Analysis of the effect of reasonable close planting on respiration characteristics of alfalfa (*Medicago sativa* L.) artificial grassland

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Abstract: The degree of dense planting affects the respiration characteristics of alfalfa artificial grassland. In the process of alfalfa seed production, high plant and multi-branch forage can be obtained by reasonable close planting. Therefore, an analysis method of the effect of reasonable close planting on respiration characteristics of garden alfalfa artificial grassland is put forward. In this method, the density characteristics of alfalfa planting were determined from three aspects of plant horizontal density, vertical density and three-dimensional density. The infrared carbon dioxide gas analyser was used to measure the carbon dioxide flux of the garden. The combined analysis method was constructed to obtain the respiration characteristics of Alfalfa artificial grassland through multiple validations, so as to achieve the degree of impact on the respiration characteristics of the grassland analysis. The experimental results show that the proposed verification methods can explain the existence of growth redundancy and propose a method to reduce redundancy. Moreover, the proposed analysis method has more complete respiratory characteristics and the analysis results of photosynthesis and total vegetation yield are more consistent with the reality.

Key words: Alfalfa, Artificial grassland, Garden, Reasonable close planting, Respiratory characteristics

1. Introduction

Alfalfa (*Medicago sativa* L.) belongs to Leguminosae is a perennial herb and its roots are thick, deep into the soil layer, root neck is developed. Stems erect, tufted and even lying flat, quadrangular, glabrous or puberulent, with luxuriant branches and leaves. Seeds ovate, 1-2.5 mm long, smooth yellow or brown. The flowering period of alfalfa is from May to July, and the fruiting period is from June to August. It is native to Asia Minor, Iran and Transcaucasia. Now it is cultivated or semi-wild all over the world. It is widely planted in Eurasia and other countries around the world as feed and forage. Alfalfa as tender and delicious stems and leaves (Joorabi et al., 2010). No matter it is used for forage, silage, preparation of hay, processing of grass powder, compound feed or mixed feed, all kinds of livestock and poultry are most fond of eating. It is also the first choice for the pig and poultry industry (Li et al., 2018a; Wang et al., 2020; Bakhshi et al., 2021a,b; Saffariha et al, 2021). However, under the background of a large number of planting and cultivation, the dense vegetation affects the growth of alfalfa itself, a large number of vegetation is too crowded, which affects the respiration of plant branches and leaves, resulting in the decrease of the total yield of alfalfa (Joorabi et al., 2010; Sarker et al., 2020; Ahmed 2020; Zeidali et al., 2021). Therefore, the forage yield can be increased by designing an alfalfa planting mode with reasonable close planting rules.

Therefore, this paper puts forward the analysis and research on the effect of reasonable dense planting on the respiration characteristics of the garden alfalfa artificial grassland. This paper analyses the relationship between the actual seed yield and the performance seed yield, the appropriate height of branches, the appropriate number of branches per m^2, the number of inflorescences/branches and the number of pods/branches, the number of flowers/inflorescences and the number of pods/pods, in order to explain the existence of growth redundancy, and proposes that to provide a basis for planting garden alfalfa artificial grassland.

2. Materials and methods

2.1. Experimental environment

The experimental site is located in the experimental site of a crop research institute. The annual average temperature was 8.6 °C, the annual precipitation is 202.2 mm, the frost-free period is 130 days, and the annual sunshine hours were 2897.5 H. The soil was irrigated silt soil, which contains 24.2 g/kg organic matter, 8.43 pH value, 1.19 g/kg total salt, 0.78 g/kg total nitrogen, 0.81 g/kg total phosphorus, 19.33 g/kg total potassium, 93.00 mg/kg available nitrogen, 12.32 mg/kg available phosphorus and

136.80 mg/kg available potassium. The previous crop was wheat. Nitrogen measurements were performed according to Haghshenas et al. (2020) method.

2. 2. Test materials

Baralfa 32iq was a new breed of the American Bailu group, which has a dormancy index of 3 and an overwintering index of 2. It has a wide range of ecological adaptability and has advantages of high quality, durability and overwintering.

