EXPERIMENTAL STUDY ON THE EFFECTS OF DIFFERENT PRESSURE METHODS ON THE GROWTH CHARACTERISTICS OF BUCKWHEAT
/
不同镇压方式对荞麦生长特性影响的试验研究

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ABSTRACT
In order to fully explore the influence of different pressure methods on the growth characteristics of buckwheat, a pressure test device with adjustable press force, and easy to replace the press wheel was designed. Using the dry matter quality of buckwheat roots, stems, leaves at seedling stage, plant height, number of main stem nodes, number of main stem branches, grain number per plant, grain weight per plant, and yield as evaluation indexes, single factor test on press force was carried out, and three-factor and three-level orthogonal test was carried out too with press wheel outer diameter, press force and press wheel type as factors. The results showed that the index values of buckwheat showed a trend of first increasing and then decreasing with the increase of press force. When the press force was 450 N, the growth and development of buckwheat performed best. The effects of press wheel outer diameter, press force, and press wheel type on growth characteristics of buckwheat was different. The effects of press force and press wheel type on the indexes were greater than that of press wheel outer diameter. The optimal pressure methods of buckwheat sowing are as follows: the press wheel outer diameter is 300 mm, the press force is 450 N, and the press wheel type is conical combined wheel. The results of this study could provide reference for the improvement of high-yield mechanized sowing technology of buckwheat and the design of rational pressure device.

摘要
为全面探究不同镇压方式对荞麦生长特性的影响，设计一种镇压力可调、镇压轮便于更换的镇压试验装置。以荞麦苗期根茎叶干物质量、株高、主茎节数、主茎分枝、单株粒数、单株粒重等农艺性状和产量为评价指标，开展了镇压力单因素试验。以镇压轮外径、镇压力、镇压轮型式为试验因素开展了三因素三水平正交试验。试验结果表明：荞麦各指标值随镇压力的增大呈先增大后减小的趋势。 当镇压力为 450 N 时， 荞麦生长发育情况表现最佳。 镇压轮外径、 镇压力、 镇压轮型式对荞麦生长特性的影响差异性较大， 镇压力和镇压轮型式对指标的影响比镇压轮外径大。荞麦播种的最优镇压方式为镇压轮外径为 300 mm， 镇压力为 450 N， 镇压轮型式为锥形组合轮。 该研究结果可为荞麦高产机械化播种技术的提升、 合理镇压装置设计提供参考。

INTRODUCTION
Buckwheat is a crop of the genus Buckwheat in the Polygonum family, which is internationally recognized as a versatile economic crop with functions such as nutrition, health, medicine, feed, etc. *(Xu et al., 2021; Lu et al., 2022)*. Buckwheat is one of the main multigrain crops in China. It has the characteristics of cold tolerance, drought tolerance, poverty tolerance, strong stress resistance and short growth period. It has become an important food crop and cash crop in hilly and alpine areas of China *(Huang et al., 2018)*.

Pressure is an important part in mechanized seeding, which mainly serves to compact the soil during the seeding process, prevent water evaporation, and make the soil particles tightly combine. Reasonable pressure can effectively improve the soil environment, play a role in preserving and increasing soil moisture, and have a positive impact on crop emergence, growth, and yield *(Lu et al., 2022)*. Jia Honglei et al. conducted an in-depth study on the structure design and function mechanism of the pressure device (*Jia et al., 2015; Jia et al., 2015; Guo et al., 2017*).

