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Research Article

Density and Reserved Leaf Number of Tobacco to be Replanted in Cold Waterlogged Paddy Field

[1]Gui-xing Meng, [1]Jun Tan, [3]Dan-ying Xing, [2]Da-peng Tang, [3]Peng-fei Li, [3]Yan-xia Zhang, [1]Guang huo and [1]Bi-kun Xiang
[1]Enshi Branch of Hubei Tobacco Companies, Enshi 445000, China
[2]Laifeng Branch of Enshi Tobacco Companies, Ehshi 445700, China
[3]Agricultural College, Yangtze University, Jingzhou 434025, China

Abstract: To study the effects of density and reserved leaf number on the growth duration, agronomic character, yield and output value, the test was conducted on the density (A_i): (16665, 13875 and 11895 plants/hm^2, respectively) and reserved leaf number (B_j): (26, 22 and 18 pieces, respectively) for planting tobacco in cold waterlogged paddy field. The results showed that: (1) the density has certain effect on the growth duration. The budding period of low density is 1.7-2 days earlier than high density; (2) In the mature period, correlative analysis showed that there was a significant positive correlation between density and plant height ($r_{31} = 0.9992$, $p<0.01$ and there were negative correlation between density and stem girth, total leaf number and maximum leaf area, but not reach significant level; (3) The results showed that there is a positive correlation between density and yield ($r_{31} = 0.9318$), but the highest output value was the one whose density was 925 plants/667 m^2; (4) Correlative analysis showed that there is a significant positive correlation between reserved leaf number and yield and output value ($r_{81} = 0.9985$, $p<0.01$, $r_{82} = 0.9851$, $p<0.05$); (5) The first five leading yield is A_1B_1, A_2B_1, A_1B_2, A_1B_3, A_2B_2. The first five leading output value is A_2B_2, A_2B_1, A_1B_1, A_1B_3, A_2B_3; (6) Analysis of output value and economic traits of tobacco result showed that the best combination of planting tobacco in cold waterlogged paddy field was 13875 plants/hm^2 with 22 pieces/plant.

Keywords: Cold waterlogged paddy field, density, flue-cured tobacco, replant, reserved leaf number

INTRODUCTION

Cold waterlogged paddy field is a kind of paddy soils that long-term flooding lead to poor permeability and low effective nutrient utilization rate. It includes cold paddy field, the mud field, rust paddy fields and duck excrement mud field (Zhu, 1985). The cold waterlogged paddy field is up to 13% of the rice paddies field in mountainous area of Enshi (Tang, 2007). It appears in low-lying and perennial flooded areas. And to improve cold waterlogged paddy field and rice productivity, paddy-upland rotation played an important role (Lin and Liu, 2011; Lan *et al*., 2009; Liu *et al*., 2011). Tobacco is an important economic crop. Research on tobacco high yield cultivation techniques in mud micro-oxygenation field can raise the utilization ratio of field and improve planting benefit, which has the extremely realistic value. In 2010, we had a study on density and reserved leaf number of tobacco replanted in cold waterlogged paddy and had the preliminary results.

MATERIALS AND METHODS

Varieties test: Yun-yan 87, which was provided by tobacco scientific research institutes of Hubei province.
Test design: The test adopt ted double factors random blocks design, the factors were density and the number of reserved leaf. The density (A) had 3 levels which were 16665 plants/hm^2 (A_1), 13875 plants/hm^2 (A_2) and 11895 plants/hm^2 (A_3). The number of reserved leaf (B) had 3 levels too, which were 26 pieces/plant (B_1), 22 pieces/plant (B_2) and 18 pieces/plant (B_3). There were totally nine plots which size was 43.2 m^2 and every plot had protect line around, repeated three times. Nitrogen rates of test is 69 kg/hm^2 and the fertilization ratio of N: P_2O_5: K_2O was 1:1.9:4.3. When sowing, the fertilization was weighed and the plot was covered with film. On May 11, the seedlings were transplanted and the film was inter-tilled and unfolded after 30 days. According to flue-cured tobacco production technology solutions, the study of the main farming operation was engaged in.