2. 3. Test method

This experiment is a single factor planting density experiment. The row spacing is 90 cm, different densities are adjusted by the plant spacing. The plant spacing treatment is 10, 15, 20, 25, 30, 35, 42 and 56 cm, the area of the plot is 15 m^2, three repetitions, each district group is arranged randomly. The other planting management measures are the same except for the density.

Before harvesting, the height of the plant extension was measured. After cutting the alfalfa, the number of branches was counted, one row and one data. There were nine rows in three communities. The number of flowers per $m^2$was measured after flowering and before podding. One plot was measured for $1m^2$. In the full bloom period, the typical branches were collected from the top to the bottom of each plot for floret number/inflorescence statistics. One week before harvest, 1 m^2 alfalfa was cut from each plot, and the number of podding flowers/branches was counted. After the cut pods are mixed evenly, the pods are randomly selected to determine the number of pods/pods. These pods were then used to determine the number of seeds per pod. When the pods were 70% mature, they were mowed by hand.

2.3.1. Multi-angle determination of garden alfalfa density

From the perspective of the plant landscape, the plant shape in the garden is three-dimensional. Therefore, in this impact analysis, the garden green plants are reasonably classified according to the three angles of horizontal density, vertical density and three-dimensional density. The garden green plant density is determined from multiple angles, and the respiration characteristics of alfalfa artificial grassland are analyzed (Ni et al., 2017).

2.3.2. The horizontal density of plants

The horizontal density of plants usually refers to the planting spacing of plants on the horizontal ground. The crown width of plants is often used as a factor to determine the horizontal planting spacing that reflecting the density of plants in the horizontal space (Timlin et al., 2014). In this paper, the horizontal density of alfalfa refers to the ratio of plant crown to plant spacing.

Due to the growth of alfalfa artificial grassland, the horizontal density of the plant community is determined by the scale of the plant and its growth speed. For plants with fast growth speed, the horizontal planting spacing should be larger than the crown width of plants, to leave enough space for the growth of alfalfa. According to the growth rate of alfalfa, it can be divided into fast-growing vegetation, medium growing vegetation and slow-growing vegetation (Malakhov and Tsychuyeva, 2020). The community formed by close planting of small-scale fast-growing vegetation will form better regional effect and scale feeling in a short period so that all plants in the garden can reach a higher level in a short period. But this is not to say that the higher the horizontal planting density, the better. Once the horizontal planting spacing of fast-growing vegetation is too small, the density perception of the plant community will be maladjusted with the growth of fast-growing trees (Qian et al., 2019).

2.3.3. The vertical density of plants

The vertical density of plants refers to the feeling of plant density on the vertical plane formed by the combination and planting of trees, shrubs and grass with different heights in the garden. The vertical density of the plant community is affected by many factors, such as the height of the plant, the height of the tree crown, the height of the tree branch point, the density of alfalfa branches and leaves, and the number of alfalfa layers (KahanjuChitiki, 2020). Objectively speaking, the larger the vertical density of the multi-layer plant community is, the richer the hierarchical structure of the plant community is, the higher the degree of closeness between the layers is, the more obvious the visual barrier effect is, the stronger the sense of spatial division is, and the better the growth state of the plant is. In this analysis, the product of the maximum planting length and height of the garden plant community is taken as the total area on the vertical plane, and the ratio of the area on the vertical plane of the plant community to the total area on the vertical plane is taken as the measurement index of the vertical density (Liu et al., 2018).

2.3.4. The 3-D density of plants

Both the horizontal density and the vertical density measure the planting density of the plant community from the perspective of a plan, but the plant is three-dimensional, and the plant community also has a complex structure level, so it should be measured and evaluated from the perspective of three-dimensional space. Three-dimensional green quantities are the basic premise to measure the ecological benefits of green space. It is defined as the volume of space occupied by the stems and leaves of all growing plants in the plant community. The simulation estimation of vegetation three-dimensional green quantity includes remote sensing technology measurement algorithm, hyperspectral measurement algorithm, simulation equation measurement method and aerial photograph computer simulation measurement method. The three-dimensional green quantity of plants breaks the limitation of the two-dimensional index and can better define the level and density of plant community. Take the maximum length, width and height of plant community as the total space volume occupied in the three-dimensional space, and the ratio of the sum of the three-dimensional green amount of plant individuals and the total space volume occupied in the community as the three-dimensional density of plant community (Li et al., 2018b).

