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Dilemma and Countermeasures on Whole Mechanization of Rice Production by Raising Seedling with Plastic Membrance Covering in Mountainous Areas

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Abstract:
That is the basis of the whole mechanized production of rice with plastic membrance covering in mountainous areas to raise strong seedlings suitable for mechanical transplanting.This paper,based on annual report data of agricultural machinery equipment from 2012 to 2023 for 12 consecutive years in Wenzhou,Zhejiang,China,studies on the current status,dilemma and countermeasures of whole mechanized production of rice in Wenzhou mountainous areas,by combining theoretical research,data analysis and typical research.The result shows that the mechanization level of rice production in Wenzhou mountainous areas is significantly lower than that in the plain areas,and the progress has been slow over the past decade.In 2023, the comprehensive mechanization level of rice in Taishun and Wencheng, which are pure mountainous areas,was 74.53% and 74.45%,respectively,lower than the average level(89.32%) of Wenzhou,and far lower than Rui'an(92.81%) and Yueqing(93.23%),which are plain in mainly areas. From 2012 to 2023, the level of agricultural mechanization in rice tillage in mountainous areas of Wenzhou improved rapidly, but the progress of agricultural mechanization in transplanting, harvesting and other field management was very slow. In 2023, the rate of machine tillage for rice in Wenzhou reached 99.9%, and that in Taishun and Wencheng, two counties of pure mountainous areas, also reached 100% and 99.5%, respectively, which basically realized the mechanization of rice tillage farming. However, in 2023, the rate of machine transplanting for rice in Taishun and Wencheng was only 28.59% and 25.72%, while the average level of Wenzhou reached 67.78%; and the rate of machine harvesting in Taishun and Wencheng was 86.5% and 89.8% respectively, lower than the average level of Wenzhou (96.8%). At present, the fertilization of rice in Wenzhou mountainous areas depends on manual operation, and the level of mechanical equipment in plant protection link is also not high.From the perspectives of geography, industry, policy, equipment and technology, this paper deeply analyses the dilemma encountered in the mechanization of rice production in Wenzhou mountainous areas, and puts forward some accurate countermeasures and suggestions.This study shows that the low rice transplanting rate is the bottleneck of the whole mechanization of rice production in mountainous areas.And it greatly improve the level of rice mechanical transplanting,combined with the use of plastic membrance cover to cultivate the strong seedlings.By the promotion and application of advanced agricultural machinery and tools,it can realize the whole mechanization of rice cropping in mountainous areas.

Keywords: rice production, mountainous areas, plastic membrance, dilemma, countermeasures

INTRODUCTION

Agricultural mechanization is the inevitable trend of modern agriculture in mountainous areas [1]. Rice is the main grain crop in the mountainous areas of southern China, and the mechanization of rice farming can reduce labor intensity, improve efficiency. However, restricted by many bottlenecks, the mechanization of rice production in mountainous areas develops very slowly. In recent years, some scholars have studied on the agricultural mechanization in mountainous areas from the level of country, province or certain region, and put forward some suggestions for solving the dilemma.R.Mehta,N.S.Chande and T.Senthilkumar analyzed the current situation and the challenges faced by agricultural mechanization in the mountainous areas of India [2].K.Virender,L.Harbans,T.Rajesh, et al. introduced the promotion effect of the application of agricultural machinery on the income increase of farmers in Himachal Pradesh, India[3]. R.Devkota proposed to accelerate agricultural mechanization and promote the sustainable development of mountainous areas in Nepal [4]. B.C.Nath,Y.S.Nam,M.D.Huda, et al. investigated the status of mechanization of rice harvesting in Bangladesh, and suggests on the improvement of rice harvesting machinery in mountainous areas [5].The some scholars in China also analyzed the bottlenecks of mechanized rice production in hilly and mountainous areas and put forward corresponding countermeasures [6-7]. However, most of the literature is not enough in degree of investigation and research, especially for the mechanization of rice production in mountainous areas.