Corresponding Author: Dan-ying Xing, Agricultural College, Yangtze University, Jingzhou 434025, China, Tel.: +86-136-0721-3390; Fax: 0716-8066314

Table 1: Growth period questionnaire of different treatments

Code of treatment	Transplanting period	Rosette stage	Faster growing stage	Bud stage	Initial bloom stage	Basic leaf maturity
A_1B_1	11/5	3/6	6/18	2/7	4/7	11/7
A_1B_2	11/5	3/6	6/18	2/7	5/7	7/13
A_1B_3	11/5	3/6	6/18	2/7	4/7	11/7
A_2B_1	11/5	3/6	6/18	2/7	4/7	11/7
A_2B_2	11/5	3/6	6/17	1/7	3/7	10/7
A_2B_3	11/5	3/6	6/18	2/7	4/7	11/7
A_3B_1	11/5	3/6	6/16	6/30	2/7	9/7
A_3B_2	11/5	2/6	6/16	6/30	2/7	8/7
A_3B_3	11/5	3/6	6/16	6/30	2/7	9/7

Table 2: Tobacco agronomic characters of faster growing stage of different treatments

Code of treatment	Plant height (cm)	Stem girth (mm)	Total leaf number (piece)	Maximum leaf area (cm^2)
A_1B_1	85.4	75.3	18.9	1221.46
A_1B_2	86.2	74.6	19.4	1239.23
A_1B_3	85.3	76.1	19.6	1251.71
A_2B_1	85.3	76.1	19.3	1282.88
A_2B_2	84.9	77.0	19.7	1234.84
A_2B_3	85.2	76.3	19.4	1296.34
A_3B_1	84.5	78.9	18.8	1329.96
A_3B_2	82.9	80.1	19.5	1381.97
A_3B_3	83.3	79.2	19.3	1339.35

Table 3: Tobacco agronomic characters of bud stage of different treatments

Code of treatment	Plant height (cm)	Stem girth (mm)	Total leaf number (piece)	Maximum leaf area (cm^2)
A_1B_1	125.7	83.3	23.3	1556.68
A_1B_2	125.9	83.5	22.9	1578.47
A_1B_3	124.5	84.6	23.4	1621.48
A_2B_1	120.8	84.7	23.3	1604.82
A_2B_2	123.6	85.6	23.7	1625.13
A_2B_3	124.1	83.9	23.2	1659.45
A_3B_1	122.6	85.8	23.6	1757.03
A_3B_2	122.4	86.6	24.1	1665.38
A_3B_3	123.1	87.1	23.4	1712.72

Table 4: Tobacco agronomic characters of maturity of different treatment

Code of treatment	Plant height (cm)	Stem girth (mm)	Total leaf number (piece)	Maximum leaf area (cm^2)
A_1B_1	134.1	90.4	24.2	1725.45
A_1B_2	133.7	90.8	23.6	1738.28
A_1B_3	133.1	91.3	24.4	1739.98
A_2B_1	129.6	91.4	24.6	1776.73
A_2B_2	131.2	92.6	24.2	1770.26
A_2B_3	132.3	90.9	24.4	1776.32
A_3B_1	125.8	93.4	24.2	1936.39
A_3B_2	129.7	93.9	24.8	1920.38
A_3B_3	131.2	94.3	24.1	1947.78

Our test was in Jianggong village six groups of Laifeng, where the altitude is 520 m. The experimental field is flat and the quality of soil is loam. The area is subtropical monsoon climate area, the frost-free period is 285 days, the annual average temperature is 16°C, the sunshine time of year is 1210 h, the activity accumulative temperature is 5051°C, the rainfall is 1380 mm, the annual evaporation is 1050 mm and the relative humidity is 82%.

Investigation records:

The growth period and agronomic characters: For every plot, the flue-cured tobacco of 10 plants was research and the main agronomic traits of growth periods, faster growing stage, bud stage and maturing stage were surveyed.

The economic characters: The grain was harvested and roasted by listing and classifying every plot. The production, production value, average price and classy smoke rate and other major economic characters were calculated.

RESULTS AND DISCUSSION

Growth period: The survey results of growth period of different treatments were presented in Table 1. It showed that the growth progress of different treatments was basically the same before rosette stage. In faster growing stage, the growing process of A_3 was faster than A_1 and A_2. The reproductive growth of A_3 was earlier 1.7-2 days than A_1 and A_2. This showed that density has an effect on the growing process. High density of flue-cured tobacco presented that fertility progress has the trend of delay.

Agronomic characters: Different treatment agronomic characters of the survey results were presented in Table 2, 3 and 4. The Table 2 showed that the average height of A_1, A_2 and A_3 were respectively 85.63, 85.13 and 83.56 cm, respectively. There is a positive correlation

Table 5: Different leave leaf number of agronomic characters comparison

Items	Reserved leaf number (piece)	Plant height (cm)	Stem girth (mm)	Total leaf number (piece)	Maximum leaf area (cm^2)
Rosette stage	26	85.07	76.77	19.00	1278.10
	22	84.67	77.23	19.50	1285.35
	18	84.60	77.20	19.43	1295.80
Bud stage	26	123.03	84.60	23.40	1639.51
	22	123.97	85.23	23.57	1622.99
	18	123.90	85.20	23.33	1664.55
Maturity stage	26	129.83	91.73	24.30	1812.86
	22	131.53	92.43	24.20	1809.64
	18	132.20	92.17	24.30	1821.36