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Wang Jingli et al. developed a variable pressure seedling belt compactor for precision seeder, and conducted post-seeding pressure tests on maize. The effects of different press forces on soil water content, soil pressure strength, germination, growth and yield of maize after seeding were analyzed, and the optimal pressure strength for crop emergence and growth was 0.5-0.7 kg/cm^2 *(Wang et al., 2009)*. Dang Hongkai et al. studied the effects of moisture creation and pressure after sowing on water consumption and growth of wheat before winter, and the results showed that suitable moisture content is the basis of pressure after sowing, and pressure is the guarantee for raising moisture and strengthening seedlings. After sowing wheat in Hebei region, a 95 kg/m compactor is easy to operate in the field, and has a good compaction effect *(Dang et al., 2016*). Lv Guangde et al. carried out field test to determine the influence of pressure at different periods on yield and dry matter quality of wheat, and found the best pressure method *(Lv et al., 2021)*. Yu Xichen et al. studied the effects of different pressure methods on the growth, development and yield of maize, and the results showed that pressure could improve soil water content and soil capacity, which was conducive to the accumulation of dry matter quality and the improvement of yield *(Yu et al., 2002)*. In summary, at present, Chinese scholars only study the influence of pressure treatment on crop growth characteristics of corn, wheat and other major food crops, and there are few studies on buckwheat, so it is necessary to carry out such experimental studies.

In this paper, a pressure test device was designed to study the effects of different press forces, press wheel outer diameter and type on the growth characteristics of buckwheat, such as the dry matter quality of roots, stems and leaves at seedling stage, plant height, number of main stem nodes, number of main stem branches, grain number per plant, grain weight per plant, and yield. The optimum pressure methods were determined in order to provide reference for the improvement of mechanized sowing technology and the design of rational pressure device of buckwheat.

MATERIALS AND METHODS

Test conditions

The test was carried out from August 13 to October 24, 2022 at Shenfeng Village Experimental Base in Taigu District, Jinzhong City, Shanxi Province. The test soil was sandy loam with medium fertility level. The soil moisture content during sowing was 10.77%. The previous crop was oat.

The test equipment included walking crawler seeder, pressure device, steel ruler, electronic scale, sample bag, aluminum box, drying oven, shovel, dustpan and cleaning screen, etc.

Design of test device

In order to explore the influence of pressure on the growth of buckwheat, eliminate the influence of other parts of the planter, a pressure test device was designed, as shown in Figure 1. The device is mainly composed of handle push rod, counterweight box, press wheel, etc., which can easily replace the press wheel, and adjust the press force. During the test, the operator drove the whole test device forward at a constant speed through the handle push rod. The weight box always kept vertical during the movement. By replacing different press wheels and changing the weight of the weight box, the pressure conditions could be changed to meet the requirements of the test design.

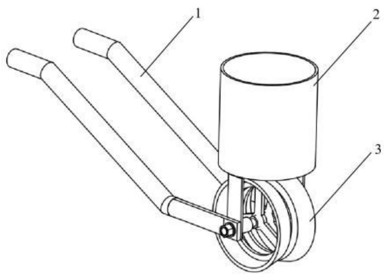
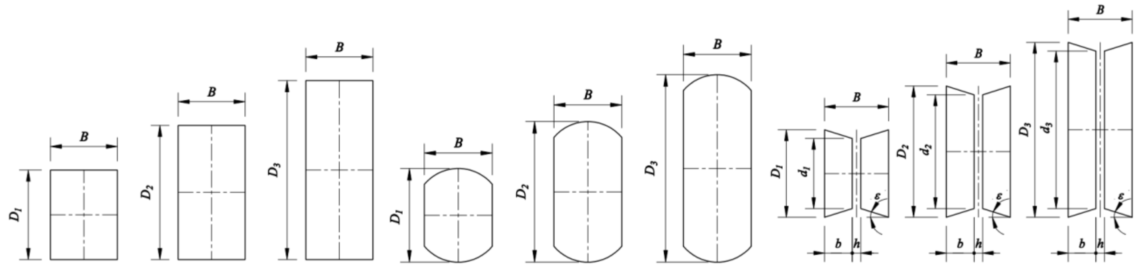


Fig. 2 - Pressure test device

1. Handle push rod; 2. counterweight box; 3. Press wheel

The press wheel is one of the important components of the pressure test device. Changing the type and size of the press wheel will have different pressure effects, which will have different impacts on crop growth and development. This study adopted three types of wheels: flat wheel, convex wheel, and conical combination wheel, the plane wheel, convex wheel and conical combined wheel. Each type is designed and processed with three different outer diameter sizes, as shown in Figure 2.

