Journal of Science and Applications:
BioMedicine

Research Paper

# *Coix lacryma-jobi* L. growth and yield response to different sowing dates in Sichuan China

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**Abstract:** *Coix lacryma-jobi* L., a potential energy source, is a very useful and productive grass. Although it is widely used in folk medicines for abdominal tumors, esophageal, gastrointestinal, lung cancers, various tumors, etc., its growth and yield response to different sowing dates has not been studied yet. In this study, three cultivars were selected and six sowing dates were designed to investigate the effects of the sowing time on its growth and yield in Sichuan China. Several agronomic characteristics of *Coix lacryma-jobi* L. such as tassel day, leaf number, plant height, effective tillers, effective panicle, grains per panicle, 1000-grain weight, and yield were recorded. The results show that different sowing dates could greatly affect the growth, development, and yield of *Coix*. This study also indicates that the yield of *Coix* is not determined by one single factor but by the product of three factors: 1000-grain weight, grain number, and effective panicles. As shown in the overall analysis, effective tillers of second and third periods were more than other periods. 1000-grain weight and grain number of these two periods on main stem and spike were also significantly higher than those of other periods. Therefore, to obtain the highest yield, the sowing date of *Coix* in Ya'an city should be late March to early April, which is in line with the analysis of tassel time, effective tillers, effective panicles, and grain number. Furthermore, our study provides valuable information on the optimal growth condition and high yield of *Coix*. ***Published by www.inter-use.com. Available online 12-8-2013 Vol. 1 Issue 1 Page 8-14.***

**Keywords:** Sowing date, *Coix lacryma-jobi* L., Job's tear, growth, yield

## 1. Introduction

*Coix lacryma-jobi* L., also called Job's tears, is a broad-leaved, grain-bearing tropical plant of the family Poaceae. It is native to Southeast Asia but is planted elsewhere in gardens as an annual grass [1]. It is considered a nutritious health cereal in Asian countries such as China, Japan, the Philippines, Burma, and Thailand [2]. The seeds of Job's tears are tear-shaped and appear in several colors used for decorative purpose, rosaries, and necklaces. The root and seed of *Coix* are very versatile and they can also be used as folk medicines. People take Job's tears for hay fever, high cholesterol, cancer, obesity, and respiratory tract infections. Many scholars have reported that it has functions such as anti-tumor, hypoglycemic, antihypertensive, and anti-virus pharmacological activity [3-7]. The high yield cultivation, genetic characteristics, nutritional value, and medicinal value of *Coix* have been studied, however, its growth and yield for responses to different sowing dates is unreported.

Light and temperature conditions of the sowing time will affect the growth and development of crop plants. The changes of sowing time will inevitably have an impact on crops' growth and grain formation [8, 9]. Therefore it will be very important to survey the impact of sowing time on the yield of the crop [10-13]. While variations in planting date are expected to influence the pattern of *Coix*'s growth and development, very few reports have examined this issue in detail. The objective of our study is to quantify the impact of planting date on the growth, development, and agronomic performance of Nanjing, Ya'an, and Shandong cultivars. These cultivars were planted at about 15 day intervals over a five-month span to identify the best planting date of *Coix*.

## 2. Materials and Methods

*2.1 The source of materials*

Three *Coix lacryma-jobi* L. cultivars — Shandong, Nanjing, and Ya'an, were obtained from Shandong Agricultural University, Nanjing Agricultural University, and Sichuan Agricultural University, respectively. These three species represented the northern, southern, and local cultivars.

