Study on whole-process mechanized production mode of spring potato in hilly area

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Abstract: The present situation of whole-process mechanized production of spring potatoes in hilly areas was investigated, and the production technology and application effects were analyzed. The present situation of whole-process mechanized production of spring potatoes in hilly areas was discussed, and the future development was prospected.

Key words: hills and mountains; Potato farming; Mechanized production; Study of patterns

1 INTRODUCTION

With the continuous development of science and technology, agricultural mechanization will inevitably become the main way of development. At present, agricultural mechanization in the plain area has achieved great development, but the agricultural mechanization in the hilly area is still in the development stage. As one of the five basic landforms in the world, the Hill has an area of 1 million square kilometers in China, about one tenth of the total area of the country, and is an important crop producing area. From north to south, there are mainly Liaodong Hills, Shandong Hills, Jianghuai Hills, Jiangnan Hills, Zhejiang and Fujian Hills, Liangguang Hills and so on. Only in the southwest of the hilly and middle-range spring potato planting area of more than 666,700 hm2. Through continuous field test, improvement, experiment, demonstration and other work, the whole-process mechanized production mode of spring potato has been gradually popularized and achieved good results.

2 CLIMATIC CHARACTERISTICS OF HILLS AND MOUNTAINS

Shandong hills are located in the south of the Yellow River, the climate is a warm temperate monsoon climate type. Precipitation concentration, rain and heat in the same season, spring and autumn short, winter and summer longer. The average annual temperature is 11~14 degrees, and the average annual precipitation is generally between 550~950 mm.Relevant research data showed that in the key period of potato sowing and seedling emergence in February, March, April and May, although the average monthly rainfall continued to rise (the average monthly rainfall in February was 8.5mm, March was 21.8mm, April was 37.44mm, and May was 47.88mm), the overall rainfall was low and the water shortage was serious. June and July are the important growing period of potato, with more rain and low temperature,

EMIS 2023, February 24-26, Chengdu, People's Republic of China

DOI 10.4108/eai.24-2-2023.2330683

which is the high occurrence period of late blight. August, September, October is the harvest season, more rain, not conducive to harvest and storage. Meteorological data show that there will be a period of continuous sunny days in mid-August, and this limited period of continuous sunny days is the best time to concentrate the harvest, considering market prices, harvest season and so on (Liu, 2022) [9].

FIG. 1 Potato mechanized planting

3 POTATO MECHANIZED PLANTING PATTERNS AND AGRONOMIC REQUIREMENTS IN HILLY AND MOUNTAINOUS AREAS

3.1 Mode of technology

In hilly areas, the soil is easy to dry out and lose soil moisture, which is not conducive to the expansion of potato seed buds and affects the growth and development of potatoes. Therefore, the flat cultivation method is better for drought resistance and soil moisture conservation. The fertilizer was applied between two rows of potatoes, about 25 cm from the row of potato plants. In normal cropping, the row number was 1, the row spacing was 60 cm, the plant spacing was 30 cm, and the sowing depth was 10 ~ 15 cm(Ding, 2022)[4]. At present, most of our country's hilly areas have small plots, low rainfall, backward economy, and low potato mechanization level. It is necessary to carry out experiment demonstration and popularization with small machines and tools. The technical mode is mainly "mechanical sowing + mechanical harvest", and the potato high-yield cultivation mechanization technology with fine varieties, virus-free seed potato and flat cultivation as the core should be implemented.

3.2 Farm machinery selection

Mechanized sowing is mainly carried out by 2CMF-1 potato layered fertilization seeder supporting 7.7 ~ 11 kW walking tractor, which can complete single row sowing, fertilization and soil covering of potatoes. Plant spacing 30 cm, sowing depth 10 ~ 15 cm, using single row seeding. The mechanical excavation is mainly based on the 4UM-1B potato excavator matching the 12-18 hp (1 hp=0.735 kW, the same below) walking tractor. The working width is 65 cm, the digging rate is ≥98%, the potato damage rate is ≤1.5%, the damage rate is ≤3%, and the single row excavation is implemented. The digging depth of ridge seed is 18 ~ 25 cm, the digging depth of ground is 12 ~ 20 cm, and the working efficiency is 1.2 ~ 1.5 mu /h. It is suitable for the potato planting area where the land is small, the mountain slope is steep, and the large agricultural machinery cannot get involved(MA, 2022)[10].