Table 6: Economic characters of different treatment

Code of treatment	Output (kg/hm^2)	Classy smoke rate (%)	Average price (Yuan/kg)	Output value ($Yuan/hm^2$)
A_2B_2	2263.5ab	81.2ab	13.5	30857.25a
A_2B_1	2346ab	79.6ab	12.8	30028.8ab
A_1B_1	2403a	70.7b	12.1	29076.3ab
A_1B_3	2287.5ab	75.2ab	12.6	28822.5ab
A_2B_3	2103b	82.6ab	13.7	28811.1ab
A_3B_1	2032.5bc	83.4a	14.1	28658.25ab
A_1B_2	2329.5ab	74.8b	12.2	28419.9b
A_3B_3	1881c	85.2a	14.8	27838.8b
A_3B_2	1909.5c	84.6a	14.5	27687.75b

between density and plant height (r_{11} = 0.9257). In the same way, significant negative correlation was observed between density and stem girth (r_{12}) as well as maximum leaf area (r_{14}). (r_{12} = -0.9397; r_{14} = -0.9446). Form the Table 3 and 4, it can be seen that there is a positive correlation between density and plant height (r_{21}) in bud stage. (r_{21} = 0.9277) In the same way, negative correlation were observed between density and stem girth (r_{22}) and total leaf number (r_{23}) as well as maximum leaf area (r_{24}) (r_{22} = -0.9623*, r_{23} = -0.9775*, r_{23} = -0.9446). In maturing stage, there is a positive correlation between density and plant height (r_{31}) (r_{31} = 0.9992^{**}). Negative correlation were observed between density and stem girth (r_{32}) and total leaf number (r_{33}) as well as maximum leaf area (r_{34}) (r_{32} = -0.9342, r_{33} = -0.8736, r_{34} = -0.9081).

The numerical analysis of three stages showed that the effect of density on the plant height along with time change has the trend of increased. In rosette stage, the correlation coefficient (r_{11}) of both is 0.9257; in bud stage, correlation coefficient (r_{21}) is 0.9276; to maturity, correlation coefficient (r_{31}) is 0.9992**, to the very significant level. The maximum leaf area of three phases has similar phenomena. In rosette stage, the maximum leaf area of A_3 was 112.96 cm^2 bigger than A_1. It was increased by 9.13%. To maturity, the former was 200.28 cm^2 bigger than the latter, increasing by 11.55%; compared with rosette stage, increment had increased 2.42%. It showed that, with the increase of tobacco individual, the contradiction among individual intensifies and the influence of the density increases gradually.

According to the number of reserved leaf, the Table 2, 3 and 4 were combined, forming Table 5.

It showed that the reserved leaf number has certain effect on tobacco agronomic characters, but different in different period. In rosette stage, positive correlation were observed between reserved leaf number and plant height (r_{41} = 0.9268). And negative correlation were observed between reserved leaf number and stem girth (r_{42}), total leaf number (r_{43}) as well as maximum leaf area (r_{44}) (r_{42} = -0.8354, r_{43} = -0.7941, r_{44} = -0.9946**). In bud stage, positive correlation were observed between reserved leaf number and total leaf number (r_{53} = 0.2836).

And negative correlation were observed between reserved leaf number and plant height (r_{51}), stem girth (r_{52}) as well as maximum leaf area (r_{54}) (r_{51} = -0.8307, r_{52} = -0.8442, r_{54} = -0.5983). In maturity stage, reserved leaf number is negatively correlated with plant height (r_{61}), stem girth (r_{62}) and maximum leaf area (r_{64}) (r_{61} = -0.9699*, r_{62} = -0.6217, r_{64} = -0.7019). Reserved leaf number and total leaf number didn't show relationship (r_{63} = 0). Due to that the reserved leaf number processing is in after the flowering period, the agronomic characters in mature stage are more to the point.

Economic characters: The survey results of economic characters of different treatments were presented in Table 6. It showed that output and output value of different treatments are different. The planting density analysis showed that the average yield of A_1 was 2340 kg/hm^2, the average of A_2 was 2238 kg/hm^2, the average of A_3 was 1941 kg/hm^2, the average output value in turn was 28772.85 $Yuan/hm^2$ (A_1), 29899.05 $Yuan/hm^2$ (A_2) and 28061.55 $Yuan/hm^2$ (A_3). The density and yield (r_{71}), production (r_{72}) are positively correlated (r_{71} = 0.9318, r_{72} = 0.2919). But the correlation coefficient of the latter is far lower than the former. This showed that the reliability of relying on planting density to gain higher output value is low.