*2.2 The design of the experiment*

The experiment was carried out at Sichuan Agricultural University in China. The screened grains were sowed on the medium plates (mixture of fine sand and sawdust, the ratio is 2:1, sterilized). The plates were placed into incubator to germinate (30℃/8 h and 25℃/16 h). Six planting dates were tested (Table 1). After three days, the shootings were transferred to the experiment field at the new district farm at Sichuan Agricultural University. All shootings were pot planted. The pots were 25 cm in height and 24 cm in diameter, and were submerged in the ground (about 20 cm). The soil was obtained from Duoying, Ya'an City (Sichuan China), and basins were filled with 2/3 soil and about 1/3 duck manure, soil, and mixture fertilizer (fertilizer 15 kg/mu), and 5 pots for each treatment (5 repeats), two shootings in each pot. All other agronomic practices were kept normal and uniform for all the treatments. Tassel day, plant height, effective tiller number, panicles, 1000-grain weight, and grain yield were recorded in detail. Field experiments were conducted in 2004 to determine the effects of six planting dates on *Coix*'s growth and yield components, ranging from March to May.

*2.3 Statistical analysis*

The data were analyzed statistically using Excel, ANOVA, SSR, etc. The differences among treatment means were compared using least significant difference test at 5% or 1% probability level.

## 3. Results

*3.1 The effects of the different sowing dates on the development of Coix lacryma-jobi L.*

The same cultivar showed significant differences on tassel time. The tassel day of the six sowing dates also showed regular changes. It shows that earlier sowing dates have longer whole growth periods (Table 1). The longest tassel time from transplanting to tassel date was S1 (Mar. 10), with an average of 87.11 days (Table 2). The tassel time was about 60 days after S5 (May 9). The tassel time of S5 and S6 showed no significant difference.

We also found that longer exposure to daylight resulted in a shorter growth period (Table 2). This indicated that temperature has a great impact on the growth and development of *Coix*. With the delayed sowing date and increased temperature, its growth period became shorter. The high temperature and long daylight could shorten its growth period and accelerate growth. This shows that *Coix* is a high temperature plant: the later the sowing date, the higher the temperature, the shorter the growth period will be.

Analysis of variance showed that the tassel day of Shandong cultivar was significantly larger than other cultivars, while the differences between the tassel days of Nanjing and Ya'an was not significant (Table 2). The whole growth periods of Nanjing, Ya'an, and Shandong were 120-150, 123-150, and 123-156 days, respectively (Table 1).

*3.2 The effects of the different sowing dates on plant height of C. lacryma-jobi L.*

For the different sowing dates S1 to S5, plant height showed regular changes, but the differences among each sowing date were not observed. Sowing date S1 had shorter plant height, with an average of 118.44 cm. Sowing dates S2 to S6 had the plant height between 120-128 cm. The differences of plant height among the six sowing dates were not significant (Table 3). This indicated that there was no direct correlation between the plant height and sowing date.

*3.3 The effects of the different sowing dates on the leaf number of C. lacryma-jobi L.*

As illustrated in Fig.1, the leaf growth rate of sowing date S1 was the lowest;the leaf growth rates of sowing

Table 1 Effects of the different sowing dates on tassel time of *C. lacryma-jobi* L.

| Sowing Date | Sprouting Date (Year 2004) | Transplanting Date (Year 2004) | Temperature (℃) | Daylight (Hours) | Tassel Temperature (℃) | Tassel Daylight (Hours) | Tassel Date | | | Tassel Day | | | Whole Growth Period (Day) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Nanjing | Ya'an | Shandong | Nanjing | Ya'an | Shandong | Nanjing | Ya'an | Shandong |
| S1 | Mar. 7 | Mar. 10 | 15.02 | 12.04 | 20.60 | 13.85 | Jun. 1 | Jun. 5 | Jun. 11 | 83 | 87 | 93 | 150 | 150 | 156 |
| S2 | Mar. 22 | Mar. 25 | 16.08 | 12.46 | 21.66 | 13.89 | Jun. 6 | Jun. 7 | Jun. 15 | 73 | 74 | 82 | 137 | 147 | 151 |
| S3 | Apr. 6 | Apr. 9 | 18.91 | 12.78 | 22.84 | 13.93 | Jun. 14 | Jun. 16 | Jun. 28 | 66 | 68 | 80 | 125 | 137 | 150 |
| S4 | Apr. 21 | Apr. 24 | 19.79 | 13.12 | 25.15 | 13.93 | Jun. 25 | Jun. 26 | Jul. 8 | 62 | 63 | 75 | 128 | 130 | 137 |
| S5 | May 6 | May 9 | 21.41 | 13.49 | 25.18 | 13.73 | Jul. 2 | Jul. 7 | Jul. 22 | 57 | 59 | 74 | 123 | 128 | 133 |
| S6 | May 21 | May 24 | 21.53 | 13.76 | 25.47 | 13.64 | Jul. 20 | Jul. 23 | Jul. 29 | 56 | 58 | 66 | 120 | 123 | 123 |