4 PRESENT SITUATION OF POTATO MECHANIZED PRODUCTION IN HILLY AND MOUNTAINOUS AREAS

4.1 Sowing operation

The key to improve potato yield and quality is to use special potato sowing technology and equipment to improve sowing quality. Potato planter is mainly composed of ditching device, fertilizing device, sowing depth control device, seeding device, soil covering and ridge setting device and other auxiliary components(Fan, 2022)[5]. Potato seeding technology is the key to affect the quality of sowing. According to the types of potato seed potatoes, the representative potato seed platters at home and abroad can be divided into belt (chain) spoon type, pneumatic type, differential conveyor belt type, rotary plate type, needle type, finger clip type, etc. In the sowing operation of southwest hilly area, the potato seed dispenser with chain spoon is the most widely used. The seed scoop is installed on the belt or chain, driven by the belt or chain,, scoop 1 ~ 2 seed potatoes from the seed box, the seed clearing device to remove the excess seed potatoes in the spoon, ensure that each seed spoon only one seed potato, with the belt or chain upward movement, over the belt wheel or chain wheel, Seed potatoes fall from the seed spoon on the back of the previous seed spoon. With the downward movement of the former seed spoon, the seed potatoes fall from the back of the seed spoon in a parabolic motion and fall in the sowing area to complete a sowing operation(Wang, 2022)[12].

4.2 Harvesting operation

Potato harvester can be divided into light simple excavator, segmented harvester and combine harvester. The light and simple excavator and the segmented harvester are widely used in the hills and mountains of southwest China. The light and simple excavator has the advantages of simple structure and is suitable for harvesting under the single ridge planting mode of loose soil In the process of harvest, the potato skin and the parts of the separation screen produce collision impact and intense friction, easy to crack the gel layer and produce damage. The segmented harvester generally includes the soil depth limit device, the digging device, the soil cutting device and the potato soil separation device and other structures. There are many kinds of segmentated harvesters, and the separation forms are various. Potato section harvester is mainly characterized by killing seedlings, harvesting separate operations, potato block excavation separation and store after manual picking, low efficiency, high cost, high labor intensity(Breivik, 2021)[3] (Zhu, 2022)[13].

4.3 Field transfer operation

Domestic field transport equipment in hilly areas can be divided into simple field transport vehicle, traction field transport vehicle and tracked field transport vehicle. The simple transport vehicle has the advantages of simple structure, low production cost and low efficiency. Traction type field transfer vehicle is pulled by tractor, easy to operate, high efficiency, suitable for leveling field. The traditional tracker-type field transfer vehicle inclines downhill, causing natural sliding of goods and easy to overturn. Meanwhile, the energy consumption of uphill is increased, the downhill braking system is burdened, the heat is serious, but the safety is poor(Nardo, 2020)[8].

5 APPLICATION EFFECT ANALYSIS OF POTATO MECHANIZATION IN HILLY AND MOUNTAINOUS AREAS

5.1 Comparison of small area sowing

The effects of three different feeding methods and soil cultivation methods on potato emergence and yield were compared, including dynamic soil cultivation with vibrating chain scoop, non-vibrating chain scoop scraper and rotary ploughshare. The results are shown in Table 1 below.

Table 1 Comparison data of planter

Mode of delivery	Mode of soil cultivation	Mode of seeding	Seed depth /cm	Leakage rate /%	Replay rate /%	Seedling emergence rate %	Yield /kg·hm-2
Vibrating chain spoon type	Powered soil raising	Double row in large ridge (single ridge)	14.9	9.4	1.0	93.6	34031.0
Non-vibrating chain spoon type	Scraper for soil	Double row in large ridge (single ridge)	8.5	12.8	4.7	97.5	31732.5
Rotary disk type	Ploughshare worked the earth	Big Ridge Single (Double ridge)	16.3	0.9	0	90.1	30994.0

FIG. 2 Potato harvest scene

As can be seen from Table 1, the potato with vibration chain scoop seed feeding, power-driven soil raising and large-ridge double-row (single-ridge) planter has the highest yield. From the point of view of the leakage rate, the rotary disc manual transmission mode of seeding machine leakage rate is the lowest. In addition, this kind of seeding method had the lowest yield, mainly because the single row cultivation mode had a larger evaporation area, and its drought resistance effect was worse than that of the double row cultivation mode in the arid area(Talagai, 2020)[11] (Upadhyay, 2020)[6](Ersson, 2018)[2]. In the southwest region, due to the drought in winter and spring, the depth of soil cultivation will affect the overall potato emergence to some extent.