The outer diameters D_1=200 mm, D_2=300 mm, and D_3=400 mm. The width of the press wheel B=150 mm. For the conical combination wheel, the horizontal width of a single conical surface b = 65 mm, the distance between two conical wheels h = 20 mm, and the inclination angle ε = 17^0.



a) b) c)

Fig. 2 - Structure of press wheel

a) Plane wheel; b) Convex wheel; c) Conical combined wheel

Test methods

Sowing test

The buckwheat variety used in the test was Hongshan buckwheat. The average 1000-grain weight was 34 g, and the moisture content of the seed was 13.2%. The Sowing text selected plot sowing method, plot area was 2 m × 5 m = 10 m^2. According to the requirements of agronomy, each plot was sown 5 rows. The sowing amount of buckwheat is generally 45-60 kg/hm^2, and the sowing amount in the plot was calculated based on the sowing amount of 53 kg/hm^2. When sowing, the walking crawler seeder was used to sow seed. The sowing depth was 5 cm. After sowing, the pressure text was carried out according to the experimental design scheme.

Test Design

(1) Single factor test design

In the process of crop sowing, low press force does not have the effect of increasing soil moisture, while excessive pressure could cause soil compaction, causing changes in soil particle structure, poor air permeability, and affecting seedling emergence *(Obour et al., 2018; Zuo et al., 2017; Shahrayini et al., 2018*). To explore the optimal press force, a conical combined wheel with an outer diameter of 300 mm was selected as the press wheel for the single factor test. During the test, the change in press force is achieved by changing the counterweight of the counterweight box. There were 6 treatments (0, 250, 350, 450, 550, and 650 N), and each treatment was repeated 3 times. The control group was selected when the press force was 0 N.

(2) Orthogonal test design

The purpose of this test was to explore the effects of different suppression methods on the growth characteristics of buckwheat. Therefore, a three-factor and three-level orthogonal test was designed. The press force, press wheel outer diameter and type were selected as test factors, and three levels were taken for each factor. To ensure the accuracy of the test, each treatment was repeated 3 times.

The experimental factors and levels are shown in Table 1.

Table 1

Factor-level table of test

Levels	Factors		
	press wheel outer diameter	press force	press wheel type
	[mm]	[N]	-
1	200	350	plane wheel
2	300	450	convex wheel
3	400	550	conical combined wheel

Determination of experimental indexes

The main indexes tested in single factor and orthogonal test included the dry matter quality of buckwheat roots, stems, and leaves at seedling stage, agronomic traits (including plant height, number of main stem nodes, number of main stem branches, grain number per plant, and grain weight per plant), and yield. The determination methods were as follows.

(1) Determination of dry matter quality at seedling stage

During the seedling stage of buckwheat, five individual plants in each plot were selected by five-point method, and the completeness of the samples was ensured. After sampling is completed, the soil at the root is cleaned, and then the roots, stems, and leaves of buckwheat were separated and dried in the dryer respectively. Finally, the dry matter quality of roots, stems and leaves was measured by electronic balance and the data was recorded. Repeat 3 times and take average value as evaluation data.

(2) Determination of agronomic traits

After maturity, 5 representative plants were selected in each plot by five-point method for seed testing, including plant height, number of main stem nodes, number of main stem branches, grain number per plant, and grain weight per plant. Repeat 3 times and take average value as evaluation data.

(3) Determination of yield

Firstly, the method of artificial harvesting was used to harvest in sequence according to the plot, and the marks were made. Secondly, clean buckwheat grains were obtained by artificial threshing and clearing in the field. Finally, the plot yield is weighed and converted into yield per hectare.