Table 2 Effects of the different sowing dates on tassel time of *C. lacryma-jobi* L.

| Cultivars | Tassel Day (mean) | Sowing Date | Tassel Day (mean) |
|---|---|---|---|
| Nanjing | 66.06bB | S1 | 87.11aA |
| Ya'an | 68.56bB | S2 | 76.89bB |
| Shandong | 78.06aA | S3 | 72.11cBC |
| | | S4 | 66.44dCD |
| | | S5 | 63.44deDE |
| | | S6 | 59.33eE |

Table 3 Effects of the different sowing dates on plant height, leaf number, and effective tillers of *C. lacryma-jobi* L.

| Sowing Date | Plant Height (cm) | | | | Number of Leaf | | | | Effective Tillers | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Nanjing | Ya'an | Shandong | Mean Height | Nanjing | Ya'an | Shandong | No. of Leaf | Nanjing | Ya'an | Shandong | Mean Tillers |
| S1 | 107.35 | 124.30 | 123.00 | 118.44bA | 15.56 | 15.80 | 16.60 | 15.89aA | 4.22 | 3.10 | 3.80 | 3.67aAB |
| S2 | 121.20 | 111.86 | 117.44 | 119.11abA | 14.78 | 15.00 | 15.33 | 15.00abAB | 3.96 | 3.75 | 3.87 | 3.89aA |
| S3 | 112.78 | 131.30 | 130.33 | 122.89abA | 13.89 | 14.67 | 15.25 | 14.67abAB | 3.78 | 4.00 | 3.22 | 3.78aAB |
| S4 | 110.11 | 136.11 | 126.30 | 124.22abA | 13.67 | 14.33 | 14.90 | 14.27bB | 3.78 | 3.20 | 2.70 | 3.00bBC |
| S5 | 111.70 | 134.70 | 138.00 | 128.67aA | 13.88 | 14.70 | 15.30 | 14.67abAB | 3.44 | 1.90 | 2.70 | 2.67bcC |
| S6 | 106.44 | 142.11 | 126.44 | 126.22abA | 13.89 | 15.30 | 15.29 | 14.87abAB | 2.63 | 1.50 | 1.80 | 2.22cC |
| Mean Height, Mean Leaf Number, or Mean Effective Tillers | 115.67bB | 129.78aA | 124.33aAB | - | 14.00bA | 15.22aA | 15.27aA | - | 3.61aA | 2.89bB | 3.11bAB | - |

dates S2, S3, and S4 were similar; the leaf growth rates of sowing dates S5 and S6 were the highest. In March, the temperature was so low that the leaf growth rate of S1 was slower. In May, the temperature and ground temperature started to rise, and *Coix* was exposed to a sufficient amount of light, therefore, the vegetative growth was stronger. However, this may affect the late reproductive growth of *Coix*. The dynamics curves of the three cultivars indicated that the leaf growth rate presented same trend in different sowing dates. With the delayed sowing date, leaf growth rate could be accelerated.

As can be seen from Table 3, from sowing dates S1 to S4, the leaf number of the three cultivars exhibited regular changes: sowing date S1 had the largest leaf number with an average of 15.89, and S4 had the smallest leaf number with an average of 14.27. Analysis of variance showed that sowing dates S1 and S4 were significantly different from others. The results also showed an increasing trend in S5 and S6. Because light condition and high temperature in late sowing dates were good for the vegetative growth of the main stem, the leaf number of main stem actually increased.