5.2 Large area production measurement

The demonstration base will be tested with an area of 932.33hm2 in 2020 and 821.80hm2 in 2021. The large-area demonstration yield and benefits will be counted and analyzed by

referring to the Method for Calculating Economic Benefits of Scientific and Technological Achievements of Agricultural Machinery and Agricultural Engineering published by Heilongjiang Agricultural Mechanical Engineering College. Where, total production =Σ (area of single township variety × yield per unit area), average yield = total production/total area(Manorama, 2016)[7]. The basic data related to the whole process of potato production mechanization are as follows. The unit price of Dongfanghong 454 tractor is 66,000 yuan/machine, 5300 yuan/machine of rototiller, 13000 yuan/machine of seeder, 12600 yuan/machine of harvester, 9000 yuan/machine of middle-tillage management. The productivity of seeding machine was 0.23hm2/h, the operating rate of artificial seeding was 0.11hm2/ (person ·d), the production efficiency of middle-tillage management machine was 0.47hm2/h, the operating efficiency of harvester was 0.33hm2/h, the operating rate of artificial middle-tillage soil raising was 0.07hm2/ (person ·d), and the productivity of human-ox plow harvest was 0.33hm2/ (person ·d), the flight prevention cost (the third party) is 150 yuan /hm2 per time, fuel cost 5.7 yuan /kg, labor wage 100 yuan /d per person, sowing charge 900 yuan /hm2, middle tiller charge 450 yuan /hm2, harvester charge 600 yuan /hm2, the tractor depreciation life is 15 years, the seeder depreciation life is 10 years, The annual working days of Dongfanghong 454 tractor are 150d, the annual working days of rotary tiller are 35d, the annual working days of seeder are 30d, the annual working days of middle tiller are 20d, and the annual working days of harvester are 45d. The working time is 8h/d. A total of 135 tractors, 135 seeders, 135 harvesters and 73 ploughing management machines were put in(Srivastava, 2015)[1]. The manual spray operation rate was 0.01hm2/ (person ·d), the average mechanized output of the whole process was 30213.5kg/hm2, and the average output of human production was 29833.0kg/hm2. The average yield increase reached 654.5kg/hm2, and the average potato selling price was 0.93 yuan /kg. Table 2 below shows the returns of some experimental fields under different planting modes in 2021.

Table 2 Yield and benefits of different potato planting methods in 2021

Test plot number	Area/hm2	Production/kg*hm-2		CK±		
		Mechanized planting method	Farming methods for humans and animals（CK）	To increase production/ kg*hm-2	Reduce cost/yuan*hm-2	Synergy/yuan*hm-2
1	90	28352.0	27923.5	428.5	5210	5831.25
2	153	29670.5	29037.5	633.0	4920	5493.30
3	120	32503.5	32934.0	-430.5	6630	5791.60
4	231	27013.0	26984.5	28.5	4430	4730.25

As can be seen from the data in the table, the use of mechanized production has effectively improved potato planting income. At present, the current situation of spring potato industry in hilly and mountainous areas is mainly manifested by a large number of varieties, and there is no single particularly prominent variety of large-scale planting. The technical index is not uniform, which has become the biggest problem of mechanization operation. The outbreak of potato late blight was serious in southwest China, and the cultivar's resistance to disease was required to be strong. Generally, potato varieties with high resistance to late blight have a long growth period, vigorous growth potential and tall plants, and the spacing between plants and

rows should be determined according to different varieties, plant types and plant growth potential. The combination of agricultural machinery and agronomic techniques is also required to be higher. Coupled with the climate characteristics of dry winter and spring and rainy summer and autumn in Southwest China, it brings great challenges to agricultural mechanization. The application of mechanized production technology has a certain effect on potato planting, and the extension effect is remarkable.

6 CONCLUSION

In this paper, the present situation of fully mechanized production of spring potato in hilly and mountainous areas is discussed. Meanwhile, through the comparative study of potato yield and benefit under different planting methods, the effect of mechanized production technology on potato planting is proved. It is also found that there are no outstanding varieties and the technical index is not uniform which affect the large-scale potato mechanization planting in hilly areas. With the continuous advancement of agricultural mechanization, agricultural machinery production in hilly areas has achieved certain results, but there are still some problems. In the future, the development direction of potato mechanized planting in hilly and mountainous areas mainly includes the following aspects: First, breeding varieties suitable for mechanization in hilly and mountainous areas. We will intensify research on the good traits of machine-friendly varieties, which will provide an important guarantee for the sustainable development of the local potato industry and the income increase of potato farmers. Second, we formulated regional development plans. Geographical conditions and agronomic diversity seriously hinder the whole-process mechanization of potato in hilly and mountainous areas. Research on the whole-process mechanization production technology and regional differences of potato in hilly and mountainous areas should be carried out, and technical regulations should be formulated for whole-process mechanization production of potato in hilly and mountainous areas. The third is to vigorously promote technological innovation, especially the small potato production machinery with simple technological principle and mechanical structure. Adhere to the combination of agricultural machinery and agronomy, pay attention to the coordinated development of agricultural machinery and agronomy technology, research and development of potato production machinery suitable for the geographical and climatic characteristics of hills and mountains with reliable performance. In the future, the full mechanization of spring potato production in hilly areas is still very important.

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