RESULTS AND ANALYSIS

Single factor test results and analysis

(1) Effects of different press forces on the dry matter quality at seedling stage

The effect of different press forces on the dry matter quality of buckwheat roots, stems, and leaves at the seedling stage is shown in Figure 3. The corresponding press forces for dry matter quality from high to low are 450, 350, 550, 250, 650 and 0 N, respectively. Without pressure, the roots dry matter quality is the lowest at 0.43 g/plant; When the press force is 450 N, the roots dry matter quality is the highest at 0.82 g/plant, which is 1.91 times higher than that without pressure. The roots dry matter quality at seedling stage of buckwheat shows a trend of first increasing and then decreasing with the increase of press force. This is because moderate pressure can make seeds better contact with soil, provide adequate nutrients and a suitable soil environment for seeds, promote roots growth and development. But when the press force is too high, the soil porosity decreases, and the growth of seed roots is hindered, resulting in a decrease in dry matter quality.

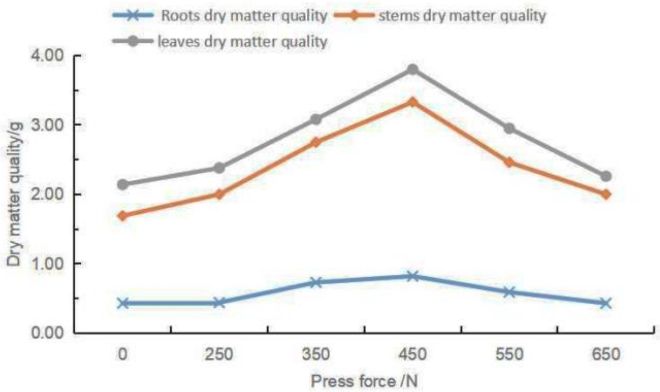


Fig. 3 - Variation curve of dry matter quality at seedling stage with press force

The variation trend of stems and leaves dry matter quality at seedling stage of buckwheat is consistent with that of roots. Without pressure, the stems and leaves dry matter quality is the lowest, at 1.69 and 2.14 g/plant, respectively. When the press force is 450 N, the stems and leaves dry matter quality is the highest, at 3.33 and 3.80 g/plant, respectively, which is 1.97 and 1.78 times higher than that without pressure. Overall, the growth and development of buckwheat after pressure should be better than those without pressure. Press treatment is conducive to the development of buckwheat seedling. Moderate pressure provides a good soil environment for the growth and development of buckwheat, promotes its growth, and is easy to grow into strong seedlings. But when the press force is too high, the soil is too dense, which is not conducive to seed emergence and rooting. The seeds consume a large amount of nutrients during the soil breaking process, which can also make the seeds appear more slender after emergence, leading to a decrease in the dry matter quality during the seedling stage.

(2) Effects of different press forces on the agronomic traits of buckwheat

Five agronomic characters of buckwheat under different press forces are analyzed, and the results are shown in Table 2.

In general, the growth trend of various agronomic traits of buckwheat is consistent with the dry matter quality at seedling stage. When the press force is 450 N, the agronomic characters of buckwheat show significant advantages. Without pressure, the agronomic characters are poor. The highest plant height is 744.44 cm, which is 14.53% higher than that without pressure. The press force has significant effects on the plant height, the grain number per plant and the grain weight per plant, but has no significant effects on the number of main stem nodes and the number of main stem branches.

There are differences in agronomic characters of buckwheat under different press forces. The agronomic trait with the greatest variation is the grain weight per plant, which is as high as 25.30%. The coefficient of variation of grain number per plant is also relatively high at 24.32%. This indicates that these two agronomic traits vary greatly with press force. The number of main stem branches is followed by the coefficient of variation of 19.21%. The coefficients of variation of the plant height and number of main stem nodes are relatively low, which are 9.22% and 10.87%, respectively. These two agronomic traits have relatively high stability in production.