Rraising rice seedlings with imembrance covering in mountainous areas can create a warm and humid growth environment for the seedlings, which can effectively keep warm and moisturize, increase the effective accumulation temperature, resist the occurrence of cold damage in spring and prevent the harm of birds and mice, and can cultivate strong seedlings suitable for mechanical planting. The temperature in mountainous areas is lower than that in plain areas, and it can be plant high-quality rice varieties with relatively long growth period by raising seedling with the plastic membrance covering,making full use of local light and temperature resources to achieve high yield and high efficiency.Wenzhou City is located in the south of Zhejiang province in China with 11,784 square kilometers the land area, in which the mountainous area is 92,123 square kilometers, accounting for 78.1% of the land area.The city has four districts, three cities, five counties.Taishun and Wencheng are pure mountain county,Yongjia, Pingyang, Cangnan are counties with mountain in the main areas. Rice is the main crop in Wenzhou mountainous areas,and accelerating the mechanization process of rice production in mountainous areas is very important in the development of modern agriculture in mountainous[8-10].Based on the annual report data of agricultural machinery and equipment in Wenzhou City for 11 consecutive years from 2012 to 2023,by the principles of statistics, economics and sociology, and using the methods of combining theoretical research with empirical analysis, literature data and typical research, this paper systematically analyses the mechanization degree, development process and status of machinery and equipment of rice tillage, planting, transplanting, harvesting, drying, fertilization, plant protection in Wenzhou mountainous areas.Furthermore,from the perspectives of geography, industry, policy, equipment and technology, this paper analyses the bottlenecks of rice mechanization in Wenzhou mountainous areas and puts forward some corresponding countermeasures and suggestions, which is of great significance to the development of agricultural mechanization and modern agriculture in Wenzhou mountainous areas,also provides reference for mechanization of rice cropping in other similar mountainous areas.

ANALYSIS ON MECHANIZATION AND MECHANICAL EQUIPMENT OF RICE IN WENZHOU MOUNTAINOUS AREAS

Mechanization Level of Rice Production in Mountainous Areas

That the mechanization degree of rice production in Wenzhou mountainous areas is increasing year by year, but it is significantly lower than that in plain areas. In 2023, the comprehensive mechanization level of rice production in Taishun and Wencheng counties in pure mountainous areas, was 74.53% and 74.45% respectively, significantly lower than the average level of Wenzhou (89.32%), and far lower than that of Rui'an (92.81%) and Yueqing (93.23%) with plain in the main areas. In the tillage process, there is not much difference between mountainous areas and plain areas. In 2023, the rice machine tillage level in Wenzhou reached 99.9%, that in the plain area reached 100%, and that in Taishun and Wencheng also reached 100% and 99.5% respectively. But in the links of rice sowing and transplanting, the mechanization degree in Wenzhou mountainous areas is significantly lower than that in the plain areas.1n 2023,the machine transplanting rate of rice in Wencheng and Taishun was only 25.72% and 28.59%, which was significantly lower than the average level of Wenzhou(67.78%), and even lower than that of Rui'an (79.58%) and Yueqing (78.66%).The mechanization degree of rice harvest in mountainous areas is also lower than that in plain areas. In 2023, the harvest machine level of rice in Taishun and Wencheng was 86.5% and 89.8%, while the average level of Wenzhou reached 96.8%, and Rui'an and Yueqing reached 96.4% and 98.8% (Table 1).

Table 1. Comparison of the comprehensive mechanization level of rice in different regions (2023)

Type	Area	Planting area (ha)	Comprehensive mechanization level (%)	Machine tillage area (ha)	Machine tillage level (%)	Machine transplanting area (ha)	Machine transplanting level (%)	Machine harvest area (ha)	Machine harvest level (%)
Whole city	Wenzhou City	84184.3	89.32	84095.1	99.9	57056.6	67.78	81490.4	96.8
Pure mountainous areas	Taishun County	5020.0	74.53	5020.0	100	1435.1	28.59	4342.3	86.5
	Wencheng County	4886.7	74.45	4860.0	99.5	1256.7	25.72	4388.3	89.8
Mountain in the main areas	Yongjia County	9833.3	86.09	9833.3	100	5608.3	57.03	9499.0	96.6
	Cangnan County	10213.3	92.13	10176.7	99.6	7950.0	77.84	9845.6	96.4
	Pingyang County	14267.8	91.93	14242.1	99.8	10471.7	73.39	14253.5	99.9
Plain in the main areas	Rui'an City	15813.3	92.81	15813.3	100	12584.8	79.58	15244.0	96.4
	Yueqing City	16000.0	93.23	16000.0	100	12585.2	78.66	15808.0	98.8