2.3.5. Garden carbon dioxide flux measurement

The infrared gas analyzer is needed to measure the assimilation rate and respiration rate of alfalfa artificial grassland. It is known that gas molecules composed of heteroatoms have special absorption bands for infrared rays. The setting in the infrared instrument only allows the infrared light to pass through the filter. When the infrared light of this wavelength passes through the contained gas, the energy will be reduced due to the absorption and the reduction is related to the concentration. The infrared detector can output the electric signal reflecting the concentration by detecting the change of infrared light energy by supplying the gas with or without the infrared instrument respectively (Wang et al., 2019). According to the working principle of the infrared gas analyzer, measure the carbon dioxide flux in the planting area of alfalfa artificial grassland in the garden. In the process of the test, the parameters set need to be adjusted in time based on the data in Table 1 to prevent the growth conditions of alfalfa artificial grassland from affecting the analysis of respiratory characteristics (Tjoelker, 2018).

Table 1. Measurement conditions of carbon dioxide flux.

Plant number / plant	Area covered/m³	Number of alfalfa ridges/piece	Average height/cm	Water quantity/ton	Plant growth rate	CO_2 absorption ratio /%
＜1000	7.5	4	86.5	0.14	0.44	1.7
1000~5000	64.25	8	86.5	0.65	0.72	6.45
5000~10000	120.68	15	86.5	1.22	0.85	9.28
10000~20000	235.49	19	86.5	1.74	0.88	19.55
20000~30000	356.75	24	86.5	3.05	0.74	25.36
30000~40000	480.9	28	86.5	4.55	0.7	40.1
40000~50000	600.58	33	86.5	6.27	0.69	48.33
>50000	725.63	37	86.5	7.45	0.55	57.64

Referring to the data in Table 1, the carbon dioxide flow in the garden is measured with a gas analyzer. The calculation formula (1) of the carbon dioxide flow fed back by the instrument is as follows:

$$E_k = \frac{p \cdot \rho \cdot (1 - S_0)}{10BC \times (T_0)} \cdot \frac{\partial t}{\partial d} \quad (1)$$

In the formula: E_k represents the carbon dioxide flux of the k garden; p represents the atmospheric pressure; p represents the green plant density in alfalfa artificial grassland; S_0 represents the initial partial pressure of water vapor; B represents the proportion of CO_2 absorption; C represents the land area of alfalfa; T_0 represents the initial atmospheric temperature; $\frac{\partial t}{\partial d}$ is the change rate of B CO_2 partial pressure modified by initial moisture(Collalti *et al.*, 2020). The calculation formula of the change rate of partial pressure is:

$$\frac{\partial t}{\partial d} = f \cdot (t - t_0) \cdot e^{-f \cdot (t - t_0)} \quad (2)$$

In the formula, f is the fitting parameter; d is the determination time; t is CO_2 in the garden in summer; t_0 is CO_2 in the garden in winter. Take formula (2) into formula (1) to get the measurement result of garden carbon dioxide (Li et al., 2018c).

2.3.6 Combination analysis method to obtain respiration characteristics of alfalfa artificial grassland

Through the above research, the respiratory characteristics of Alfalfa artificial grassland were obtained by comprehensive analysis. This method is based on the analysis model established by traditional evaluation methods, including the efficacy coefficient method, grey correlation analysis method, entropy weight method and solution distance method. It analyzes the evaluation object and obtains different analysis results. Then, the Kendall coefficient is used to test the consistency of the ranking results of each independent method. On the premise that the analysis results of each method pass the consistency test, it can be used again, the average value method is used to evaluate the evaluation results of each method. Finally, the Spearman rank correlation coefficient is used to conduct the post-test of the combination analysis method, and then the final analysis results are determined (Chen and Han, 2019).

