
The Effect of Afforestation Way on Growth and Wood Properties of Hybrid Larch Fiber Wood

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Abstract: Hybrid Larch is the main plantation tree species for fiber wood. We examined the impact on wood properties of Hybrid Larch by four kinds planting densities (such as 2500 tree/hm², 3300 tree/hm², 4400 tree/hm² and 6600 tree/hm²) and four site preparing mode (such as open turf, point - land, high - profile land and control). Selected four standard woods as a material analysis of the sample in the every afforestation way in 2007, We found that the growth rate, fiber length and width were significantly impacted by different afforestation ways ($P < 0.05$), but non-significantly for wood density and cellulose content. The average fiber length, fiber width, aspect ratio and cellulose content were 2.52mm, 40.56 μm , 64.88 and 50.41%. This had some practical advices in planting method for fiber wood forest.

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Key words: Afforestation Way; Hybrid Larch; Fiber Wood; Growth; Wood Properties

1. Introduction

The hybrid larch is an inter-species hybridizer with a local larch as the one parent and Japan larch as the other parent, its heterosis is obvious, generally increases production above 20% compared to the fine local larch, moreover resistance to disease strong (Benli Pan et al., 1997). There are so many researches on the larch textile fiber, but nearly the blank regarding hybrid larch fiber wood.

The 10 kinds wood property of plantation wood, such as Chinese fir, Masson pine, Pinus Yunnanensis, slash pine, loblolly pine etc., and 4 kinds of natural forests such as Chinese fir, Masson pine, *Larix Olgensis*, and Pinus Yunnanensis were studied by Fucheng Bao, Zehui Jiang and the other 15 experts in 1998. From wood anatomy, chemistry, physics, mechanics and comprehensive reveal the trait of the wood characteristics of China's timber plantation, the difference in the laws between the young forest and mature forest, and the material difference in the law between some species of natural forest and wood; From the varieties of sources, populations, clonally plantations reveal the variation law of wood nature on different genetic structure levels of major plantation tree species; From different site conditions, planting density, thinning intensity, fertilizer application, soil type, etc. reveals the properties affect of cultivation measures on major plantation tree species; From the wood property variation law of the wood growth and phases of development reveal the early prediction method of the plantation wood properties; From wood physical mechanical and chemical properties targeting on the exploration of adaptability and its optimization process conditions

of the wood property of the plantation tree species.

At present, domestic research proceeded in China on wood properties mainly related to the 41 test items: The wood anatomy aspect has fiber length and width, cell wall thickness, the rate of cell wall, cell-diameter, the cell number of the growth round, tissue proportion, micro-fibrils angle, ultra structure; The wood chemistry aspects consist of holocellulose, -cellulose, multi-pentose, lignin, 1% NaOH extract, the phenol extract, the cold water extract, the hot water extract, PH value, acid buffer capacity, alkali buffer capacity, mineral elements, the relative degree of crystalline, sugar-based ratio, differential thermal analysis, thermal gravimetric analysis; The wood physics and mechanics aspect has latewood percentage, treeing width, the fresh material moisture content, water absorption, shrinkage, wood density, permeability, diffusivity, thermal properties, longitudinal compressive strength, flexural strength, modulus of elasticity, tensile strength parallel to grain, Shear Strength Parallel, impact toughness and Cleavage strength et al(Jingjing Wang, 2008).

The wood density is an important indicator to revalue the quality of Pulp Wood, closely relates with latewood percentage, cell wall thickness, extract content and the density of cell wall, has important effects to the pulp output and the paper quality (Changhua Fang,2001). The wood fiber shape has consanguineous relation with the pulping papermaking performance, the fiber shape characteristic is the important factor to effect the papermaking quality (Shanshan Chang et al,2007). The chemical composition also has the material effect to the wood pulping papermaking performance,

the cellulose content immediate influence pulps rate, the cellulose content of raw material is high, the pulps rate is also high. In this paper, research on the effect of afforestation way on the growth and wood properties of Hybrid Larch fiber wood, provides the technical support to impel large scale promotion of Hybrid Larch and construct fast-growing, high-yield plantation base.