Current Status of Mechanical Equipment for Rice in Mountainous Areas

Tillage machinery

The mechanization level of rice tillage farming in Wenzhou mountainous areas is relatively high, and the gap between the mountainous area and the plain is not large. However, the tillage machinery in the mountainous area is mainly small and micro

machine, and the plain areas is large and medium-sized machine. In 2023, rice machine tillage rate in Wenzhou is 99.9%, that of plain area is 100%, and that of Taishun, Wencheng also reached 100% and 99.5% respectively. In Wenzhou mountainous areas, it has realized mechanization in rice tillage farming, which is mainly due to the rapid application of micro-cultivators in recent years. For example, the total number of micro-cultivators in Wencheng was less than 1,000 in 2016, and jumped to 7766 in 2023, which basically solved the mechanization problem of tillage farming in mountainous areas [11]. From 2012 to 2023, the tillage farming machinery in the mountainous areas of Wenzhou showed a rapid development trend. For example, in Wencheng, the total power volume of tillage machinery increased from 4,973 kilowatts in 2012 to 80143 kilowatts in 2023.

Sowing and transplanting machinery

In mountainous areas, the mechanization degree of rice planting and transplanting is generally low [12-13].Data shows that the mechanization degree of sowing and transplanting link in Wenzhou mountainous area is far lower than that in the plain areas. In Wenzhou mountainous area, only single season rice is planted, transplanting period concentrated in mid to late May, the utilization rate of trans planter is lower than that of plain double rice area. In 2023,in Wencheng, the pure mountain county, the rice machine transplanting rate is only 25.72%,in which planted 4886.7 hectares rice with the only 15 rice trans planters (14 low efficiency hand walking trans planters and only 1 high efficiency on-seat trans planter)(Table 2).The rice machine transplanting rate in Taishun County, another pure mountainous area, was only 28.59%,lower than the average level of Wenzhou(67.78%),and far lower than that of Ruian (79.58%) and Yueqing (78.66%) with plain in main areas. Data shows that progress of the mechanization of rice transplanting in mountainous areas is slow, for example the total number of rice trans planters in Wencheng County has only changed between 11-15 units from 2012 to 2023 (Table 3). Rice trans planter has been promoted in Wenzhou mountainous area for many years, but it is not widely applied. The mechanization of planting and transplanting has become the main bottleneck of the whole mechanization of rice cropping in the mountainous area. It is necessary to explore the solution from the planting mode, planting scale and the development and popularization of suitable machine [14-16].

Table 2. Comparison of rice sowing and transplanting machine in different regions (2023)

Type	Area	Rice trans planter	Rice trans planter power (kw)	On-seat rice trans planter	On-seat rice trans planter power (kw)	Rice sowing assembly line (set)
Whole city	Wenzhou City	2372	25226.8	1738	22623.9	327
Pure mountain areas	Taishun County	4	33	1	30	
	Wencheng County	14	54	1	4	9
Mountain in the main areas	Yongjia County	114	1121	85	980	36
	Cangnan County	279	4375.1	266	4330.6	3
	Pingyang County	557	6354	455	5889	33
Plain in the main areas	Rui'an City	636	6617.9	531	6043.5	130
	Yueqing City	563	4341	203	3045	98

Table 3. Changes of rice sowing and transplanting machine in pure mountain area (Wencheng County) (2012-2023)

Years	Amount of Rice trans planter	Rice trans planter power (kw)	On-seat rice trans planter	On-seat rice trans planter power (kw)	Rice sowing assembly line (set)
2012	12	46	2	8	
2013	12	46	1	4	
2014	12	46	1	4	
2015	12	46	1	4	
2016	11	43	1	4	
2017	11	43	1	4	
2018	11	43	1	4	
2019	13	51	1	4	
2020	14	53	1	4	8
2021	15	58	1	4	9
2022	14	54	1	4	9
2023	14	54	1	4	9

Harvest and drying machinery

The mechanization level of rice harvest in mountainous areas has increased year by year, but it is far lower than that in the plain areas [17]. At present, the plain areas in Wenzhou mainly uses combine harvesters to simultaneously complete rice harvesting,

threshing and straw crushing back to the field, while in the mountainous areas, it still mainly use artificial harvesting, electric threshing. In 2023, the rice sown area in Wenzhou is 84184.3 hectares, with 1893 combine harvesters, power of 111578 kW, the sown area of rice per hectare has an average of 0.022 combine harvesters, with 1.33 kw, while Taishun County of pure mountainous area has an average of only 0.005 combine harvesters and 0.12 kw per hectare of rice sown area; and in Wencheng County of other pure mountainous area, the average sown area of rice per hectare is only 0.007 combine harvesters, 0.25 kw per hectare of rice sown area, which was far lower than that of Ruian city(0.030,1.52 kW) and Yueqing city(0.025,1.77 kW)(Table 4).