For different cultivars, the leaf number of Nanjing cultivar was the smallest while the leaf number of Shandong and Ya'an cultivars was better. This may be caused by genetic factors and has nothing to do with the sowing period. Analysis of variance showed that Nanjing cultivar was significantly different when compared to the other cultivars, while the differences between Ya'an and Shandong were not significant.

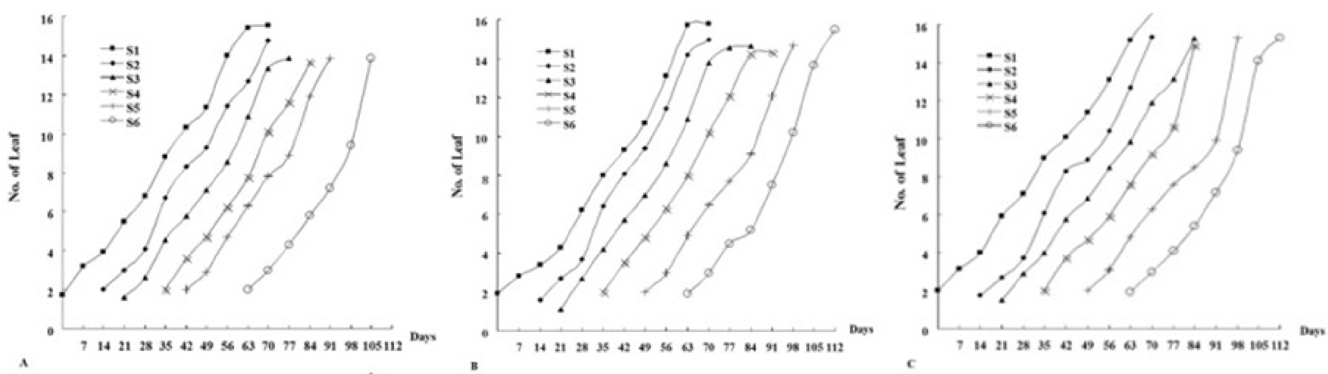


Fig.1 Effects of the different sowing dates on the leaf number of *C. lacryma-jobi* L. (A: The dynamic curve of Nanjing leaf number; B: The dynamic curve of Ya'an leaf number; C: The dynamic curve of Shandong leaf number.)

*3.4 The effects of the different sowing dates on the tiller number of C. lacryma-jobi L.*

As seen from Fig. 2, the former two periods (sowing dates S1 and S2) from initial tiller to tiller end (including ineffective tillers) lasted about 40 days, and the four later periods lasted about 30 days. The tiller number of each cultivar initially increased quickly, reached the maximum, and later degraded. The tiller growth rates of sowing dates S2 and S3 increased fast, after reaching the top, the death of the ineffective tillers quickened. Ground and air temperatures were beginning to increase in May; therefore, the late growth and tiller number accelerated, this is consistent with the leaf growth rate. The tiller number of S5 and S6 was significantly less than other four periods, which indicated that it was not conductive to the tiller after May, and it may be a reason for the lower production. The tiller number of Nanjing cultivar was the greatest among the three cultivars, which may contribute to the final yield. Based upon the results of the number of tillers, the suitable sowing date of Ya'an should be from late March to early April.

In comparison, Nanjing cultivar had the greatest effective tillers, Shandong cultivar was second, followed by Ya'an cultivar. Analysis of variance showed that the effective tillers of Nanjing cultivar were significantly higher than other cultivars, which also contributed to its high yield.