From the reserved leaf number to see, the average yield of B_1, B_2 and B_3 were respectively 2260.5, 2167.5 and 2090.55 kg/hm^2, the output value in turn is 2925 4.5, 28988.25 and 28490.85 $Yuan/hm^2$, respectively. The reserved leaf number and yield (r_{81}), production (r_{82}) are positively related (r_{81} = 0.9985**, r_{82} = 0.9851*) and up to the level of significance. It indicated that in the test range, higher reserved leaf number can help to acquire more yield and benefit. Further analysis found that, when the planting density of tobacco and reserved leaf number are determined, the yield and superior in the percentage of tobacco must be thought over and in this way good results can be achieved.

Comprehensive analysis of different treatments showed that the top five output order was A_1B_1, A_2B_1, A_1B_2, A_1B_3 and A_2B_2, while the output of A_3B_3, A_3B_2 and A_3B_1 were lower. The top five output value order was A_2B_2, A_2B_1, A_1B_1, A_1B_3 and A_2B_3 and the output value of A_3B_2, A_3B_3 and A_1B_2 were lower.

CONCLUSION

The result of study showed that density and reserved leaf number have great influence on growing process, economical character, yield and output:

- Density has an effect on the growing process. High density of flue-cured tobacco presented that fertility progress has the trend of delay; the growing process of A_3 was faster than A_1 and A_2. The reproductive growth of A_3 was earlier 1.7-2 days than A_1 and A_2.
- In vigorous growing stage, There is a positive correlation between density and plant height (r_{11} = 0.9257), significant negative correlation was observed between density and stem girth (r_{12}) as well as maximum leaf area (r_{14}). (r_{12} = -0.9397, r_{14} = -0.9446); In bud stage, there is a positive correlation between density and plant height (r_{21} = 0.9277), negative correlation were observed between density and stem girth (r_{22}) and total leaf number (r_{23}) as well as maximum leaf area (r_{24}), (r_{22} = -0.9623*, r_{23} = -0.9775*, r_{23} = -0.9446); In maturing stage, there is a positive correlation between density and plant height (r_{31} = 0.9992**). Negative correlation were observed between density and stem girth (r_{32}) and total leaf number (r_{33}) as well as maximum leaf area (r_{34}), (r_{32} = -0.9342, r_{33} = -0.8736, r_{34} = -0.9081).
- In rosette stage, positive correlation were observed between reserved leaf number and plant height (r_{41} = 0.9268). And negative correlation were observed between reserved leaf number and stem girth (r_{42}), total leaf number (r_{43}) as well as maximum leaf area (r_{44}), (r_{42} = -0.8354, r_{43} = -0.7941, r_{44} = -0.9946**); In bud stage, positive correlation were observed between reserved leaf number and total leaf number (r_{53} = 0.2836) and negative correlation were observed between reserved leaf number and plant height (r_{51}), stem girth (r_{52}) as well as maximum leaf area (r_{54}) (r_{51} = -0.8307, r_{52} = -0.8442, r_{54} = -0.5983); In maturity stage, reserved leaf number is negatively correlated with plant height (r_{61}), stem girth (r_{62}) and maximum leaf area (r_{64}) (r_{61} = -0.9699*, r_{62} = -0.6217, r_{64} = -0.7019). Reserved leaf number and total leaf number didn't show relationship (r_{63} = 0).
- The density and yield (r_{71}), production (r_{72}) are positively correlated (r_{71} = 0.9318, r_{72} = 0.2919, the reserved leaf number and yield (r_{81}), production (r_{82}) are positively related (r_{81} = 0.9985**, r_{82} = 0.9851*).
- Comprehensive analysis of different treatments showed that the top five output order was A_1B_1, A_2B_1, A_1B_2, A_1B_3 and A_2B_2, while the output of A_3B_3, A_3B_2 and A_3B_1 were lower. The top five output value order was A_2B_2, A_2B_1, A_1B_1, A_1B_3 and A_2B_3 and the output value of A_3B_2, A_3B_3 and A_1B_2 were lower.

Discussion: The ultimate goal of planting tobacco in cold waterlogged paddy field is to gain more output value and output is the precondition of output value. In this experiment, the output of A_1 (16665 plants/hm^2) was more than the other two levels (F_a>$F_{0.01}$), but its value was different. The value of A_2 (13875 plants/hm^2) was higher than the other two levels. The yields of treatments which keep 26 leaves/plant were higher than other treatments. The treatment whose density was 11895 plants/hm^2 and whose reserved leaf number was 18 had lower yield and yield value. So it has no value in the production. Analysis of economic traits of tobacco result showed that the best combination of planting tobacco in cold waterlogged paddy field was 13875 plants/hm^2 with 22 pieces/plant. Considering the influence of many factors on output value comprehensively is an important way to improve benefit of planting tobacco in cold waterlogged paddy field. In production, the influence of planting density and reserved leaf number on yield and value is needed to be seriously considered. The influence of planting time, soil fertility, fertilizer rates and repetition effect among different years should be considered as well. Only in this way better technical effects can be obtained.

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