The data of 12 consecutive years in 2012-2023 shows that the amount of rice combine harvesters in the mountainous areas of Wenzhou was a growth trend, but the overall level was still low. Taken pure mountain Wencheng county as an example, in 2012, it had 9 rice combine harvesters with power of 351 kilowatts, and in 2023, it increased to 24 harvesters with power of 616 kilowatts. At present, the harvest rate of rice combine harvesters in mountainous areas is still very low. In 2023, the rice planting area of Wencheng County is 4680.0 hectares with 24 combine harvesters, it can harvest 720 hectares with operating at full load, by each harvester harvesting 2 hectares per day and 15 days, which account for only 15.4% of the total harvest area. In 2023, the rice planting area of Taishun county is 5009.4 hectares, and there are 20 combine harvesters. With operating at full capacity, the annual harvest area is 600 hectares, accounting for only 12.04% of the total harvest area. Due to the mountainous terrain and small fields, the combine harvester models at present are too large, which is difficult to expand the application, therefore it is urgent to develop small and medium-sized combine harvester suitable for mountainous areas. At present, the rice in the mountainous area of Wenzhou is still mainly harvested manually. Although the rice motorized threshers can partially alleviate the hard work of manual threshing, it has lower threshing efficiency and higher labor intensity than that of combine harvester. In 2023, Wencheng and Taishun counties had a total of 4,559 electric threshers, accounting for 46.93% of the total number of 9,713 in Wenzhou.The data from 2012 to 2023 shows that the number and power of rice motorized threshers in mountainous areas had a slow downward trend. For example, the number of rice threshers in Wencheng County has decreased from 4115 units and 7216 kW in 2012 to 3 576 units and 6478 kW in 2023. The main reason is that the combine harvesters gradually replaces the threshing operation of rice motorized threshers (Table 5).

Table 4. Comparison of number of combine harvesters in different regions (2023)

Type	Area	Planting area of rice (ha)	Amount	Amount per hectare	Total power (kW)	Power per hectare (kW/ha)
Whole city	Wenzhou City	84184.3	1893	0.022	111578	1.33
Pure mountainous areas	Taishun County	5020.0	27	0.005	601.8	0.12
	Wencheng County	4886.7	36	0.007	1216	0.25
Mountain in the main areas	Yongjia County	9833.3	67	0.007	3183	0.32
	Cangnan County	10213.3	216	0.021	12239	1.20
	Pingyang County	14267.8	454	0.032	27139	1.90
Plain in the main areas	Rui'an City	15813.3	475	0.030	24026	1.52
	Yueqing City	16000.0	422	0.025	28274	1.77

Data shows that the machinery of rice drying equipment in Wenzhou, mountainous area is far less than that of the plain area. In 2023, Wencheng and Taishun, two pure mountain counties, had only 10 and 1 grain dryers. The drying rate of rice grain machinery is only 21.5% and 2%, while the average machine drying rate of Wenzhou is 71%. The number of grain dryers in Wencheng County gradually increased from 1 in 2012 to 10 in 2014, and then remained at the level of 10(Table 5). It can be seen that the application of rice drying machinery in mountainous areas has met the ceiling. The main reason is that the batch processing capacity of mainstream dryers applied reaches 10 tons, while the amount of rice harvest of most small-scale farmers in mountainous areas rarely reaches 10 tons, but the farmers are unwilling to mix grain drying with others. It can be seen that through the moderate scale operation and the development of small drying equipment can effectively improve machine drying rate of rice in the mountainous areas.

