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Study on plant characteristics of ophiopogon japonicus adapted to mechanized harvesting

Weikai Gao[1], Huishuang Yu[1] ,XiaosongFu[1], WenkaiMei[1], ,Aichao Li[1],Zhian Zheng[1]

[1](engineering institute, China Agricultural University,china)

Abstract: *In order to develop the harvesting equipment of ophiopogon japonicus, the planting system of ophiopogon japonicus was investigated to explore the possibility of mechanization. Through field investigation and experimental research, the mechanical properties related to the measurement of plant property parameters of Ophiopogon japonicus in the harvest period were studied, and the planting plant spacing, plant shape parameters in the harvest period, and the shear and compression properties of Ophiopogon japonicus plant were obtained. At the same time, the planting soil of Ophiopogon japonicus was analyzed and studied, and the data such as water content and soil solidity of the planting soil were obtained, which laid a foundation for the development of harvesting machinery of Ophiopogon japonicus.*

Key Word*:Ophiopogon japonicus; Mechanical properties; Shear properties; Soil firmness.*

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I. Introduction

Ophiopogon japonicus is the dry root of Liliaceae plant. It is slightly fragrant, sweet and bitter. It has the functions of anti fatigue, scavenging free radicals, improving cellular immune function and lowering blood sugar [1]. Ophiopogon japonicus is mainly distributed in Sichuan, Zhejiang, Hubei, Shandong, Fujian and other places, among which the "Sichuan Ophiopogon japonicus" produced in Sichuan is called genuine medicinal materials [2]. In 2020, the planting area of Ophiopogon japonicus in Santai County, Mianyang City, Sichuan Province will reach 60000 mu, with a total output of more than 15000 tons. The demand for Ophiopogon japonicus harvesters is growing [3]. When harvesting ophiopogon japonicus, it is required to avoid omission and damage of underground tubers, and not damage the bud core wrapped in the middle of the lower part of ophiopogon japonicus seedlings. At present, the harvesting of ophiopogon japonicus is basically completed manually. When harvesting, first irrigate the soil for 2-3 days, loosen the soil layer with a fork, then pull the ophiopogon japonicus out of the soil, smash the soil, and finally cut the tuber with a fruit cutting frame. High cost and low efficiency of manual harvesting. The existing rhizome medicine harvesters cannot meet the mechanized harvesting of ophiopogon japonicus [4-11], and the dedicated ophiopogon japonicus harvesters cannot meet the needs of farmers [12,13]. Aiming at the development of harvesting machinery for ophiopogon japonicus, this paper measured the plant row spacing, plant physical properties and planting soil parameters of ophiopogon japonicus.

II. Material And Methods

The experiment was conducted in the planting base of ophiopogon japonicus in Santai County, Mianyang City, Sichuan Province. The variety of ophiopogon japonicus was Chuanmaidong 1, as shown in Figure 1.

Randomly sample and test the plants and soil in the field [14]. Select sampling points in four diagonal areas in the field. Randomly select plants within each 1m2 sampling point range, measure the plant height and the extension width of stems and leaves, and excavate the section where the plants are excavated, measure the burial depth of plants. After measuring the basic parameters of the field, excavate and harvest five plants at each point, and classify the samples according to the serial number, The relevant parameters shall be measured separately. Specific parameters include: plant height, diameter of stems and leaves on the surface, diameter of underground roots, burial depth, root traits and size. At the same time, measure the soil hardness and take the soil out, hit the drying box and take it back to measure the soil moisture content. Test tools: soil hardness tester, scissors, meter ruler, vernier caliper.

Figure 1. Ophiopogon japonicus and its tubers

The root tuber and stem leaf tensile test [15-17]: sample and test the above Ophiopogon japonicus plants according to the stems and leaves at different positions. When sampling, randomly select the stems and leaves of different sizes, and carry out tensile test on the stems and leaves on the universal testing machine in the laboratory. Carry out tensile tests on the corresponding parts of the same stem at different positions, take the bottom of the stems and leaves, test different parts of different diameters at an interval of 30mm, and then calculate the average value; Take samples of the above ophiopogon japonicus plants according to the root tubers at different positions. When taking samples, randomly take root tubers of different sizes, and carry out tensile tests on the stems and leaves on the universal testing machine in the laboratory. Carry out tensile tests on the corresponding parts at different positions of the same plant. Test the different parts of the main root, the outer layer of the main root, and the outer layer of the main root with the main root as the benchmark, and then calculate the average value.

The tensile test of stems, leaves and roots was carried out on SANS-CMT6104 universal testing machine, with the maximum test force of 10 KN, accuracy class of 0.5 and power of 0.4 KW. Wedge type tensile fixture is selected for the test. 200 N sensor with accuracy class of 5% is used during the test, and the loading speed is 10 mm/min. The stem, leaf and root tuber are cut from the plant. The stem, leaf and root tuber are bound with soft foam tape to facilitate clamping. During the test, one end is placed in the middle of the upper clamp and the lower end is placed in the middle of the lower clamp. The clamping length is 20-30 mm. When the test machine is stretched, the branches and stems are guaranteed to be in a vertical state. After tensile fracture, the data is generated and converted into a chart.

