# Effect of Planting Density, Fertilizer Level, and Number of Seedlings per Hole on Yield of *Coix Lachryrma-jobi L.*

**Zhiqin SONG[1], Maohong AO[2]*, Gang SHEN[2], Pengfei LIU[2]**

1. Guizhou Institute of Modern Chinese Medicinal Materials, Guiyang 550006, China; 2. Guizhou Subtropical Crop Institute, Guizhou 562400, China

**Abstract** In order to study high yield cultivation technology for *Coix Lachryrma-jobi L.*, and discuss the effect of planting density, fertilizer level, and number of seedlings per hole on yield of *Coix Lachryrma-jobi L.*, this paper took domesticated variety Xingren Small White Shell of *Coix Lachryrma-jobi L.* as an example. Using $L_9(3^4)$ orthogonal design, it selected optimum combination of planting density, fertilizer level, and number of seedlings per hole to guide planting of *Coix Lachryrma-jobi L.*. Experiment indicated that the optimum planting density (spacing in the rows and spacing between rows) of *Coix Lachryrma-jobi L.* is 40 cm x 80 cm; the optimum fertilizer level is pure nitrogen 15 kg, pure phosphorus 15 kg and pure potassium 15 kg per mu; the optimum number of seedlings per hole is 5 seedlings per hole. Through variance analysis, it indicated that planting density exerts significance effect on the yield of *Coix Lachryrma-jobi L.*

**Key words** *Coix Lachryrma-jobi L.*, Orthogonal design, Planting density, Fertilizer level, Number of seedlings per hole

## 1 Introduction

*Coix Lachryrma-jobi L.* is an annual or perennial Gramineae C4 herb plant. Its common names include coix seed, Job's tears (Australia), adlay (Philippines), sila (Fiji), and ma yuen (China)[1]. It is an important medicinal and edible plant resource. As medicinal material, *Coix Lachryrma-jobi L.* has sweet, bland, and slightly cold properties. It has functions of inducing diuresis for removing edema, invigorating the spleen and dispelling dampness, and clearing heat and discharging pus. As edible material, *Coix Lachryrma-jobi L.* contains higher calorie than rice and wheat, and it is rich in fat, variety of amino acids, and vitamin $B_1$, vitamin $B_2$, Ca, P, Mg, K, has high nutritive value, and can be rated as king of Gramineae crops[2]. Guizhou Qianxinan Buyei and Miao Autonomous Prefecture is the major area of planting *Coix Lachryrma-jobi L.* The planting area remains in 300000 mu approximately. *Coix Lachryrma-jobi L.* is the major characteristic cash crop in local area. In order to study high yield cultivation technology for *Coix Lachryrma-jobi L.*, and discuss the effect of planting density, fertilizer level, and number of seedlings per hole on yield of *Coix Lachryrma-jobi L.*, and select optimum combination of these factors, and guide production and planting, we took domesticated variety Xingren Small White Shell of *Coix Lachryrma-jobi L.* as an example. Using $L_9(3^4)$ orthogonal design, we studied the effect of planting density, fertilizer level, and number of seedlings per hole on yield of *Coix Lachryrma-jobi L.* It is expected to provide reference for high yield cultivation technology of *Coix Lachryrma-jobi L.*

Received: April 23, 2015 Accepted: June 20, 2015
Supported by Key Agricultural Project of Guizhou Province (NY (2011) 3093); Guizhou Provincial Science Foundation (J (2013) 2192); National Spark Plan Project (2013GA820001); Joint Fund Project of Guizhou Academy of Agricultural Sciences (LH (2014) 7692).
* Corresponding author. E-mail: aomaohong@126.com

## 2 Materials and methods

**2.1 General information of experimental site** The experimental site is situated in Tuanpo Village in Xingren County of southwest Guizhou and the geographical position is E105°23.266′, N25°22.687, the altitude is 1260 m. It is dry slope land, sandy soil, fertility is moderate. The *Coix Lachryrma-jobi L.* land is continuous cropping land.

**2.2 Experimental materials** We took domesticated variety Xingren Small White Shell of *Coix Lachryrma-jobi L.* planted in southwest Guizhou as experimental material.

**2.3 Experimental methods**

**2.3.1** Experiment design. The experiment adopted $L_9(3^4)$ orthogonal design. Experimental factors are planting density (A), fertilizer level (B), number of seedlings per hole (C), and each factor is arranged at three levels[3]. Namely, $A_1$, $A_2$, and $A_3$; $B_1$, $B_2$, and $B_3$; $C_1$, $C_2$, and $C_3$. For spacing in the rows x row spacing, $A_1$ is 40 cm x 40 cm, $A_2$ is 40 cm x 60 cm, and $A_3$ is 40 cm x 80 cm. $B_1$ is 25 kg pure nitrogen, 25 kg pure phosphorus, and 25 kg pure potassium (calculated at 667 $m^2$, the same below); B2 is 20 kg pure nitrogen, 20 kg pure phosphorus, and 20 kg pure potassium; $B_3$ is 15 kg pure nitrogen, 15 kg pure phosphorus, and 15 kg pure potassium. $C_1$ is 3 seedlings per hole, $C_2$ is 5 seedlings per hole, and $C_3$ is 7 seedlings per hole. The above three factors at three levels form 9 orthogonal processing. According to $L_9(3^4)$ orthogonal layout design (as listed in Table 1), each processes 3 repetitions, obtaining a total of 27 plots, randomly distributed with area of 24 $m^2$.