2. Materials and Methods

2.1 Data collection

The samples were setted in 4 kinds of planting density (2500 tree/hm², 3300 tree/hm², 4400 tree/hm², 6600 tree/hm²) and 4 site preparation modes (open turf, point-land, the high-profile land, currently ground prepared), were created in 1998 in Jiangshanjiao forest farm, Mudanjiang city of Heilongjiang province, Northeastern China, with two years old level seeding of Hybrid Larch of Qingshan forest farm, four repetition every way. Selected fixed standard place in 2004, and investigated the diameter every year. Selected four standard trees as stem

analysis and material analysis sample in every afforestation way in 2007.

2.2 Mensurate method

Wood density is measured with saturated water content; fiber length and width are measured by the 1:1 mixture of hydrogen peroxide and acetic acid to segregation; cellulose content is measured by nitric acid.

2.3 Data analysis method

The variance analysis, correlativity and regression analysis were made in SAS, SPSS and Excel.

3. Result and Analysis

3.1 DBH

3.1.1 Planting Density and DBH

Tab.1 showed the average diameter and average growth increment of hybrid larch from 8 to 13 age in four kinds of planting density.

Table 1. The average diameter and growth increment of hybrid larch on the different planting densities

Planting densities	Average diameter(cm)						Average growth increment
	8	9	10	11	12	13	
2500	5.1±1.6	6.4±1.6	7.6±1.8	8.7±2.1	9.4±2.3	10.3±2.6	1.04±0.24
3300	4.9±1.4	6.2±1.6	7.3±1.8	8.4±2.1	9.0±2.3	9.8±2.5	0.98±0.28
4400	4.8±1.3	6.0±1.6	7.0±1.8	7.8±2.1	8.4±2.3	9.1±2.6	0.86±0.24
6600	4.5±1.3	5.5±1.6	6.3±1.8	7.2±2.1	7.7±2.3	8.3±2.6	0.76±0.21

The smaller planting density was, the higher average diameter was. And the average growth increment was also getting higher; instead, the average diameter was getting smaller, the average growth increment was also getting smaller. The average DBH of planting density of 2500 tree/hm² was higher than the other three kinds of planting density during the period of 6 years, The average DBH of 2500 tree/hm² at 13 age was 0.5cm higher than 3300 tree/hm², accounting for 5.1% of 3300 tree/hm²; 1.2cm higher than 4400 tree/hm²,

accounting for 13.2% of 4400 tree/hm²; 2cm higher than 6600 tree/hm², accounting for 24.1% of 6600 tree/hm². The average growth increment was also the largest of four kinds of planting density, 0.05cm higher than 3300 tree/hm²; 0.151cm higher than 4400 tree/hm²; 0.234cm higher than 6600 tree/hm² (Tab.1).

3.1.2 Site Preparation Mode And DBH

Investigated the diameter of the hybrid larch under different site preparation modes for 6 years, obtained the DBH were shown in Tab.2.

Table 2. The average diameter of hybrid larch on the different site preparation modes

site preparation modes	average diameter(cm)					
	8	9	10	11	12	13
Open turf	5.15±1.27	6.41±1.49	7.60±1.72	8.64±1.99	8.88±2.17	9.75±2.45
Point-land	5.17±1.53	6.41±1.57	7.64±1.81	8.65±2.11	8.95±2.32	9.66±2.57
High-profile land	4.56±1.36	5.78±1.65	6.77±1.92	7.73±2.28	8.24±2.51	8.88±2.81
Currently ground prepared	4.08±1.34	5.36±1.58	6.48±1.82	7.55±2.14	7.94±2.38	8.72±2.75

The growth of hybrid larch under open turf and point-land showed the more apparent positive phenomena than the other modes did during the period of 6 years, the DBH of these two modes were 9.75cm and 9.66cm at the age of 13, about 1cm higher than high-profile land (8.88cm) and currently ground prepared (8.72cm). The effect of open turf on the ground diameter and height was not very significant (Sun Nan, etc., 2008), but with the growth of the young trees, the influence was getting more and more obvious.