The first step of combinatorial analysis is to determine the evaluation index system, collect and process the required data. The second step is to use four independent analysis methods to analyze the respiratory characteristics of alfalfa artificial grassland. The third step is to use the Kendall coefficient to test the consistency of each single analysis result. The consistency test is carried out before a combination evaluation, so it is called a pre-test. If the sorting results are consistent, it means that the analysis results of several methods are basically consistent, and the next step will be taken directly; if there is inconsistency in the consistency test, the third step will be taken. In Kendall consistency coefficient test method, assume that the analysis results of n analysis methods on respiration characteristics of alfalfa artificial grassland do not have consistency, and use F_0; if the analysis results of n analysis methods on respiration characteristics of alfalfa artificial grassland are consistent, use F_1 to express (Li et al., 2018d). When $n \leq 7$, the test formula is:

$$Y = \sum_{i=1}^{a} \left(X_i - \frac{n(a+1)}{2} \right)^2 \tag{3}$$

In the formula: $X_i = \sum_{j=1}^{n} E_k \cdot Z_{ij}$, where E_k is the calculation result of the formula (1), Z_{ij} is the respiration rate of j artificial grassland in the i analysis method, X_i is the analysis ranking of i analysis method; a is the number of iterations. Given the significance level β, look up "Kendall critical value table of consistency coefficient" and get the critical value Y and probability P corresponding to Y value. When $P < \beta$, reject F_0 and think that n analysis methods are consistent and can be combined. When $P > \beta$, F_0 cannot be rejected and n analysis methods cannot be denied to be inconsistent (Sonawane *et al*., 2018). When $n > 7$, the test statistic is:

$$\varphi^2 = n(a-1) \cdot \mu = \frac{12Y}{na(a+1)} \tag{4}$$

The statistic obeys φ^2 distribution with $a-1$ degree of freedom. Given significance level β, the critical value $\varphi^2(a-1)$ and probability P corresponding to the critical value are obtained by looking up φ^2 distribution table. When $P < \beta$, F_0 is rejected and n analysis methods are considered to be consistent and can be combined. When $P > \beta$,

F_0 should not be rejected and n analysis methods should not be denied to be inconsistent. When the analysis results do not have consistency, we will test the correlation coefficient of two Spearman grades for various methods, put the methods with consistency together and then analyze the sample data, analysis results and method characteristics, select several methods that are objective, practical and consistent and return to the second step. In the fifth step, the average method is used to evaluate the independent analysis results and the combined evaluation value is obtained, and the ranking results are obtained according to the size of the combined evaluation value. In the sixth step, we use the Spearman rank correlation coefficient to test the closeness between the results of combination and sorting of the average method and the original independent analysis results. This test is carried out after a combination evaluation, so it is called a post-test. If it passes the test, go to step 7, otherwise, select the combined evaluation method again, and return to step 5. Spearman rank correlation coefficient test method, assuming that the average combination method is independent of the original n analysis method, expressed by F_0; F_1 means that the average combination method is closely related to the original n analysis method (Hosaena, 2019). Calculate the average correlation degree g between the combination method of average value and the original n analysis method and the formula is:

$$g = \frac{1}{n}\sum_{j=1}^{n} G_j \qquad (5)$$

Where: G_j is the Spearman rank correlation coefficient between the mean combination method and the original j method. Then calculate the test statistics. The calculation expression is:

$$\lambda = g \cdot \sqrt{\frac{a-2}{1-G^2}} \quad (6)$$

In the formula, the statistic λ obeys the λ distribution with a degree of freedom $a-2$. Given the significance level β, check the λ distribution table to get the critical value $\lambda_{\frac{\beta}{2}}(a-1)$ and the probability P corresponding to the critical value. When $P<\beta$, reject F_0, and think that the combined evaluation method of average value is closely related to the original n analysis methods. When $P>\beta$, F_0 will not be rejected, and the correlation between the average combination evaluation method and the original single evaluation method is low, so it is not suitable for combination (Paugh and Gordon, 2019). According to the results of the combined evaluation of the average value and the actual situation of the evaluation object, the analysis results of the respiration characteristics of the alfalfa artificial grassland were obtained, so as to realize the analysis of the impact of reasonable close planting on the respiration characteristics of the garden alfalfa artificial grassland.