Table 2

Results of agronomic trait analysis

Press force [N]	**Plant height**	**Number of main stem nodes**	**Number of main stem branches**	**grain number per plant**	**grain weight per plant**
	[mm]	-	-	-	**[g]**
0	650.00±69.69 b	7.33±0.50 a	5.33±0.71 a	29.44±6.09 c	0.94±0.20 c
250	703.22±52.41ab	7.78±1.30 a	5.56±1.42 a	30.56±6.84 c	1.00±0.22 c
350	723.33±62.65 a	8.11±0.60 a	6.11±1.27 a	38.56±9.07 ab	1.24±0.29 b
450	744.44±45.65 a	8.11±0.93 a	6.22±0.67 a	43.00±5.27 a	1.84±0.20 a
550	712.22±38.74ab	7.89±0.78 a	5.44±0.73 a	35.56±7.21 b	1.13±0.23bc
650	681.89±84.10ab	7.56±0.73 a	5.33±1.41 a	28.89±6.49 c	0.95±0.21 c
SD	64.79	0.85	1.09	8.35	0.28
Mean	702.52	7.80	5.67	34.33	1.12
C·V	9.22%	10.87%	19.21%	24.32%	25.30%

Note: Different letters indicate significant differences ($P<0.05$), the same below.

(3) Effects of different press forces on buckwheat yield

The effect of different press forces on buckwheat yield is shown in Figure 4. The yield shows a trend of first increasing and then decreasing with the increase of press force. The press force has significant effects on the yield. When the press force is 450 N, the yield is the highest, at 2401.20 kg/hm^2, which is significantly higher than that under other press forces. When the press force is 350, 550 and 220 N, the yield is 2092.75, 1867.60 and 1775.90 kg/hm^2, respectively, which is 49.41%, 33.33% and 26.79% higher than that without pressure, respectively. When the press force is 0 and 650 N, the yield is 1400.70 and 1567.45 kg/hm^2, respectively, significantly lower than that under other press forces.

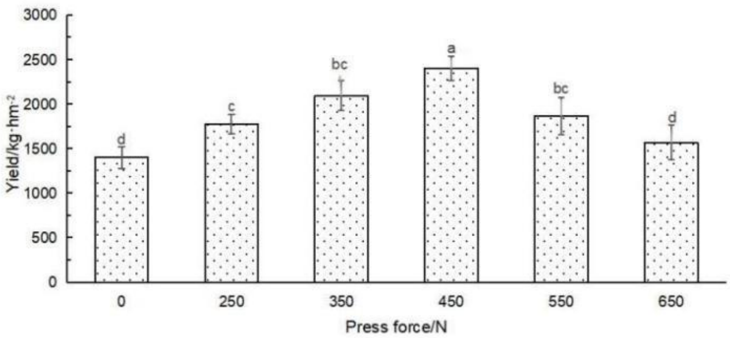


Fig. 4 - Buckwheat yield under different press forces

Orthogonal test results and analysis

The measurement results of Orthogonal test are shown in Table 3. In the table, A, B and C are the coded values for the press wheel outer diameter, press force and press wheel type, respectively. The results of variance analysis are shown in Table 4.

Table 3

Orthogonal test results of growth characteristics

Groups	Factors			Dry matter quality at seedling			Agronomic traits					Yield
	A	B	C	roots	stems	leaves	Plant height	number of main stem nodes	number of main stem branches	grain number per plant	grain weight per plant	
				[g]	[g]	[g]	[g]	-	-	-	[g]	[kg/hm^2]
1	1	1	1	0.27	1.98	2.11	703.33	7.56	4.89	19.89	0.38	800.40
2	1	2	2	0.38	2.04	2.74	704.44	7.64	5.44	32.44	0.88	1245.62
3	1	3	3	0.52	1.75	2.85	724.44	7.88	5.63	38.89	1.12	1960.98
4	2	1	2	0.39	2.41	2.53	705.00	7.86	5.43	23.89	0.85	955.48
5	2	2	3	0.75	2.42	3.22	774.22	8.05	6.08	54.56	2.00	2626.31
6	2	3	1	0.58	1.88	2.79	694.44	7.690	5.56	35.33	1.04	1815.91
7	3	1	3	0.46	2.28	2.39	741.11	8.11	5.56	32.44	0.92	1880.94
8	3	2	1	0.56	2.25	2.43	732.22	7.89	6.24	39.89	1.22	2111.06
9	3	3	2	0.50	1.85	2.42	665.56	7.71	5.76	23.22	0.56	1275.64