Through the variance analysis on the DBH of hybrid larch from 8 to 13 age targeting on the

different site preparation modes, F test values obtained, $F_8=44.005$, $F_9=31.063$, $F_{10}=33.593$, $F_{11}=25.359$, $F_{12}=75.464$, $F_{13}=69.099$, far greater than the $F_{0.05} = 3.49$, it showed that the effect of site preparation method on the DBH was significant at the 0.05 level.

3.2 Wood density

3.2.1 Planting Density and Wood Density

The arithmetic average of the wood density of the hybrid larch under the four kinds of planting density is shown in Fig.1.

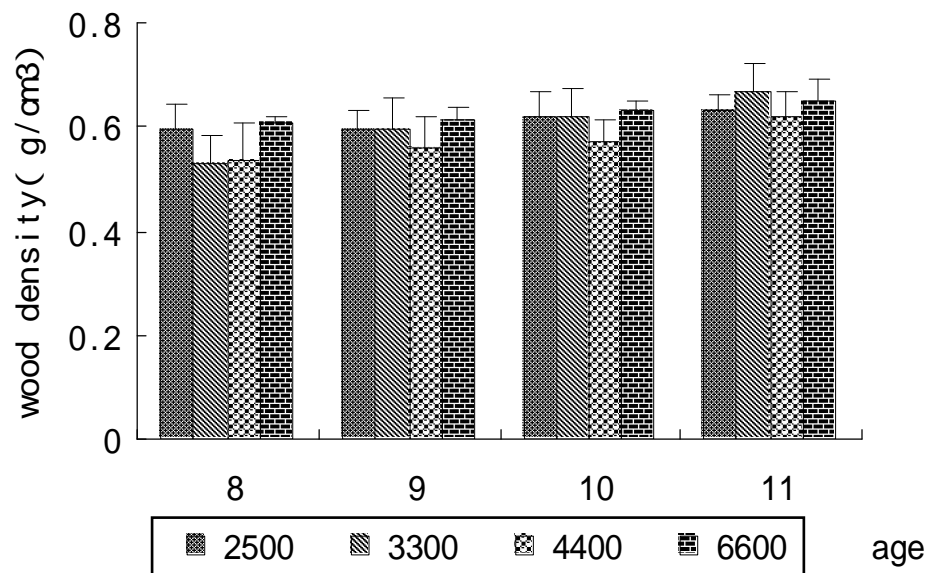


Fig.1. the wood density under different planting densities

There was a little difference from the wood density of hybrid larch within four kinds of planting density at the age of 8, both of the wood density of 2500 tree/hm² and 6600 tree/hm² were about 0.60g/cm³, the other two planting densities were approximately between 0.52g/cm³ and 0.53 g/cm³. The increment rate of the large wood density was gradually reduced and the increment rate of the small wood density was gradually increased along with growth of the age. The discrepancy between the wood density of the four kind of planting density went less and less at 11 age (Fig.1).

Variance analysis on the wood density of hybrid

larch whose age was from 8 to 11 under the different planting densities, the obtained F test values were, $F_8=2.313$, $F_9=0.911$, $F_{10}=1.503$, $F_{11}=1.021$, and all are lower than the $F_{0.05} = 3.49$, it showed that the effect of planting density on the wood density was not significant.

3.2.2 Site Preparation Mode And Wood Density

The wood density of hybrid larch had been measured, and obtained the average figure results from different site preparation methods, the results for the measurement was shown in Fig.2.