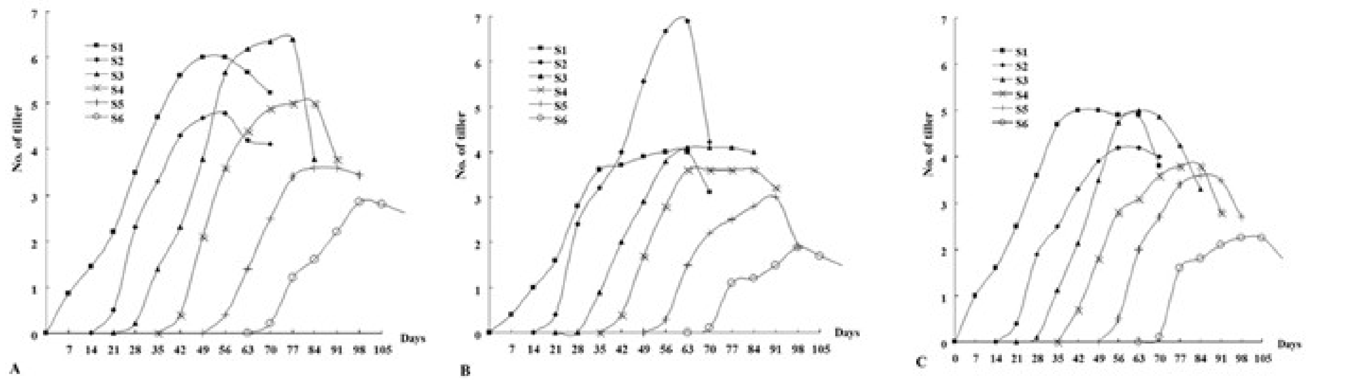


Fig. 2 Effects of the different sowing dates on tiller number of *C. lacryma-jobi* L. (A: The dynamic curve of Nanjing tiller number; B: The dynamic curve of Ya'an tiller number; C: The dynamic curve of Shandong tiller number.)

*3.5 The effects of the different sowing dates on the yield and yield character of C. lacryma-jobi L.*

*3.5.1 The effects of the different sowing dates on the effective panicle of C. lacryma-jobi L.*

The number of effective panicles of different areas, different cultivars, and different environmental conditions was quite different. Analysis of variance showed that there is a significant difference in sowing time and cultivars (Table 4). The effective panicles of sowing date S1 (16.23) and sowing date S2 (17.21) were significantly higher than that of sowing date S5 (11.80) and sowing date S6 (9.83). This indicated that late sowing date would reduce the effective panicle and decrease the yield. The differences of effective panicles between the cultivars were also very remarkable and Nanjing cultivar was significantly higher (15.98) than other cultivars.

*3.5.2 The effects of the different sowing dates on the grains per panicle of C. lacryma-jobi L.*

Variance analysis results of grains per panicle showed that differences among the sowing time reached the significant level. Sowing dates S1, S2, and S3 had higher grains, and sowing date S4 had the smallest amount of grains (Table 4). This could be caused by the higher temperature, lower humidity, and damaged leaves, which ultimately affected the grain filling. Meanwhile, this also indicated that water demand was a critical factor for *Coix* grouting. Water shortage resulted in a substantial reduction in yield. The difference between the cultivars is not significant, but the average of Nanjing cultivar is slightly higher than that of other cultivars.

*3.5.3 The effects of the different sowing dates on 1000-grain weight of C. lacryma-jobi L.*

1000-grain weight among different sowing dates and cultivars all reached significant levels. 1000-grain weight of sowing date S3 was significantly higher than those of other periods (Table 4). This indicated that even though the grains per panicle of S3 were not the highest, all the grains were relatively filled once the grouting was completed. According to 1000-grain weight, this also showed the best sowing period of *Coix* in Ya'an should be from late March to early April. Among the different cultivars, 1000-grain weight of Shandong cultivar was significantly higher than other cultivars, which indicated that genetic characteristics not the sowing time could play an important role in the yield.

*3.5.4 The effects of the different sowing dates on grain setting rate of C. lacryma-jobi L.*

As seen from Table 4, for different sowing dates and cultivars, the grain setting rate all reached significant levels. The grain setting rates of sowing dates S1, S2, and S3 were significantly higher than those of sowing dates S4, S5, and S6. The grain setting rates of sowing dates S4 and S5 were lower, which may be caused by heat injury. All three cultivars suffered the same natural disasters. The grain setting rate of Shandong cultivar was significantly higher than other cultivars, and this showed that Shandong cultivar had stronger resistance to natural damages than other cultivars.