For the determination of soil moisture content and soil firmness, the drying method is used to determine the soil moisture content and directly measure the soil moisture, which is also the current international standard method. Use a soil sampler to take soil samples, use a 0.1g precision balance to weigh the soil samples, record it as the wet weight M of the soil samples, and bake the soil samples in an oven at 105 ℃ for 6-8 hours to constant weight. Then measure the dried soil sample and record it as the dry weight Ms of the soil sample. The soil moisture content is equal to the result of the mass of aluminum box and soil sample before drying minus the mass of aluminum box and soil sample after drying divided by the result of the mass of aluminum box and soil sample after drying minus the mass of empty aluminum box after drying, and finally converted into a percentage. Soil firmness shall be measured by soil hardness tester.

III. Result

The plant height of Ophiopogon japonicus can be divided into natural state and extension state. The natural state refers to the direct data obtained without human intervention in the field, and the extension state refers to digging Ophiopogon japonicus out of the soil and laying it flat on the ground. The specific results are as follows:

Table no 1: Plant height parameter table

data type	In natural state/mm	Under extension/mm
average value	18.75	20.86
Standard error	1.8	3.04
Maximum	24	28
minimum value	10	11
Observations	25	25

The results of the distribution diameter of the ground stems and leaves, the distribution diameter of the underground roots, and the burial depth of Ophiopogon japonicus are as follows:

Table no 1: Plant burial depth and distribution

data type	Distribution diameter of stems and leaves on the ground/mm	Underground root distribution diameter/mm	Burial depth/mm
average value	22.5	18.33	15.5
Standard error	2.12	1.33	0.85
Maximum	35	24	18
minimum value	14	15	12
Observations	25	25	25

Through the universal material testing machine, the tensile test results of stems, leaves and roots are shown in the following figure,

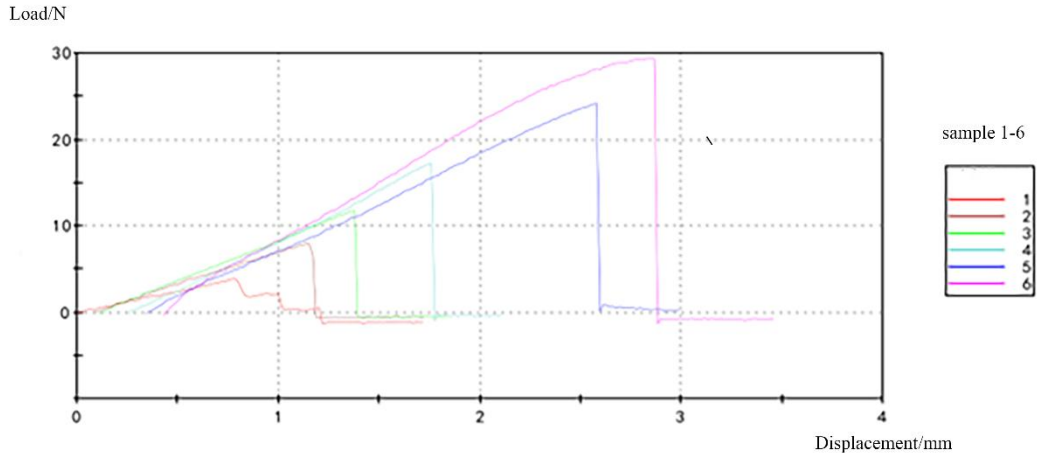

Figure 2. Tensile load of stem and leaf

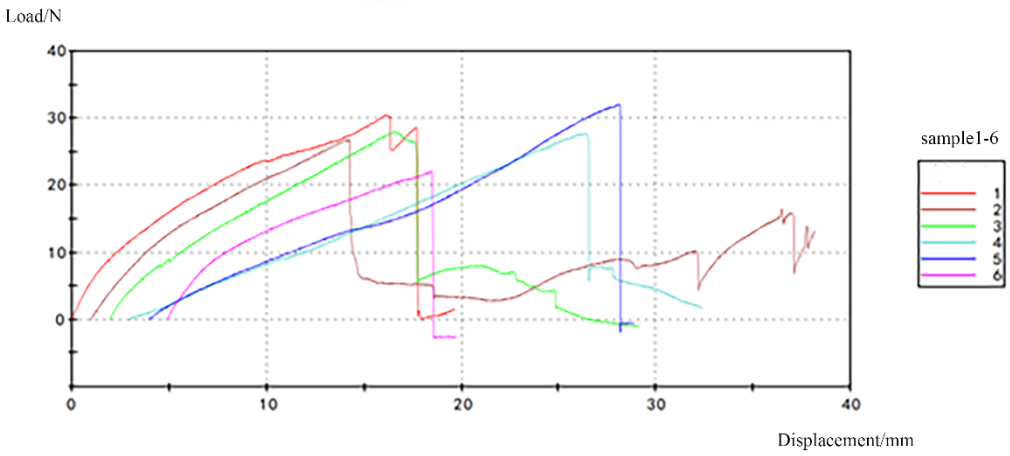

Figure 3. Tensile load of Root

The results of soil moisture content and soil firmness test are shown in the following figure:

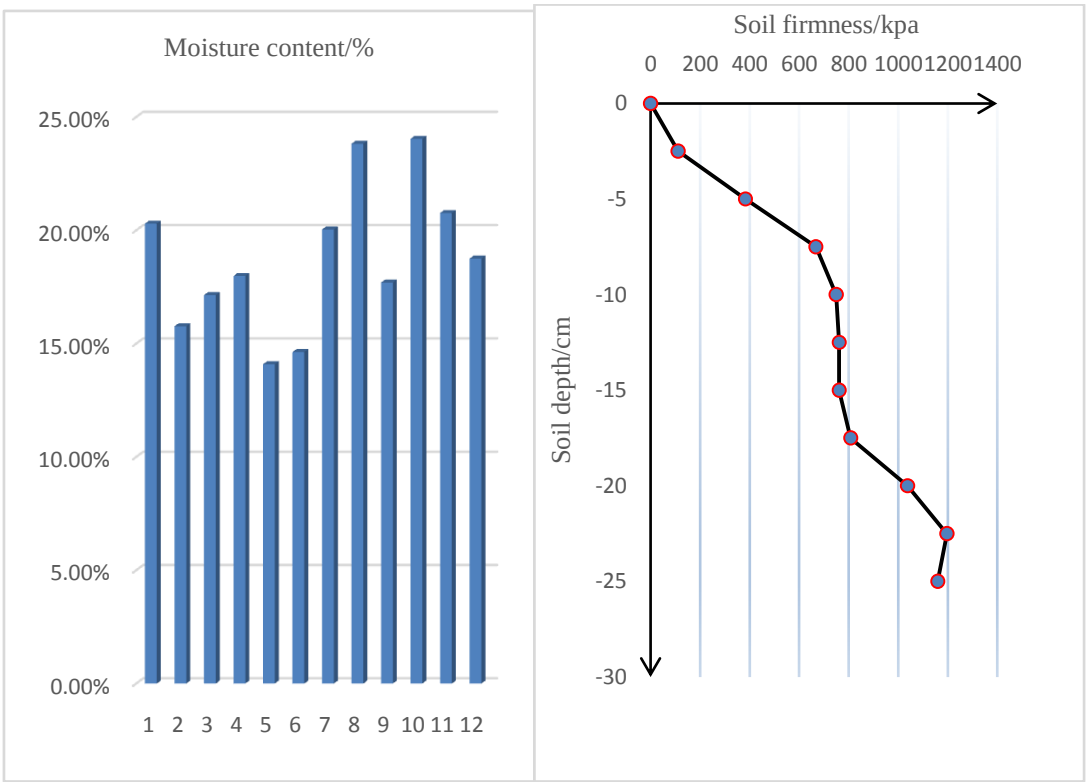

Figure 4. Tensile load of Root

IV. Discussion

The plant spacing of Ophiopogon japonicus is 10mm, and the row spacing is 10mm, which belongs to the average distribution planting. The average diameter of the above ground stems and leaves is 22.5mm, which indicates that the stems and leaves of Ophiopogon japonicus basically cover the ground. For harvesting machinery, it is very difficult to harvest rows between such small plant and row spacing. Therefore, when considering the design of harvesting machinery, it should be considered to achieve unified harvesting of multiple rows, Harvest more than 4 lines each time. At the same time, the burial depth of Ophiopogon japonicus is 15.5 mm. Considering that some Ophiopogon japonicus has a large burial depth, the harvesting depth should reach 20 mm. Through the tensile test on the stems, leaves and roots of Ophiopogon japonicus by the universal material testing machine, the tensile fracture value of the stems and leaves will increase with the increase of the diameter of the stems and leaves. Regardless of the top section of the stems and leaves that is easily broken, it should be ensured that the mechanical damage force of the stems and leaves during harvesting is less than 30 N. The root tuber of ophiopogon japonicus is the main target of harvesting. It is not allowed to leave the root tuber during harvesting. Therefore, the smaller value should be taken after excluding the test results with large errors. According to the chart, the force of mechanical damage to the root tuber of ophiopogon japonicus should be less than 20N. At the same time, the average water content of the soil planted with ophiopogon japonicus during harvesting is 18.75%, and the average firmness is 816kpa, These data provide data support for the calculation of traction resistance of winter wheat harvesting machinery.

V. Conclusion

(1) This paper introduces the shape structure of Ophiopogon japonicus. On the basis of structure division, the height, burial depth, distribution diameter of stems and leaves on the ground, distribution diameter of underground roots, number and size of roots of each Ophiopogon japonicus were measured and counted.
(2) The tensile test was carried out on the stems, leaves and roots of Ophiopogon japonicus, and the breaking limit value between the stems and leaves and the tensile limit of the roots breaking away from the plant were obtained, which provided data support for Ophiopogon japonicus to reduce the damage and fall during harvest.
(3) The soil moisture content and soil firmness of ophiopogon japonicus planting soil were measured, which provided data support for the calculation of design power and traction resistance of ophiopogon japonicus harvesting machinery.

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