2.4. Experimental verification

Choose a reasonable close planting garden as the experimental test object, set up a two-stage experimental test, the first stage is the analysis of alfalfa artificial grassland, vegetation photosynthesis; the second stage is the analysis of alfalfa artificial grassland, vegetation total yield.

2.5 Experiment preparation

Set the sample number of alfalfa artificial grassland selected in the experiment, and Table 2 is the basic information of the experimental test sample.

Table 2. Basic information of test sample.

Sample No	Floor area / m^2	Daily average temperature (°C)	Estimated number of samples
a1	665.5	26.5	6500
a2	667	26.5	6800
a3	665.5	25.5	6550
a4	667	25.5	6700
a5	665.5	25.5	6650

According to the sample information, the difference between the four groups of samples is small, which will not affect the final results of the experimental test. A1-A5 is taken as the analysis object of the experimental group. To investigate the plant characters, 10 representative plants were selected at the mature stage of alfalfa to investigate and record the plant height, ear height, stem diameter, leaf number and green leaf number. The investigation methods were as plant height: To investigate the distance from the top of 10 plants to the ground at the mature stage, and to take the average value of 10 plants. Purple flower diameter: investigate 10 mature plants, the distance from the first flower node to the ground, take the average value of 10 alfalfa plants. Stem diameter: the average value of 10 alfalfa plants was taken from the central oblate part of the first complete internode exposed to the ground. Leaf number: investigate the number of leaves of 10 alfalfa plants in the whole growth period, and take the average value of 10 alfalfa plants. The number of green leaves: investigate the number of green leaves of 10 alfalfa plants in the mature stage, and take the average value of alfalfa plants. The average value calculated according to the above steps shall be used as the unified data for this experimental analysis. The leaf area index of alfalfa artificial grassland was the multiple of plant leaf area in land area. Therefore, it is necessary to select representative plants in the middle two lines of each density treatment, measure the length and width of a single leaf with a ruler, and calculate the leaf area and leaf area index of a single plant. The formula of single leaf area is:

$$s = l \times w \times \delta \tag{7}$$

In the formula: l represents the blade length; w represents the blade width; δ represents the blade coefficient, usually, the value is between. Assuming that the number of undeveloped blades is q_1 and the number of expanded blades is q_2, the coefficient of expanded blades is $\delta_2 = 0.5$, the coefficient of undeveloped blades $(\delta_2 + 1)$ is $\delta_1 = \frac{\delta_2 - (0.75 - 0.5)}{q_1}$, the coefficient of undeveloped blades $(\delta_2 + 2)$ is $\delta_3 = \frac{\delta_1 - (0.75 - 0.5)}{q_1}$, and so on, the calculated leaf area index is:

$$R = sn \times \frac{m}{c} \tag{8}$$

In the formula: n represents the total number of leaves per plant of alfalfa; m represents the number of alfalfa plants per unit land area; c represents the unit land area of alfalfa (Mangalassery *et al*., 2019).

3. Result

Reasonable close planting is an important technical way to realize the good growth of alfalfa artificial grassland. Under the condition of reasonable close planting, the arrangement of different plant row spacing is of great significance for cultivating a good canopy structure of alfalfa artificial grassland and realizing the stable yield of alfalfa.

Figure 1 shows the growth cycle of Alfalfa artificial grassland under reasonable and unreasonable intensive planting.

(a) Growth period (b) Maturity period

Figure 1. Growth state of alfalfa under unreasonable dense planting.

According to Figure 1, it can be seen that under the reasonable intensive planting conditions, the flower diameter of Alfalfa in the development period is dense, which shows that the growth state is good. However, under the influence of multiple vegetation, alfalfa competed in light, water and soil nutrients, and some weak alfalfa died. Therefore, it is necessary to determine the density of garden green plants from many aspects to analyze the effect of reasonable density on respiration characteristics of garden alfalfa artificial grassland. According to the above three aspects, the reasonable density of dense planting can be determined to provide the original data for impact analysis.

3.1. Phase I test

It is known that plants use photosynthetic pigments to convert carbon dioxide produced by respiration into organic matter through light and dark reactions. Therefore, according to the respiratory characteristics obtained by four groups of methods, the photosynthesis of alfalfa artificial grassland in the same garden is analysed under the premise of the same photo, the same average temperature and the same soil nutrients. The results of photosynthesis analysis are shown in Figure 2.

