patterns of single crop rice

Species	Region	Way of transplanting	Number of ears //10^4/ha	Grains per ear			Seeding rate//%	1 000-grain weight//g	Theoretical yield //kg/ha	Actual yield //kg/ha	Contrast of actual yield//%
				Filled	Empty	Total					
No.3 Wuyugan	Fuyang, Zhejiang	Mechanical seedling arranging	408.6	81.15	3.85	85.00	95.47	26.60	8 818.5	8 512.5	+2.82
		Mechanical seedling casting	368.0	93.10	2.40	95.50	97.40	26.42	9 049.5	8 490.0	+2.56
		Manual seedling planting	318.6	103.00	3.10	106.10	97.00	26.71	8 764.5	8 272.5	0.00
Tihuluo	Yuexi, Suzhou, Jiangsu	Mechanical seedling arranging	346.5	92.20	3.52	95.72	96.32	27.00	8 625.8	7 770.6	+6.14
		Manual seedling planting	378.8	73.52	1.85	75.37	97.54	27.00	7 518.3	7 320.8	0.00

Table 4 Yield of first crop of double rice of crop rotation with different planting patterns in Yuexi

Pattern	Species	Number of ears//10^4/ha	Filled grains per ear//grain	Rate of fruit//%	1000-grain weight//g	Theoretic yield//kg/ha	Actual yield//kg/ha	Comparison of practical yield//%
Manual planting	Jiayu 293	416.1	73.26	66.68	22.75	6 935.0	6 857.1	0
Mechanical arranging	Jiayu 293	534.9	76.39	72.22	21.99	8 988.3	8 748.0	+21.62
Direct planting	Zhe 9248	441.5	78.68	74.74	21.44	7 446.8	7 151.4	+4.12
Manual casting	Jiayu 293	484.8	74.17	70.21	21.90	7 874.7	7 645.5	+10.31

Table 5 Yield of single crop of rice with different transplanting patterns in Yuexi

Pattern	Area ha	Number of ripe ears//hole	Number of ears//10^4/ha	Filled grains per ear//grain	Rate of fruit//%	1000-grain weight//g	Theoretic yield//kg/ha	Actual yield//kg/ha	Comparison of actual yield//%
Manual seedling planting	0.16	12.64	378.6	90.00	97.12	29.01	9 884.9	8 038.8	0.00
Mechanical seedling arranging	0.28	14.50	846.1	88.94	97.43	27.06	10 505.4	8 834.7	+9

5 Conclusions

(i) The 2ZB-79 shallow rice transplanter is a new type of high efficient planting machine with the development of rice light planting technology. The technique of the 2ZB-79 shallow rice transplanter, integrating the production advantages of shallow and orderly planting, realized significant yield increase.

(ii) The 2ZB-79 shallow rice transplanter is a type of cheap machine. As a consequence of planting the seedling into the soil, the rice seedlings transplanting machine has a complicated mechanism with more malfunctions, more wearing parts and high cost. On the contrary, because of planting seedlings shallowly in soil, not entering soil of separating mechanism and simple mechanism, the cost of the 2ZB-79 shallow rice transplanter is low, with less damaging part easily and low using cost. According to current trial-manufacturing cost, the cost of the 2ZB-79 shallow rice transplanter is about 10% lower than that of the rice seedling-transplanting sample machine.

(iii) The 2ZB-79 shallow rice transplanter has high productivity and has wide application prospect. It has great realistic significance for improving rural economy and reducing the labor intensity. It provides a new type of rice light transplanting machine for the rice planting mechanization in China.

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problem of roof ecological thermal insulation. After nearly 10 years of research, Huanggu Company developed "Luditie" vegetation blanket in 2008, and the production technology of "Luditie" vegetation blanket is similar to that of *Sedum lineare* seedling, that is, the non-woven cloth or geotextile root reinforcement is used to fix root and form blanket. The main advantage of "Luditie" lies in the full excavation and application of green roofing plant—*Callisia repens*.

Huanggu Company has carried out a long-term screening experiment on many kinds of wild plants in the roofs of South China, comparing their resistance, ornamental features and root growth regularity, and finally selected a fine plant called *C. repens*. *C. repens* is a vine grass of the genus *Phyllostachys* L. native to tropical America. Its root system is slender and shallow. It has a green period of more than 300 d in South China and can reproduce itself after planting. Its root system and cultivation substrate are bonded into one, which can effectively prevent rainwater from washing the substrate and root system penetrating the waterproof layer. The specification of "Luditie" vegetation blanket is 50 cm × 30 cm, the thickness of substrate is 1.5 – 2.0 cm, the coverage of plant is 85% – 100%, and the wet weight of "Luditie" vegetation blanket is 15 – 30 kg/m^2. Nowadays, "Luditie" products have been popularized and applied in Guangdong Province and Jiangxi Province. In 2011, Huanggu Company and South China Agricultural University successfully applied for the inclusion of *C. repens* in *2011 National Grass Variety Regional Trial*, and the Ministry of Agriculture will set up regional trial sites in Guangzhou, Nanning, Wuhan and Quannan.

5 Comparison of products

5.1 Plants Vertige has 10 – 12 Crassulaceae plant species suitable for roof landscaping, greatly enriching the landscape design elements. KLD environment-friendly grass blanket uses the Poaceae plant species, relatively single, the landscape effect is poor. The "Luditie" vegetation blanket plant is *C. repens*, relatively single, and the landscape effect is poor.

5.2 Irrigation Vertige uses the irrigation blanket that is developed independently, and it is stable and can save water. KLD environment-friendly grass blanket and "Luditie" adopt common irrigation or artificial irrigation.

5.3 Cost The cost of roof greening with KLD environment-friendly grass blanket (excluding construction) is 258 yuan/m^2; the cost of roof greening with *Crassulaceae* mixed vegetation blanket is 500 yuan/m^2; the cost of roof greening with "Luditie" vegetation blanket is 150 yuan/m^2.

5.4 Structure KLD environment-friendly grass blanket is manufactured at one time by German MST's complete production equipments, while Vertige and "Luditie" adopt common artificial preculture mode.

5.5 Rapid landscaping KLD environment-friendly grass blanket needs grass seeds after a certain growth period to become a landscape, while Vertige and "Luditie" can become a landscape immediately after the construction.

5.6 Landscape effect Vertige *Crassulaceae* plant has rich colors and good landscape effect, while KLD environment-friendly grass blanket and "Luditie" have poor landscape effect.

6 Conclusions

There are few studies on vegetation blanket in our country, but there are some mature vegetation blanket products in foreign countries. Its complete set of vegetation blanket technology has a lot of experience that we can learn from, but because of the difference of climate and national conditions, our country must develop vegetation blanket technology according to our own specific situation. At present, the rooftop greening in China is still in its infancy, there are many factors that limit the research and development of vegetation blanket technology. It is necessary to further increase research investment in vegetation blanket plants, technology and so on[2].

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