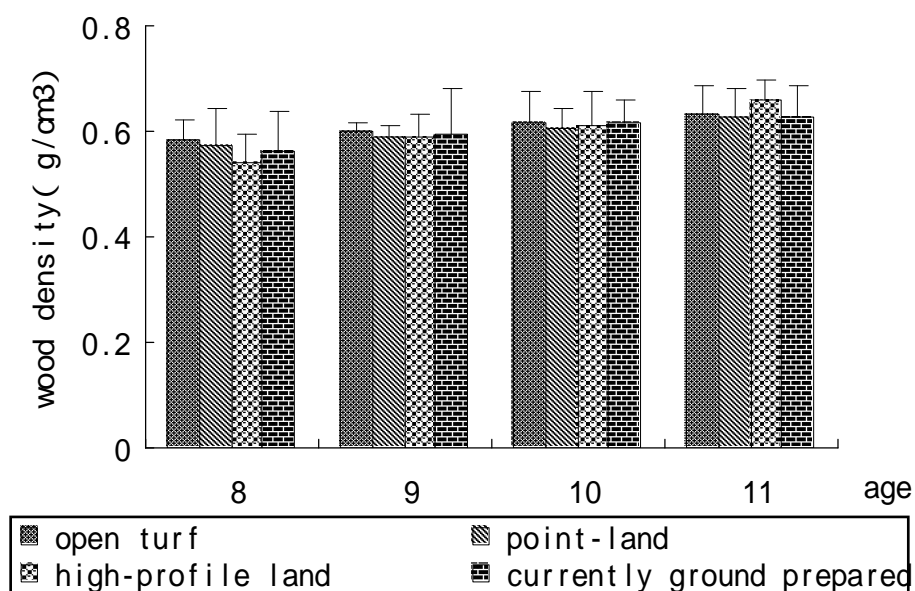


Fig.2. the wood density under different site preparation modes

The wood density of hybrid larch under high-profile site preparation mode was the fastest among four kinds of soil preparation methods, at the age of 8, the wood density was only $0.5\text{g}/\text{cm}^3$, that was the lowest of the four soil preparation methods, and at the age of 11, the wood density approached $0.65\text{g}/\text{cm}^3$, which was the highest; there was inconspicuous differences among the other three soil preparation methods. Variance analysis on the wood density of hybrid larch whose age from 8 to 11 under the different soil preparation methods, the obtained F

test values were, $F_8=0.390$, $F_9=0.036$, $F_{10}=0.039$, $F_{11}=0.3621$, all of which are lower than the $F_{0.05} = 3.49$. Consequently it showed that the effect of soil preparation method on the wood density is insignificant.

3.3 Fiber Length, Width and Aspect Ratio

3.3.1 Planting Density and Fiber Shape

The fiber length, width and aspect ratio of hybrid larch under different planting densities were shown in Fig 3, Fig 4, Fig 5.