**2.3.2** Experiment method. Using direct seeding technology, we sowed in the manner of bunch planting in the middle of April. When 2 -3 leaves appear, we thinned out excessive seedlings according to experiment design, and each hole keeps different number of seedlings. In accordance with fertilizer demand of *Coix*

*Lachryrma-jobi L.*, fertilizer was applied in 4 times[4]: base manure accounts for 30% of total fertilizer, the first time fertilizer application (when 4 – 5 leaves appear) accounts for 20% of total fertilizer, the second time fertilizer application (at the jointing stage) accounts for 40% of total fertilizer, the third time fertilizer application (in the flowering period) accounts for 10% of total fertilizer. In the breeding period, it is required to pay attention to field management and prevention and control of plant diseases and insect pests. It is required to strengthen record of field observation, and make record of period of emergence, period of heading, period of flowering, and mature period of processing plots. In the mature period, we randomly sampled 10 holes in experiment plots to test seeds, and make record of tillering rate, plant height, number of ears per hole, number of grains per ear, and weight of thousand grains.

**Table 1 Design of $L_9(3^4)$ orthogonal layout**

| Level | Factor | | |
|---|---|---|---|
| | Planting density (A) | Fertilizer level (B) | Number of seedlings (C) |
| 1 | $A_1$ | $B_1$ | $C_1$ |
| 2 | $A_2$ | $B_2$ | $C_2$ |
| 3 | $A_3$ | $B_3$ | $C_3$ |

**2.3.3** Data analysis. We made variance analysis using DPS data processing software.

## 3 Results and analyses

**3.1 Variance analysis of orthogonal experiment**[5] Yield of combination of orthogonal experiment with different planting density, fertilizer level and number of seedlings is listed in Table 2. From the extreme difference in Table 2, it indicates that the action of effect of factors on the yield is A > C > B, namely planting density > number of seedlings per hole > fertilizer level. Through variance analysis in Table 3, we know that there is significant difference ($P < 0.05$) in the effect of factor A, namely, the planting density, on the yield; there is no significant difference in the effect of factor B and C on the yield, showing the dominant factor influencing the yield of *Coix Lachryrma-jobi L.* is planting density. Combining the extreme difference analysis in Table 2, it is known that the optimum combination of planting is $A_3$ $B_3$ $C_2$, namely, the planting density is 40 cm x 80 cm, the fertilizer level is pure nitrogen 15 kg, pure phosphorus 15 kg, and pure potassium 15 kg, and the number of seedlings per hole is 5.

**Table 2 Yield of combination of orthogonal experiment with different planting density, fertilizer level and number of seedlings**

| Experiment plot | A | B | B | D | Yield//kg (converted into yield per mu) |
|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 300 |
| 2 | 1 | 2 | 2 | 2 | 303 |
| 3 | 1 | 3 | 3 | 3 | 285 |
| 4 | 2 | 1 | 3 | 3 | 304 |
| 5 | 2 | 2 | 2 | 1 | 285 |
| 6 | 2 | 3 | 1 | 2 | 315 |
| 7 | 3 | 1 | 3 | 2 | 310 |
| 8 | 3 | 2 | 1 | 3 | 325 |
| 9 | 3 | 3 | 2 | 1 | 350 |
| Mean value K1 | 296.00 | 304.67 | 313.33 | 311.67 | |
| Mean value K1 | 301.33 | 304.33 | 319.00 | 309.33 | |
| Mean value K1 | 328.33 | 316.67 | 293.33 | 304.67 | |
| R | 32.33 | 12.33 | 25.67 | 7.00 | |

**Table 3 Variance analysis of combination of orthogonal experiment with different planting density, fertilizer level and number of seedlings**

| Source | Partial regression square sum | Degree of freedom | F ratio | Critical value of F | Significance level |
|---|---|---|---|---|---|
| A | 1802.89 | 2 | 23.653 | 19.00 | P < 0.05 |
| B | 296.22 | 2 | 3.886 | 19.00 | P > 0.05 |
| C | 1 090.89 | 2 | 14.312 | 19.00 | P > 0.05 |
| Error | 76.22 | | | | |

$F_{0.05(2.2)} = 19.00$

**3.2 The effect of planting density on economic properties of *Coix Lachryrma-jobi L.*** In the condition of different planting density, taking 5 seedlings per hole as plot of seed test, we selected 10 holes to make random seed test, the test results are listed in Table 4. From Table 4, we can see that with constant decrease of planting density, although the number of seedlings per mu is reduced, the tillering rate, number of ears per hole, and number of grains per ear have increase. Therefore, in the planting process of Coix Lachryrma-jobi L, it is required to properly reduce the planting density. Lower planting density will bring better ventilation and sunshine penetration, higher tillering rate, and more effective number of ears, side branches and grains, so as to significantly increase the yield of *Coix Lachryrma-jobi L.*

**Table 4 The effect of planting density on economic properties of *Coix Lachryrma-jobi L.***

| Planting density | Basic number of seedlings $10^4$/667m$^2$ | Tillering rate % | Plant height cm | Number of ears Ears/hole | Number of grains per ear Grains/ear | Weight of thousand of grains//g |
|---|---|---|---|---|---|---|
| $A_1$ | 2.08 | 256.66 | 1.78 | 12.25 | 156.55 | 90.56 |
| $A_2$ | 1.39 | 325.58 | 1.68 | 15.67 | 202.68 | 90.58 |
| $A_3$ | 1.04 | 398.67 | 1.85 | 17.68 | 238.87 | 92.98 |

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