Table 4

Results of variance analysis of dry matter quality at seedling stage

Index	Source	SS	DF	MS	F	P	k1	k2	k3	R	Optimization level	Optimal combination
Roots dry matter quality	A	0.05	2	0.03	31.00	0.031*	0.39	0.57	0.51	0.18	A_2	$A_2B_2C_3$
	B	0.06	2	0.03	37.56	0.026*	0.37	0.56	0.53	0.19	B_2	
	C	0.04	2	0.02	22.24	0.043*	0.47	0.42	0.58	0.15	C_3	
	Error	0.002	2	0.001								
	Total	0.15	8									
Stems dry matter quality	A	0.15	2	0.08	18.90	0.050*	1.92	2.24	2.13	0.31	A_2	$A_2B_2C_3$
	B	0.33	2	0.16	40.59	0.024*	2.22	2.24	1.83	0.40	B_2	
	C	0.02	2	0.01	2.41	0.293	2.04	2.10	2.15	0.11	C_3	
	Error	0.008	2	0.004								
	Total	0.51	8									
Leaves dry matter quality	A	0.29	2	0.15	58.46	0.017*	2.57	2.85	2.41	0.43	A_2	$A_2B_2C_3$
	B	0.34	2	0.17	67.70	0.015*	2.34	2.80	2.69	0.45	B_2	
	C	0.22	2	0.11	44.83	0.022*	2.44	2.56	2.82	0.38	C_3	
	Error	0.005	2	0.002								
	Total	0.29	8									
Plant height	A	330.19	2	165.09	3.61	0.217	710.74	724.56	712.96	13.81	A_2	$A_2B_2C_3$
	B	2665.22	2	1332.61	29.13	0.033*	716.48	736.96	694.81	42.15	B_2	

Table 4
(continuation)

Index	Source	SS	DF	MS	F	P	k1	k2	k3	R	Optimization level	Optimal combination
	C	4691.63	2	2345.82	51.28	0.019*	710.00	691.67	746.59	54.93	C_3	
	Error	91.492	2	45.746								
	Total	7778.53	8									
Number of main stem nodes	A	0.05	2	0.02	2.92	0.255	7.73	7.83	7.90	0.18	A_3	$A_3B_2C_3$
	B	0.04	2	0.02	2.69	0.271	7.84	7.89	7.73	0.17	B_2	
	C	0.18	2	0.09	10.95	0.084	7.68	7.77	8.01	0.33	C_3	
	Error	0.016	2	0.008								
	Total	0.29	8									
Number of main stem bran-ches	A	0.45	2	0.22	4.47	0.183	5.32	5.69	5.85	0.53	A_3	$A_3B_2C_3$
	B	0.59	2	0.30	5.92	0.145	5.29	5.92	5.65	0.63	B_2	
	C	0.08	2	0.04	0.83	0.546	5.56	5.55	5.76	0.21	C_3	
	Error	0.100	2	0.050								
	Total	1.22	8									
Grain number per plant	A	95.56	2	47.78	22.93	0.042*	30.41	37.93	31.85	7.52	A_2	$A_2B_2C_3$
	B	431.67	2	215.84	103.59	0.010**	25.41	42.30	32.48	16.89	B_2	
	C	370.77	2	185.38	88.98	0.011*	31.70	26.52	41.96	15.44	C_3	
	Error	4.167	2	2.084								
	Total	902.17	8									
Grain weight per plant	A	0.42	2	0.21	19.48	0.049*	0.79	1.30	0.90	0.50	A_2	$A_2B_2C_3$
	B	0.67	2	0.34	30.93	0.031*	0.72	1.37	0.91	0.65	B_2	
	C	0.57	2	0.29	26.39	0.037*	0.88	0.76	1.35	0.58	C_3	
	Error	0.022	2	0.011								
	Total	1.69	8									
Yield	A	393352.81	2	196676.41	20.75	0.046*	1335.67	1212.27	1575.79	463.57	A_2	$A_2B_2C_3$
	B	930500.48	2	465250.24	49.08	0.020*	1799.23	1994.33	1158.91	782.06	B_2	
	C	1504853.48	2	752426.74	79.38	0.012*	1755.88	1684.18	2156.08	997.17	C_3	
	Error	18958.516	2	874.12								
	Total	2847665.29	8									