*3.5.5 The effects of the sowing dates on the yield of C. lacryma-jobi L.*

Seen from analysis of variance in Table 4, both different sowing dates and cultivars showed significant differences in yield. Sowing date S1 had the highest yield, which could be caused by earlier planting and the finished seed-filling period when faced the occurrence of natural disasters or diseases. The yield of sowing date S4 was even lower than those of sowing dates S5 and S6, which further demonstrated that the yield of *Coix* production was not only influenced by the genetic factors, but also affected by environmental factors.

*3.5.6 The effects of different sowing dates on the yield characters of C. lacryma-jobi L.*

Analysis of different sowing dates showed that sowing date S3 had higher 1000 grain-weight on either the main stem or spike than other periods. The differences among other periods were not significant. 1000-grain weight of sowing date S4 was the lowest. Theoretically, sowing date S4 should not be the lowest, and this could be a result of high temperature and some unfilled grouting. Surprisingly, the grain number of main stem of sowing dates S1 and S2 was significantly higher than those of other sowing dates, while the differences among others were not significant. The grain number of spike of sowing dates S2 and S3 significantly increased. Therefore, from the overall analysis, it indicates that the grain number of sowing date S2 is the best period for sowing.

## 4. Discussions

*4.1 The effects of the different sowing dates on the growth and development of C. lacryma-jobi L.*

Both long-day and short-day plants have their own suitable planting time. The planting time can have different impact on the development of crops [10-12]. Based on analysis from tassel day, plant height, leaf number, and effective tillers, sowing date S2 shows the best quality, S1 also is a good choice, and qualities of sowing dates S3, S4, S5, and S6 were decreased sequentially. Our results could be greatly related to the climate conditions of Ya'an city. In early March, the temperature was low and ground temperature did not rise up. Therefore, the plants grew slowly. After May, temperature drastically increased and the growth and development of plants were increased. With the delayed sowing, the differences became obvious in effective panicles. The tiller numbers of sowing dates S5 and S6 were significantly reduced. Some plants had no tillers, with an average tiller number of 1-2. Overall, the tiller numbers of sowing dates S2 and S3 were higher than other periods. The tiller number of Nanjing cultivar was highest, which may be related to the genetic factors.

The effects of different sowing dates on final leaf number and plant height were not obvious. With the different sowing dates, the growth period of *Coix* was shortened and the time from sowing to flowering also truncated. It could be associated with local temperature. With increased temperature, the plants grow faster and growth period becomes shorter. This is similar to the results of Yu [14] on Mexican corn. His studies showed that the sooner the sowing date was, the longer the growth period was.

*4.2 The effects of the different sowing dates on the yield and yield character of C. lacryma-jobi L.*

Sowing date is also extremely important to the yield. Different sowing dates will produce the significantly different yield. Farmers have a saying "Time and tide wait for no man." If farmers missed the best planting season, it would result in reduction or no yield. Analysis from yield components, 1000-grain weight of S3 was the highest; the effective panicles of S2 and S3 were more higher than those of other sowing dates; the spike grain number of S1 and S2 was higher than those of other periods. The final yield of S1was the highest. This could be caused by several reasons: the temperature of Ya’an city was too high in May, sowing dates of S2 and S3 suffered heat damage, high temperature led to reduction in humidity, air was drought, plants underwent water shortage, many leaves were burned, parts of the stems were affected by sunburn.

*Coix*, a high-temperature and short-day plant, theoretically should be planted at the end of March or early April in Ya’an city to obtain the highest yield. It means that the yield of sowing dates S2 and S3 should be higher. However, the temperature was higher from late June to early July in Ya'an city, potted planting had a weak water retention capacity, the air humidity was low; therefore, the grouting of sowing dates S2 and S3 and the demanding water of *Coix* could not be fulfilled, which resulted in lower yield. But the overall yield of sowing date S2 was still relatively higher, and this revealed that late March should be more appropriate for transplanting *Coix* in Ya'an.