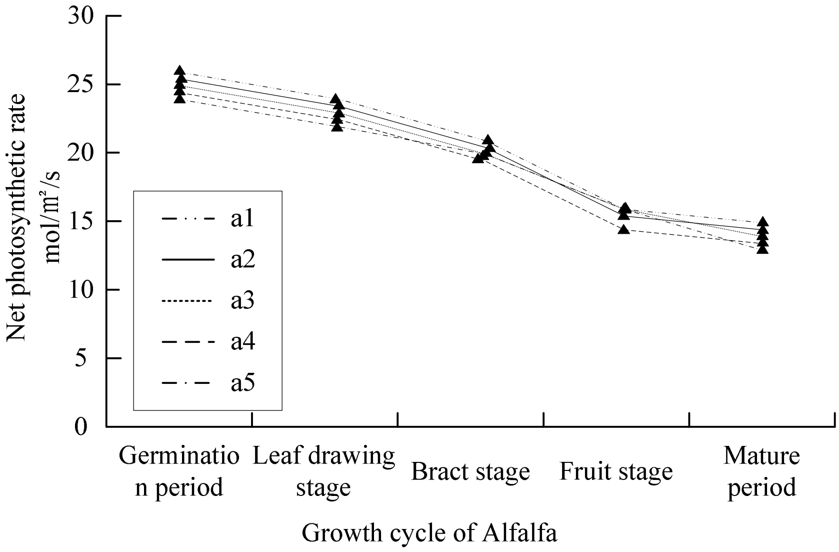

Figure 2. Analysis of photosynthesis effect.

According to the above experimental results, the net photosynthetic rate of alfalfa leaves showed different trends with the change of plant growth cycle, and the curve of net photosynthetic rate was not exactly the same because of the slight differences among the five groups.

3.2. Phase II test

In order to ensure the reliability of the test results, the total yield of the plant was analysed, and the growth rate of alfalfa artificial grassland under reasonable close planting was analysed on the premise of the same garden, light, average temperature and soil nutrients. Table 3 shows the results of the growth rate analysis.

Table 3. Analysis results of the experimental group.

Experimental group	Stage I	Stage II	Stage III	Stage IV	Stage V	Average growth rate (%)
a1	324.2	376.5	416.9	463.5	517.9	83.96
a2	328.9	379.4	415.8	460.1	519.6	84.15
a3	330.2	384.7	420.3	468.8	522.3	85.05
a4	325.5	376.1	415.5	458.9	518.4	83.78
a5	328.5	383.5	418.4	465.2	518.4	84.56

According to the data in the above four groups of tables, the data in the experimental group are also accompanied by the change of vegetation growth cycle. Under the reasonable dense planting conditions, the five experimental groups have a regular growth amount, and the average growth rate of vegetation is relatively similar. According to the analysis results of the vegetation growth rate obtained above, the total vegetation output of alfalfa artificial grassland in the garden is counted. Figure 3 shows statistical results of total vegetation output.

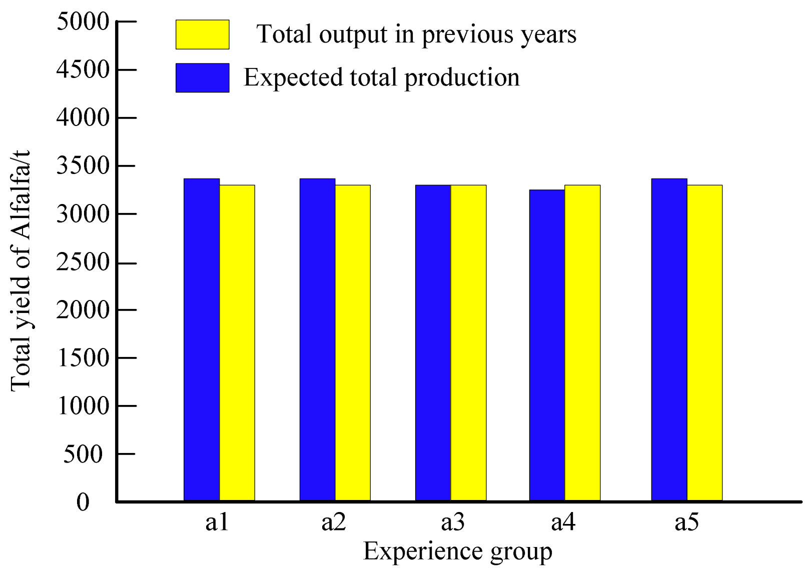

Figure 3. Statistical results of total vegetation output.