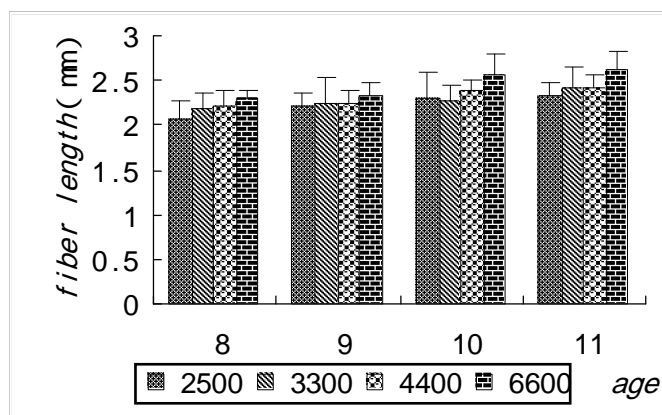


Fig 3. The fiber length under different planting densities

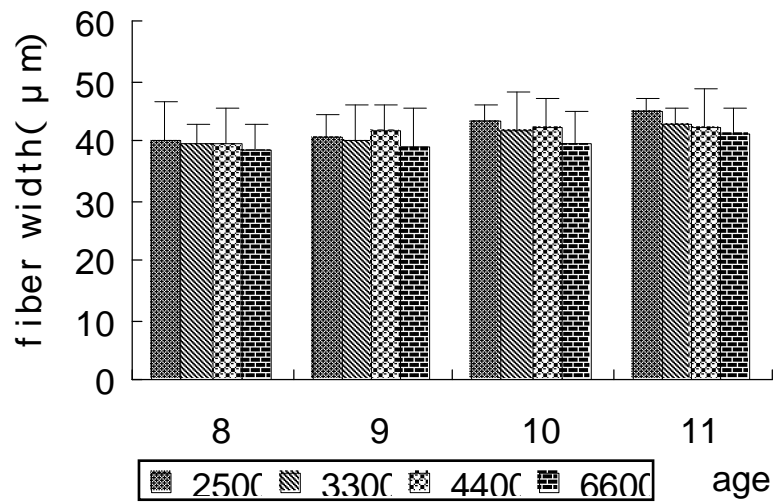


Fig 4. The fiber width under different planting densities

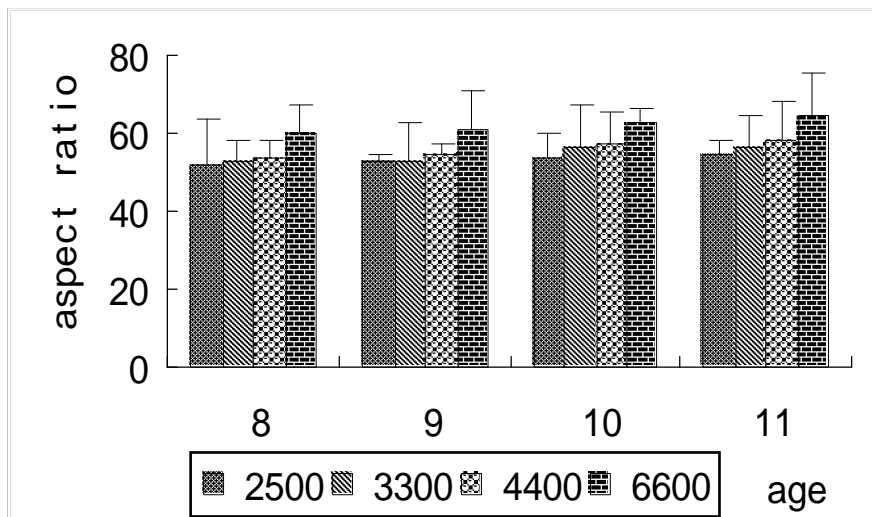


Fig 5. The aspect ratio under different planting densities

Variance analysis on the fiber length, width and aspect ratio of hybrid larch from 8 to 11 age under the different planting densities, obtained F test value, that were shown in Tab.3.

Tab.3.The variance analysis result Under different densities of planting

	F			
	8 age	9 age	10 age	11 age
Fiber length	2.887**	1.786	5.870**	2.732**
Fiber width	1.125	3.224**	2.516*	3.749**
Aspect ratio	0.863	1.085	0.986	1.122

* and ** means significant differences among 0.10 and 0.05 level respectively.

The fiber length whose planting density is 6600 tree/hm² was the longest of the four planting densities, and there are not different from the other three densities, which may be connected to that the faster growth of the smaller planting density, and the fiber has no sufficient time to elongation, so the length was relatively short (Zhou Liang, et al., 2005). From the result of F test value, the effect of planting density on the fiber length was significant, the effect at the age of 8, 10 and 11 are more evident at the level of 0.05 (Tab.3).

The fiber width of 2500 tree/hm² was the largest, the rate of rise of 2500 tree/hm² was quite high and that of 3300 tree/hm² was lower, so the fiber width of 3300 tree/hm² was the shortest of the four kinds of planting density. The fiber width of the other planting

densities was around the average width (Fig. 5). The effect of planting density on the fiber width at the age of 9 and 11 were significant at the level of 0.05 and the effect at 10 age was significant at 0.10 level.

Aspect ratio is the result of fiber length and fiber width, fiber length was much greater than its width, and the radial direction change of fiber length was also significantly than its width, so the radial direction change of aspect ratio mainly reflects the radial direction change of fiber length(Fig. 6). Variance analysis showed that the effect of planting density on the aspect ratio was not significant.