Table 5. Changes of rice treatment machine after harvest in pure mountain area (Wencheng County) (2012-2023)

Years	Amount of motorized thresher	Power of motorized thresher(kW)	Grain dryer	Grain dryer power (kW)	Grain drying capacity (t)
2012	4115	7216	1	6	12
2013	4053	7202	4	24	42
2014	4055	7180	10	60	102
2015	4026	7104	10	60	102

2016	3873	6881	10	60	102
2017	3777	6749	10	60	102
2018	3777	6749	10	60	102
2019	3652	6646	10	60	102
2020	3675	6672	10	60	102
2021	3675	6672	10	60	102
2022	3576	6478	10	60	102
2023	3576	6478	10	60	102

Field management machinery

The data shows that the number and power of plant protection machinery in the mountainous area are slightly higher than that in the plain. However the modern plant protection machinery with high efficiency, uniform spraying quantity have not been popularized and applied in Wenzhou mountainous areas [18]. In 2023, there was 633 agricultural drone in Wenzhou, while only 16 in Wencheng and Taishun counties. The plant protection technology of rice drone has not been popularized in the mountainous areas. From 2012 to 2023, the number and power of plant protection machinery in Wenzhou mountainous areas increased slightly. For example, the number of plant protection machinery in Wencheng County increased from 969 in 2012 to 1133 in 2023, and the total power increased from 2419 kW in 2012 to 2927 kW in 2023.

The paddy fields in the mountainous areas are mostly distributed in steps and small blocks with the poor and complex irrigation conditions, so the irrigation machinery needed is relatively more. At present, the main irrigation machinery in the mountainous areas is water pump, which is more than that in the plain areas. From 2012 to 2023, the change of irrigation machinery in Wencheng County was very small. In 2012, there were 5395 drainage and irrigation machinery in Wencheng County, which was slightly more than 4910 in 2023. At present, the fertilization link of rice in mountainous areas is mainly artificial. Therefore, it is also urgent to develop topdressing machine for rice farming [19].

THE DILEMMA AND COUNTERMEASURES OF MECHANIZATION RICE PRODUCTION IN MOUNTAINOUS AREAS

Geographic Dilemma and Countermeasures

Geographic dilemma

The mountainous terrain is rugged and complex. A few paddy fields are located in flat valleys and valleys, and most are scattered on the hillside with small area, irregular shape. In mountainous areas, machine farming roads are difficult to reach all the fields, so that only some small and light agricultural machinery and tools can be used, and large and medium-sized agricultural machinery and tools cannot enter the field and operate [20]. In mountainous areas, the operation conditions of agricultural machinery are poor, and the transfer site of agricultural machinery is difficult, which affects the operation quality and efficiency of agricultural machinery. In the operating process of agricultural machinery in mountainous areas, there are much turn, transfer and other no-load travel, so that the fuel consumption cost is high and the efficiency of agricultural machinery is low. Because of rice just planted one season a year, the idle rate of agricultural machinery is high in Wenzhou mountainous areas. Coupled with poor geographical conditions in mountainous areas and small scale of rice production, and the popularizing benefit of agricultural machinery is not high.

Countermeasures

In view of the small, irregular paddy fields and narrow and rugged roads in mountainous areas, the construction of mechanized farming roads and the traffic conditions of agricultural machinery in mountainous fields should be improved [21].It should be promoted on the basic construction and transformation of farmland suitable for mechanized operations in mountainous areas by transforming small fields into large fields and irregular fields into square fields, so as to facilitate the field operations of agricultural machine. It should be encouraged in the orderly transfer of land management rights to skilled farmers and large households of agricultural machinery for expanding the planting scale of rice. It should be strengthened on coordination and cooperation between agricultural and natural resources departments in mountainous areas, for providing land for the construction of agricultural machinery sheds in mountainous areas.

Industrial Dilemma and Countermeasures

Industrial dilemma

In Wenzhou mountainous area, there are less arable land with paddy field mostly scattered, in which rice is mainly grown by farmers on a small scale and there are few large grain growers of more than 10 hectares. Most of the farmers in the mountainous areas in Wenzhou produce rice for self-sufficient, with a small amount of sales. The concentration and the industrialization level of rice production is very low, so it is difficult to form scale benefits. In the mountainous area of Wenzhou, the strong labors mostly go out to work or do business and the partial farmers in rice production are elders and women, who have weak ability to accept new technology, new varieties and new agricultural machinery, therefore the new technology application degree is far less than that in the plain areas and the rice yield and efficiency are low. The enthusiasm of farmers to purchase agricultural machinery is not high. The industrialization chain is short and there are few products of rice deep processing. The added value of the rice products and the degree of commercialization is low. Wencheng, Taishun counties are the national ecological demonstration area with superior ecological environment conditions to develop the pollution-free, green, organic rice, but so far there are no green ecological rice with known brand.