According to the above test results, the predicted total yield of vegetation is close to the total yield of alfalfa in the previous years. It can be seen that the respiratory characteristics of vegetation obtained by the analysis method are in line with the actual situation.

3.3. Phase III test

In Table 4, the difference between the actual seed yield and the surface Shanzi yield ranges from 5559.6kg/hm2 to 8457.9kg/hm2, the harvest coefficient ranges from 13.6% to 16.6%, and the ratio of the non-harvest part ranges from 86.4% to 83.4%, showing that there is a large gap between the seed yield and the actual seed yield, including the growth redundancy, seed dropping and harvest loss.

Table 4. The difference between seed yield and actual seed yield.

Plant spacing (CM)	10	15	20	25	30	35	42	56
Performance seed yield	6666.3	8389.4	8464.3	8961.4	9844.6	9964.1	8066	8502.6
Actual seed yield	1106.7	1140.1	1160.1	1220.1	1386.7	1560.1	1226.7	1160.1
Difference	5559.6	7249.3	7304.2	7741.3	8457.9	8404	6839.3	7342.5
Actual seed yield ratio	16.6	13.6	13.7	13.6	14.1	15.7	15.2	13.6

3.4. Phase IV test

Table 5 shows that in the treatment of plant spacing of 10-35cm, the actual seed yield/branch decreased with the increase of the number of branches and the height of branches, and the correlation coefficients were -0.974 * *, - 0.883 *, respectively. The actual seed yield was the highest at the density of 35cm, indicating that the average 121.8 branches were the most appropriate. If the number of branches continues to decrease, it will not support the high yield of seeds, and the increase of the number of branches will become the redundant part. The most redundant part is the density treatment of 10 cm, and the number of redundant branches is 58. At the same time, it showed that the height of the branch was 128.7cm under the treatment of 35cm was the most suitable, and the branch with the height lower than 128.7cm could not support the high yield of seed, and the branch with the height higher than 128.7cm was wasteful. The treatment with the most redundant part was the density of 10cm and the redundant height of 27.8cm.

Table 5. The relationship between the actual seed yield and the number of branches / m2 and the height of branches.

Plant spacing (CM)	10	15	20	25	30	35	42	56
Number of branches / m2	179.8	169.4	158.5	155.8	147.4	12L8	108.8	93.8
Height of branch	156.5	147.7	145.1	137.3	134.6	1287	123.4	118.8
Yield / Branch	0.62	0.67	0.73	0.78	0.94	1.28	1.13	2.15

The smaller the difference between the number of inflorescences/branches and the number of pods/branches, the number of flowers/inflorescences and the number of pods/inflorescences, the smaller the redundancy.

3.5. Phase V test

Tables 6 and 7 show that the difference between the number of inflorescences/branches and the number of pods/branches, between the number of flowers/inflorescences and the number of pods/pods is very large, that is, the difference between the number of flowers/branches and the number of pods/branches is 8.8-13, that is to say, 8.8-13 inflorescences on each branch are sterile inflorescences without pods, and the abortion rate or redundancy rate is 16.8% - 23.5%, The rate of podding was 76.5% ~ 83.2%. The difference between the number of flowers/inflorescence and the number of pods/sequence of pods is 3.4-4.9, that is to say, there are 3.4-4.9 flowers abortion in each inflorescence, the abortion rate or redundancy rate ranges from 19.2% to 26.6%, and the pod rate ranges from 73.4% to 80.8%.

Table 6. Relationship between flower number/branch and pod number/branch.