## 5. Conclusions

As can be seen from the above analysis, different planting time had an impact on 1000-grain weight, grain number, and effective panicles. The yield of *Coix* is not determined by one single factor but by the product of three factors: 1000-grain weight, grain number, and effective panicles. In total, effective tillers of S2 and S3 were more higher than other periods, 1000-grain weight and grain number of S2 and S3 on main stem and spike were also significantly higher than other periods. Therefore, the sowing date of *Coix* in Ya'an should be from late March to early April, which is consistent with the analysis of tassel time, effective tillers, effective panicles, and grain number.

## References


[1] Taylor GD. Some crop distributions by tribes in upland Southeast Asia. Southwestern Journal of Anthropology 1953, 9 (3).

[2] Marco K, Wunwisa, Krasaekoopt. The use of job's tear (*Coix Lacryma-jobi* L.) flour to substitute cake flour in butter cake. AU JT, 2012, 15 (4):233-238.

[3] Lu Y, Zhang BY, Jia ZX, et al. Hepatocellular carcinoma HepG2 cell apoptosis and caspase-8 and Bcl-2 expression induced by injectable seed extract of *Coix lacryma-jobi*. Hepatobiliary Pancreat Dis Int, 2011, 10 (3):303-307.

[4] Seo WG, Pae HO, Chai KY, et al. Inhibitory effects of methanol extract of seeds of Job's Tears (Coix lachryma-jobi L. var. ma-yuen) on nitric oxide and superoxide production in RAW 264.7 macrophages. Immunopharmacol Immunotoxicol, 2000, 22 (3):545-554.

[5] Kondo Y, Nakajima K, Nozoe S, et al. Isolation of ovulatory-active substances from crops of Job's tears (*Coix lacryma-jobi* L. var. ma-yuen STAPF.). Chem Pharm Bull (Tokyo), 1988, 36 (8):3147-3152.

[6] Bao Y, Yuan Y, Xia L, et al. Neutral lipid isolated from endosperm of Job's tears inhibits the growth of pancreatic cancer cells via apoptosis, G2/M arrest, and regulation of gene expression. J Gastroenterol Hepatol, 2005, 20 (7):1046-1053.

[7] Ary MB, Richardson M, Shewry PR. Purification and characterization of an insect alpha-amylase inhibitor/endochitinase from seeds of Job's Tears (Coix lachryma-jobi). Biochimica et biophysica acta, 1989, 999 (3):260-266.

[8] Sun H, Shao, L., Chen, S., Wang, Y., Zhang, X. Effects of sowing time and rate on crop growth and radiation use efficiency of winter wheat in the North China Plain. International Journal of Plant Production, 2013, 7 (1):117-138.

[9] Chamarthy VR, Sivauri, Ravi Kumar, Bathula, Swaroop Vijay Kumar, Dasari, Gopapla krishana, Jagannath, Vishnu Patil. Effect of time of Planting on Cane yield and quality characters in sweet Sorghum. Journal of Sustainalbe Bioenergy Systems, 2012, 2 (1):1-9.

[10] Zhang SJ, Li L, Zhang CL. Effects of sowing date and planting density on the seed yield and oil content of winter oilseed rape. Ying Yong Sheng Tai Xue Bao, 2012, 23 (5):1326-1332.

[11] Chen Y, Yan X, Guo Q, et al. Effects of sowing date on morphologic characteristics, yield and quality of Radix isatidis. Zhongguo Zhong Yao Za Zhi, 2009, 34 (21):2709-2712.

[12] El-Gengaihi S, Abdallah N. The effect of date of sowing and plant spacing on yield of seed and volatile oil of fennel (Foeniculum vulgare Mill.). Pharmazie, 1978, 33 (9):605-606.

[13] Olesen JE, Borgesen CD, Elsgaard L, et al. Changes in time of sowing, flowering and maturity of cereals in Europe under climate change. Food Addit Contam Part A Chem Anal Control Expo Risk Assess, 2012, 29 (10):1527-1542.

[14] Yu Y. Preliminary study of the photoperiod characteristics of Mexican corn. Hubei Agricultural Sciences, 1989, (6):12-14.