3.3.2 Site Preparation Mode And Fiber Shape

The fiber length, width and aspect ratio of hybrid larch under different site preparation modes were shown in Fig.6, Fig.7, and Fig.8.

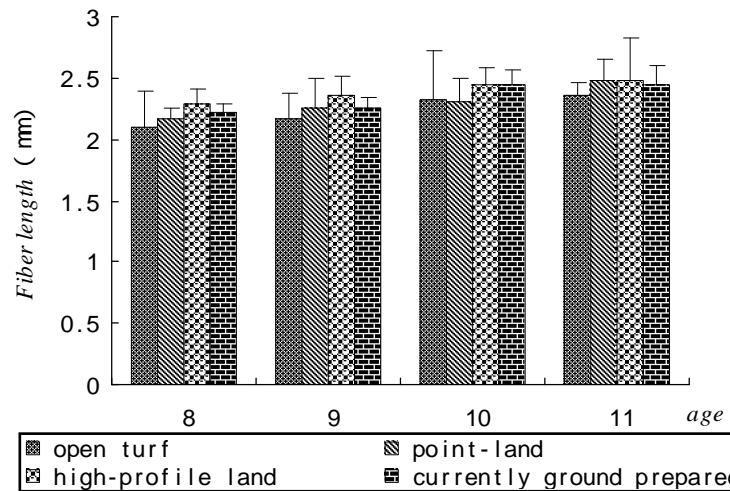


Fig.6. The fiber length under different site preparation modes

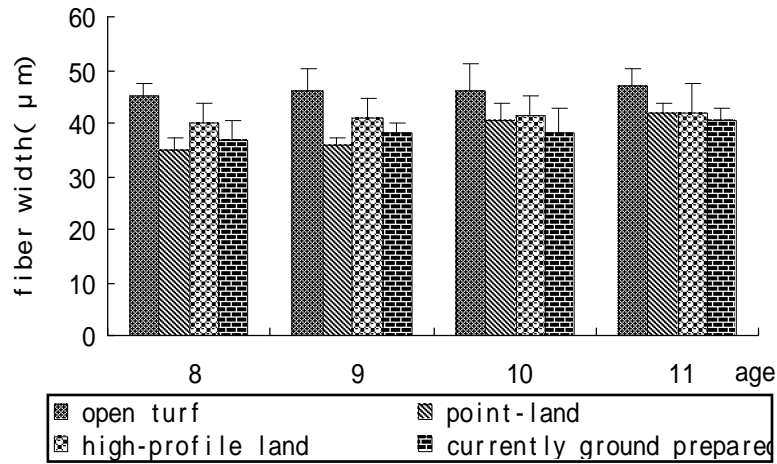


Fig. 7 the fiber width under different site preparation modes

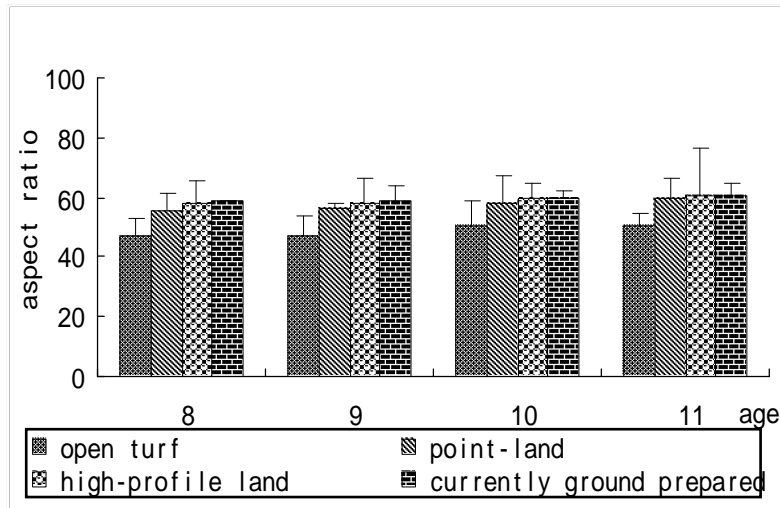


Fig8.The aspect ratio under different site preparation modes

Variance analysis targeting on the fiber length, width and aspect ratio of hybrid larch whose age from 8 to 11 under the different site preparation modes, the obtained F test values were shown in Table 4.