Countermeasures

It should be promoted on the industrialization of rice production in mountainous areas to improve the scale effectiveness [22]. The new varieties of rice with the best quality should be applied to improve the commodity of rice. The socialization service of agricultural machinery for increasing the use efficiency of agricultural machinery should be promoted. Relying on the excellent ecological environment in mountainous areas and the favorable conditions of soil, water and air being unpolluted, The main entities of rice production in mountainous areas should be supported to develop ecological rice brands, and form a mountain ecological rice value system with “product value + ecological value + brand value”.

Policy Dilemma and Countermeasures

Policy dilemma

In recent years, it has carried out the action of strengthening agriculture through science and technology and agricultural machinery, and introduces some policies and measures to promote agricultural mechanization in Wenzhou mountainous areas. However, due to the relatively weak government financial capacity in mountainous areas, the financial subsidies for agricultural mechanization, such as agricultural machinery purchase and infrastructure construction of agricultural mechanization in mountainous areas, are generally insufficient [23].The amount of special funds for agricultural machinery promotion allocated by the governments is not much, which cannot meet the capital needs of agricultural machinery demonstration and popularization. The popularizing system of agricultural mechanization in mountainous areas is weak, the public service capacity of agricultural mechanization, information service and technical training is insufficient, and many places lack agricultural machinery maintenance service facilities. The degree of socialization and specialization of rice production in mountainous areas is relatively low, and the co-sharing mechanism of agricultural machinery service has not yet formed, which also affects the improvement of agricultural mechanization level.

Countermeasures

It should increase on the financial support for the demonstration and popularization of new agricultural machinery technology and the construction of agricultural machinery infrastructure [24].The new policy should be explored to support mechanization of rice production in mountainous areas and support farmers in purchasing agricultural machinery and tools suitable for rice farming in mountainous areas, specially carry out the police of agricultural machinery subsidies for mechanical transplanting, mechanical harvesting, mechanical drying, fertilization and plant protection on rice. The professional cooperatives and farmers, who actively promote the application of intelligent, light and simplified new rice machinery and tools, should be rewarded. The agricultural machinery service entities and agricultural machinery production enterprises, that make breaking through in rice sowing, transplanting and harvesting machine, should greatly be supported and rewarded. It should be innovated on the incentive and reward mechanism for the socialized service of advanced intelligent equipment. It should be encouraged on agricultural machinery operators or service organizations to provide cross-county or cross-district services for rice production machinery by the seasonal time difference of rice farming operation between mountains and plains for improving the utilization rate of agricultural machinery and the operating efficiency of agricultural machinery [25].

Equipment Dilemma and Countermeasures

Equipment dilemma

At present, there is a serious shortage of economic, light, durable and intelligent agricultural machinery products suitable for rice production in Wenzhou mountainous areas. By the popularization and application of micro tillage machine in recent years, the mechanization problem of rice tillage link in mountainous areas has been basically solved, however, there is low mechanization degree in other links of rice production. In transplanting link, it is still a lack of small rice trans planter suitable for rice cropping in mountainous areas, and the mainstream self-propelled trans planters are still too large, leading to the low mechanization degree of transplanting in mountainous areas. In the harvest link, it is a lack of small harvester suitable mountainous areas. In the drying link, the capacity of the existing drying equipment is too large. In the fertilization, weeding, planting protection and other links, it is still in the situation of no good machine. The above reasons have become the main equipment bottlenecks of the full-process mechanization of rice farming in mountainous areas.