Note: * indicates significant difference (0.01<P<0.05), * * indicates extremely significant difference (P ≤ 0.01)

(1) Effects of pressure methods on the dry matter quality at seedling stage

It can be seen from Table 4 that the press wheel outer diameter, press force and press wheel type have significant effects on the roots dry quality at seedling stage, and the optimal combination is $A_2B_2C_3$. The press wheel outer diameter and press force have significant effects on the stems dry quality at seedling stage, but the press wheel type has no significant effects on that. The optimized combination is $A_2B_2C_3$. The three factors have significant effects on the leaves dry matter quality at seedling stage, and the optimal combination is $A_2B_2C_3$. The order of influence from large to small is the press force, the press wheel outer diameter, and the press wheel type.

(2) Effects of pressure methods on the agronomic traits of buckwheat

It can be seen from Table 4 that the press force and press wheel type have significant effects on the plant height of buckwheat, but the press wheel outer diameter has no significant effects on that. The order of influence from large to small is the press wheel type, the press force, and the press wheel outer diameter. The optimal combination is $A_2B_2C_3$. The press wheel outer diameter, press force and press wheel type have no significant effects on the number of main stem nodes, and the number of main stem branches. The optimal combination is $A_3B_2C_3$. The press force has extremely significant effects on the grain number per plant, and it has significant effects on the grain weight per plant. The press wheel outer diameter and press wheel type have significant effects on the grain number per plant and the grain weight per plant, and the order of influence from large to small is the press force, the press wheel type, and the press wheel outer diameter. The optimal combination is $A_2B_2C_3$.

(3) Effects of pressure methods on buckwheat yield

The effects of pressure methods on buckwheat yield are shown in Table 3 and 4. The press wheel outer diameter, press force and press wheel type have significant effects on the yield. The order of influence from large to small is press wheel type, press force and press wheel outer diameter. The optimal combination is $A_2B_2C_3$, with a yield of up to 2626.31 kg/hm^2.

DISCUSSION

Effects of different press forces on the growth characteristics of buckwheat

Yang Xiaojuan et al. showed that unreasonable mechanical operations in farmland would increase soil compactness, and mechanical compaction would not only affect root growth, but also limited the growth of above-ground parts of plants *(Yang et al., 2008)*. Dauda et al. found in two years of experiments that serious soil compactness affected the yield of cowpea *(Dauda et al., 2002)*. Jiang Yecheng et al. showed that the application of seeding weight pressure technology significantly improved the emergence rate, plant dry matter and yield of maize *(Jiang et al., 2022)*. The results of this experiment showed that the growth characteristics of buckwheat were significantly affected by press force. The dry matter quality, agronomic traits and yield showed a trend of first increasing and then decreasing with the increase of press force. These was consistent with the above research conclusions.

Before the start of the test, the test field was tilled by rotary tiller, and the surface soil was relatively weak. After pressure, the soil of the seed bed changed from loose state to compact state, improving the soil compactness and increasing the ability of the seedling soil to absorb underground water. Timely pressure after sowing can make the seed bed compact appropriately, and also make the seeds closely connected to the surrounding wet soil, playing a role in increasing, preserving, and supplying soil moisture, which is conducive to the growth and development of buckwheat and the increase of yield.

However, when the ballast pressure is too high, the soil is too dense, affecting the porosity and moisture content of the soil, which is not conducive to the growth and extension of roots. Thus the growth and development of crops are hindered.