Tab. 4.The variance analysis result under different site preparation modes

	F			
	8 age	9 age	10 age	11 age
Fiber length	2.565*	2.034	6.456**	1.144
Fiber width	11.012**	5.442**	16.488**	11.99**
Aspect ratio	3.524*	3.662*	1.72	1.131

The fiber length of open turf was the shortest and the currently ground prepared was the highest of four site preparation modes (Fig. 7), which was related to the growth velocity of the hybrid larch. The data showed the growth velocity of the open turf was the fastest, the currently ground prepared was the lowest, and the other two modes between open turf and currently ground prepared, so the faster growth speed went, the shorter fiber length it became (Zhou Liang, etc., 2005). From the F test value, the effect of site preparation mode on the fiber length was significant at the level of 0.05 only at the age of 10, at level of 0.10 at the age of 8 and no difference at the age of 9 and 11 (Tab.4).

The fiber width of hybrid larch under open turf mode was the largest, and the other three modes all were under the average width (Fig. 8), the effect of site preparation mode on the fiber width were all significant at the level of 0.05.

When the fiber length of the open turf was the shortest and the width was the largest, the aspect

ratio of the open turf was the smallest. The aspect ratio of hybrid larch was more than 45 from age 8 (Fig. 9), it can illustrate that hybrid larch was a more high-quality fiber materials. Variance analysis showed that the effect of site preparation mode on the aspect ratio was significant at level of 0.10 at the age of 8 and 9, and no difference at 10 and 11 age.

3.4 Chemical Composition

3.4.1 Planting Density and Chemical Composition

The change of the cellulose content of 3300 tree/hm² was larger than the other three planting density, from 47.15% at the age of 8 to 50.88% at the age of 11, which was the highest of the four densities. There was no difference among these four planting densities at the age of 11 of hybrid larch, and theoretically according to the development trend of the chemical composition, the change of the cellulose content of four densities were smaller and smaller (Fig.9).

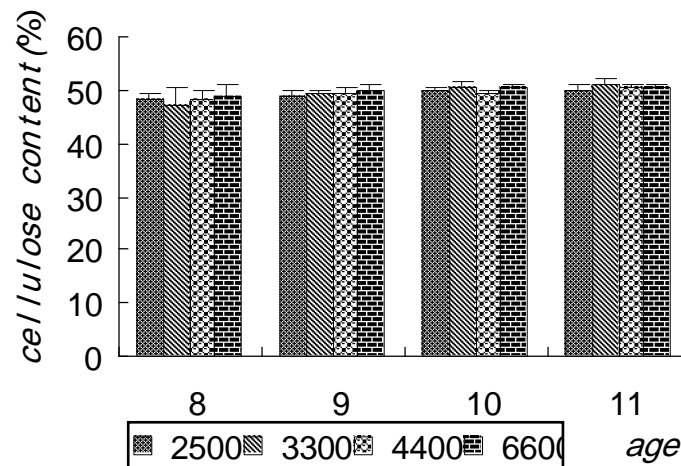


Fig 9. Influence of Cellulose content on different planting densities

Variance analysis on the cellulose content of hybrid larch whose age from 8 to 11 under the different planting densities, the obtained F test values were, $F_8=0.318$, $F_9=0.240$, $F_{10}=0.610$, $F_{11}=0.219$, all of which are lower than the $F_{0.05} = 3.49$, it showed that the effect of planting density on the cellulose content was not significant.

3.4.2 Site Preparation Mode and Chemical Composition

The cellulose content of hybrid larch under different site preparation modes were shown in Fig.10.