Plant spacing (CM)	10	15	20	25	30	35	42	56
Number of inflorescences / branches	37.7	40.5	43.7	45.2	46.5	56.5	62.4	71.1
Pod number/Branch	28.9	31.7	34.4	35.9	37.3	46.6	51.9	58.1
Difference	8.8	8.8	9.3	93	9.2	9.9	10.5	13.0
Percentage of pods (%)	76.5	78.2	78.6	79.4	80.3	82.5	83.2	81.7

Table 7. Relationship between the number of flowers/inflorescence and number of pods/number of pods.

Plant spacing(CM)	10	15	20	25	30	35	42	56
Number of flowers/inflorescence	18.2	18.1	18.4	18	18.3	18.6	17.7	18.5
Pods/spikes	13.5	13.7	13.5	14.1	14.7	15	14.3	14.7
Difference	4.7	4.4	4.9	3.9	3.6	3.6	3.4	3.8
Ratio of pods (%)	74.2	75.7	73.4	78.3	80.3	80.6	80.8	79.5

4. **Discussion**

Alfalfa seed production is a population process. The appropriate density can control the number of branches, reduce the height of branches, control the number of inflorescences, flowers and shorten the length of the flowering period, so as to improve seed yield.

4.1. Improve population awareness and pay attention to the best combination of comprehensive measures

The goal of modern specialized seed production of alfalfa is the maximum grain yield per unit land area, which is a biological index of population level. In order to get a high yield of alfalfa seeds, we must not only see a single individual but also see their whole population. If individuals are independent of each other, the best of individuals does not mean the best performance of the population. In the field, there is very fierce competition among alfalfa individuals for limited resources. This kind of mutual interference between individuals will cause serious losses to the high yield of alfalfa seeds. Therefore, only by coordinating the relationship between population and individuals and finding out the distance between individuals with the largest seed production can a high yield be achieved. The highest yield of this experiment is 90 cm row spacing, 35 cm plant spacing, the number of branches is 121.8 / m^2, the height of branches is 128.7 cm, 240 kg/m^2 in autumn of 2018, the rainfall in 2019 is 256 mm, the highest yield of this experiment is 1560.2 kg/m^2 without irrigation in the whole seed production season.

4.2. Control the number of branches, height, inflorescence and flowers

In 2019, the correlation coefficient between density and branch number and height is 0.980 and 0.985, respectively. Therefore, it is an effective measure to control redundancy by reducing density and controlling branch number and height. It is very important to control the number of branches. In order to determine the number of branches, it is necessary to test the relationship between seed yield and branches of specific varieties under certain environmental conditions. If it is found that the number of branches is too large in the production, the branches should be thinned as early as possible, which can be pulled out by hand, uprooted with a hoe or raked with a disc harrow after the first autumn, which can play the role of cutting roots. When the number of branches of alfalfa is controlled, the number of flowers per unit area is also controlled (Joorabi et al., 2010).

4.3. Shorten the flowering period of population

The flowering period of the alfalfa population is very long, 40-60 days from the initial flowering period to the end of the flowering period. It takes 2-6 days for a raceme to bloom and the seeds are very irregular when they mature. Thus, flowering, podding, maturing and early maturing may occur. In order to obtain a higher actual seed yield, lock the mature seeds at the full bloom stage, pull out those plants that bloom too early or too late, or remove the inflorescences that bloom too early or too late at the flowering stage of the population so that continuous breeding will improve the ratio of inflorescences at the full bloom stage and shorten the length of the population's flowering period.

5. Conclusion

This paper puts forward the analysis method of the effect of reasonable density planting on the respiration characteristics of the garden alfalfa artificial grassland. According to the distribution characteristics of alfalfa under reasonable density planting, combined with the combination evaluation method to analyse the respiration characteristics of the grassland, according to the actual seed yield and the performance seed yield, the appropriate height of branches, the appropriate number of branches per square meter, the number of inflorescences/branches and the number of pods/branches, the number of flowers/inflorescence and the number of pods/inflorescence were analysed in order to show the existence of growth redundancy, and the methods to reduce redundancy were proposed. However, the proposed analysis method is only based on the vegetation density, and the vegetation respiration is also affected by the light duration. In future research and analysis, we can carry out the impact analysis on the respiration characteristics of alfalfa artificial grassland according to the light duration.

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