Countermeasures

It should be promoted on the optimization and upgrading of rice farming agricultural machinery equipment in mountainous areas and encourage agricultural machinery production enterprises to develop and customize small and medium-sized, light and durable new agricultural machinery and tools suitable for mountainous areas. The small and medium-sized rice trans planter, rice sowing assembly line, small and medium-sized rice combine harvester and small rice drying machinery should be demonstrated and applied, for solving the equipment problem of low mechanization degree of rice planting, transplanting, harvesting and drying in mountainous areas[26-27].Agricultural intelligence is the trend of modern agriculture, which also brings new opportunities for the full-process mechanization of rice farming in mountainous areas[28-29].The artificial intelligence, agricultural drone and other intelligent machinery and equipment should be actively applied to solve the problems of no good machine in rice planting, transplanting, harvesting and threshing, fertilization and plant protection [30-32].

Technical Dilemma and Countermeasures

Technical dilemma

At present, the mechanization degree and the technical level of rice production in Wenzhou mountainous areas is low, and the working intensity and cost is high. The farmers have low level of education, lack of knowledge of agricultural machinery operation and maintenance, which leads to the slow promotion of new rice farming technology and new agricultural machinery. That the fusion degree of agricultural machinery and agronomy is not enough also limit the application of some new agricultural machinery suitable for mountainous areas. For example, the rice drone sowing seed can solve the problem of no good machine in rice planting and transplanting link in mountainous areas, but it has not yet solved in the agronomy problems such as shortening the growth period, weed control and difficult of population control by drone sowing seed, which leads to not yet a large scale application of the technology in Wenzhou mountainous area.

Countermeasures

The excellent rice varieties and technologies, modern agricultural machinery should be applied in mountainous areas.It should be increased on the training of farmers on production technology and agricultural machinery operation technology for improving the ability of them to apply the new rice technology and new agricultural machinery combined with characteristics of agricultural machinery and rice high yield. The technology research and demonstration should be put into effect to solve technical problems of mechanization in seedlings, transplanting, harvesting, fertilization and plant protection link in rice production. The integration technology of agronomy and agricultural machinery in rice should be implemented for improving the efficiency of agricultural machinery and the yield of rice [33]. Taken the application of agricultural drone sowing seeding technology of rice in mountainous areas as an example, in agronomic aspect it needs to solve the shortening of growth period of single-season rice in mountainous areas after direct sowing seed by replacing the original varieties by applying the excellent varieties with a longer growth period. In agricultural machinery, manufacturers of drone should develop and produce special small drone with intelligent and stronger ability to avoid obstacle. Through the integration of agricultural machinery and agronomy, it can solve the problem of low degree of mechanization in rice transplanting link.

CONCLUSION

In Wenzhou mountainous areas, rice is the main grain crop and the main ration of local residents. The degree of rice farming mechanization is closely related to the development of modern agriculture in mountainous areas. The research shows that the mechanization of rice production in Wenzhou mountainous area is restricted by many bottlenecks, including geography, industry, policy, equipment and technology, and its mechanization degree is far lower than that in plain areas, and the progress is very

slow in recent years. The research also shows that due to the rapid popularization of micro tiller in mountainous areas, the mechanization problem of rice tillage farming in Wenzhou mountainous areas has been basically solved, but the mechanization level of sowing, transplanting, harvesting, drying and field management of rice in mountainous areas is still very low. Relying on digital technology and modern manufacturing technology to develop intelligent, light and small agricultural machinery and tools suitable for mountainous areas is the key to break through the slow progress of rice cropping mechanization in mountainous areas. The low machine transplanting rate of rice in mountainous areas is the bottleneck of the whole mechanization of rice production. Taken Wencheng County in pure mountainous area as an example, in 2023, the mechanical tillage rate of rice reached 99.5%, and the mechanical tillage rate reached 89.8%, while the mechanical tillage rate was only 25.72%. The main reason that affects the level of rice mechanical transplanting is that it is difficult to cultivate strong seedlings suitable for mechanical transplanting, and the plastic membrance has the characteristics of increasing temperature, shelter from wind and rain. Through plastic membrance covering and combined with reasonable water and fertilizer management measures, it can cultivate suitable strong seedlings and improve the mechanical transplanting rate.This paper puts forward some suggestions and countermeasures, such as consolidating the foundation of agricultural mechanization, increasing financial support, expanding the scale of production, innovating agricultural machinery service mechanism, introducing intelligent light agricultural machinery, popularizing new varieties and technology of rice production, and promoting integration of the agronomy and agricultural machinery, which could effectively break through the bottleneck of full-process mechanization of rice production in mountainous areas, greatly reduce intensity and costs of working, and improve yield and efficiency of rice production.

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