Effects of different pressure methods on the growth characteristics of buckwheat

In addition to the soil condition in the field, the main factors affecting the pressure quality include the press force, press wheel diameter and type, and speed of the pressure operation etc. *(Wang et al., 2009)*. Liu Hongjun showed that the press wheel type had significant effects on maize seedling emergence rate, plant height consistency, and seedling growth status. The optimal combination of press wheel type and operation speed is obtained *(Liu et al., 2019)*. Lu Qi et al. found that the pressure strength, press wheel type and sowing depth had significant effects on seedling emergence rate, growth, and yield of oats. The optimum sowing conditions of oat were as follows: pressure strength was 50 kPa, sowing depth was 5 cm, and press wheel type was conical combined wheel *(Lu et al., 2022)*. The results of this experimental study indicated that press wheel outer diameter, press force, and press wheel type had significant effects on the dry matter quality, plant height, and yield of buckwheat, which was consistent with the above research conclusions. In terms of the press wheel outer diameter, 300 mm is the optimal level. In terms of press force, 450 N is the optimal level. The press wheel outer diameter and press force have comprehensive effects on the strength of the soil compaction by the compactor. Excessive or insufficient pressure strength will affect soil performance, thereby affecting the growth of buckwheat. In terms of the press wheel type, the conical combined wheel exhibited the best compaction effect, which was consistent with the research results obtained by *Lu Q, Zheng D.C., Li L.H., Liu Y, (2022)*.

Perhaps it is because the conical combination can suppress the two sides of the seedling belt, playing a role in water storage and moisture preservation, while forming a soft small soil pile in the middle, which is conducive to the emergence and growth of seeds. In terms of the importance of influencing factors, the press force and press wheel type had greater effects on the indexes than press wheel outer diameter. The three factors comprehensively reflected the compaction effect of the pressure device on the soil.

Overall, the optimal pressure method for buckwheat sowing is $A_2B_2C_3$, which means that the press wheel outer diameter is 300 mm, the press force is 450 N, and press wheel type is a conical combined wheel.

The above experimental results are only data from one-year field trials, and a large number of field trials need to be tracked and demonstrated for many years.

CONCLUSIONS

(1) In this paper, a pressure test device was designed with adjustable pressure control, 9 different structural sizes of press wheels were designed and processed. The results of the single factor test showed that the index values of buckwheat showed a trend of first increasing and then decreasing with the increase of press force. When the pressure is 450 N, the growth and development of buckwheat performed best. The dry matter quality of roots, stems, and leaves was 0.82, 3.33, and 3.80 g/plant, respectively, which was increased by 1.91, 1.97, and 1.78 times compared to that without compaction. The press force had significant effects on the plant height, grain number per plant, and grain weight per plant of buckwheat, but had no significant effects on the number of main stem nodes and number of main stem branches. The agronomic traits with the largest coefficient of variation were grain weight per plant and grain number per plant, which were 25.30% and 24.32%, respectively. When the press force was 450 N, buckwheat yield was the highest at 2401.20 kg/hm^2, which was significantly higher than that under other press forces.

(2) The results of orthogonal test showed that the press wheel outer diameter had significant effects on the dry matter quality of buckwheat roots, stems, and leaves, grain number per plant, grain weight per plant, and yield, but had no significant effects on the plant height, number of main stem nodes, and the main stem branching. The press force had significant effects on the dry matter quality of buckwheat roots, stems, and leaves, plant height, grain weight per plant, and yield. It had extremely significant effects on the grain number per plant. But it had no significant effects on the number of main stem nodes and number of main stem branches. The press wheel type had significant effects on the dry matter weight of buckwheat roots and stems, plant height, grain number per plant, grain weight per plant and yield, but had no significant effects on the dry matter weight of stems, number of main stem nodes and number of main stem branches. In terms of the importance of influencing factors, the press force and press wheel type had greater effects on growth characteristics than the press wheel outer diameter. The optimal pressure methods of buckwheat sowing are as follows: the press wheel outer diameter is 300 mm, the press force is 450 N, and the press wheel type is conical combined wheel.

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