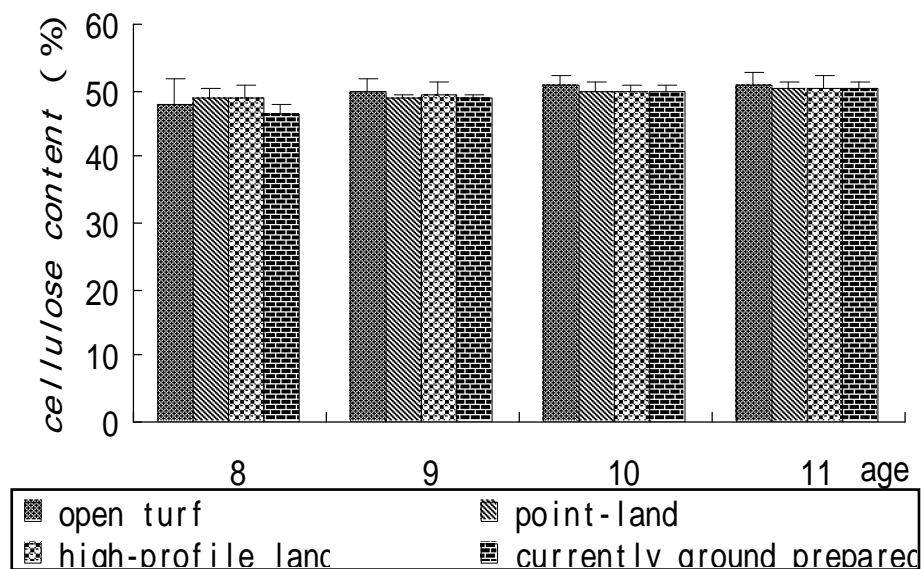


Fig10. Influence of Cellulose content on different site preparation modes

The cellulose content of the hybrid larch were increasing with age. The cellulose content of the currently ground prepared was only 46.58% at 8age, lower than the other three modes, which were between 48% and 49%, and had no obvious differences; the cellulose content under the four modes has changed 3 years later, the cellulose content of open turf was 50.71%, larger than the other, and the high-profile land mode was 50.12%, which was the lowest; the other two modes were 50.47% and 50.36%, which had no difference with 50.36% the average cellulose content. So it showed that the effect of site preparation mode on the cellulose content was comparative, but the effect went less and less with age until the cellulose content arrived steady(Figure 10).

Variance analysis on the cellulose content of hybrid larch whose age from 8 to 11 under the different site preparation modes, the obtained F test values were, $F_8=0.769$, $F_9=1.376$, $F_{10}=0.554$, $F_{11}=0.098$, all of which are lower than the $F_{0.05} = 3.49$, it showed that the effect of site preparation mode on the cellulose content was not significant, and the F value showed a gradual downward trend, which meant that the effect of site preparation methods on cellulose content was getting smaller and smaller.

4. Conclusion and Discussion

The effect of afforestation way on the DBH were more significant, the smaller planting density, the larger DBH; the DBH of the open turf and the point-land were larger than the other modes.

The wood density of hybrid larch were between 0.56 and 0.64 g/cm³, which was usually negatively related to the speed of the DBH(Eva Fruhwald, 2007), but hybrid larch had the fast speed of the growth and provided a wood density not related to the fast growth, so it is a better material forest for papermaking. The wood density under different planting densities and site preparation modes had little effect that may be related to the young age of hybrid larch.

The effect of planting density on the fiber length and width were more significant, the larger the planting density was, the larger the fiber length became, and the smaller fiber width went. The influence of site preparation mode on the fiber length and width were also significant, the fiber length of the open turf was shorter, and the width was longer; the fiber length of currently ground prepared was the largest.

The cellulose content of hybrid larch at the age

of 11 was 50.41%, which enables to meet the paper requirements. The site preparation mode and planting density had no effect on the cellulose content, and the effect became weaker gradually along with the age.

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