

**BREEDING OF A NEW COMMON BEAN (*PHASEOLUS VULGARIS* L.)
VARIETY: LONGYUNDOU 10**

**XIANXIN MENG, SHUHONG WEI¹, QIANG WANG¹, YIFAN GUO¹, ZHENGONG YIN¹,
GUANGDONG YANG², WEI ZHANG³ AND MING LI***

*College of Agriculture, Northeast Agricultural University, Harbin 150030,
People's Republic of China*

Keywords: Small black common bean, Variety, Crossbreeding, Longyundou 10, Yield

Abstract

The hybrid 'Longyundou 10' was bred by combining the Australian variety F2153 as the female and the Guizhou cultivar F1870 as the male parent. Longyundou 10 is a new, erect, medium mature, small, black variety of the common bean (*Phaseolus vulgaris*) which is the result of six years of crossbreeding. Its growth period ranges from 95 to 103 days after planting, depending on the season and location. It requires 1945°C of active accumulated temperature, with a daily temperature $\geq 10^{\circ}\text{C}$. It has a finite pod setting, compact plant type, an average yield is 2555.6 kg/hm² and is resistant to lodging.

Introduction

The common bean, *Phaseolus vulgaris* L., belonging to the Leguminosae is one of the major edible legumes. It has high nourishment value, a large cultivation area, and accounts for 50% of the global consumption of legumes. As a very important source of plant protein, it has played a significant role in addressing nutritional deficiencies in poverty-stricken areas, and it is also good for regulating the dietary structure in developed regions (Zong 2002). In recent years, with the improvement of living standards and the adjustment of the dietary structure, market demand for beans has been increasing.

China is a large producer and exporter of the common bean. Common beans are widely distributed in China, and they are mainly grown in the cold and cool regions of China, such as the northeast, north, northwest, and southwest. At present, the provinces which have large scale common bean production are: Heilongjiang, Inner Mongolia, Hebei, Shanxi, Xinjiang, Yunnan, and Sichuan.

In China, three main methods of breeding varieties of the common bean are used. The first method is to collect and select well-known varieties in China, which are also consumed in other parts of the world, such as red kidney beans, cranberry beans, navy beans, and pinto beans, and then purify, rejuvenate, and use them directly in production. The second method is to import new varieties to China. Since the climatic conditions of common bean production around the world are basically similar, generally, foreign varieties can be successfully grown in China. The common bean varieties which are suitable for cultivation in China can be identified and screened through testing in suitable areas. The third way is by crossbreeding; however, in China, breeding programs for the common bean have fallen rather far behind, especially in the area of crossbreeding. There are only a few scientific research units that this type of breeding research perform and carry out improvement work on varieties.

*Author for correspondence: <liming@neau.edu.cn>. ¹Crop Breeding Institute, Heilongjiang Academy of Agricultural Sciences, Harbin 150086, People's Republic of China. ²Keshan branch, Heilongjiang Academy of Agricultural Sciences, Keshan 161600, People's Republic of China. ³Virus-free Seedling Research Institute, Heilongjiang Academy of Agricultural Sciences, Harbin 150086, People's Republic of China.

In Heilongjiang Province, the small black common bean is the main variety of exported bean (Feng *et al.* 2005). At present, the varieties of the small black common beans planted in production are simple, have mixed and severe degradation, low yield, serious diseases, and poor product quality. Therefore, it is difficult to meet the standards of the international market, which has led to difficulty in selling the beans (Meng *et al.* 2016). Therefore, the development of new varieties of the small black common bean is urgently needed. Thus in the present study the Australian variety F2153 used as the female parent and the Guizhou variety F1870 was used as the male parent were hybridized, and the new small black common bean 'Longyundou 10' was bred over six years from 2007 to 2012.

Materials and Methods

The breeding goal was to obtain a new, small black variety of the common bean that has early or medium maturity and is of high quality, erect, and suitable for spring, open-field planting in the northern part of Heilongjiang Province. Australian cultivar F2153, a late-maturing, short, erect, commercial common bean cultivar with a determinate growth habit, and the Guizhou cultivar F1870 an early maturity, commercial common bean cultivar with a half-vine indeterminate growth habit were crossed. The experiment was carried out in 2000 with systematic breeding to offspring. The F₁ were grown in the experimental field of the Heilongjiang Academy of Agricultural Sciences. A single F₂ plant was selected based on agronomic and seed traits. The F₃ was planted in the same field, and a single-plant was selected. A single-plant selection was made in F₄ - F₅, selected on the basis of agronomic and seed traits. The single row that showed uniform growth and included the objective traits was selected in the F₆ nursery. Six generations were completed over six years. The new strain, called 'Long 24 - 0511,' was selected in 2006 based on the breeding goal (Fig. 1). The yield identification trials were carried out from 2007 to 2008, and the variety comparison trials were carried out from 2009 to 2010. The regional trials were performed in Heilongjiang Province from 2011 to 2012, and a large area production trial was carried out in 2013 in Heilongjiang Province. The trial for quality and resistant identification was carried out from 2012 to 2013.

Results and Discussion

The yield trial was carried out from 2007 to 2008 in the experimental field of the Heilongjiang Academy of Agricultural Sciences. The control variety was Longyundou 3, and an open field planting design was used. The plot area was 10.05 m² with a randomized arrangement of three rows; each row was 5 m long, with a row spacing of 0.67 m and a plant spacing of 0.20 m.

The results of the yield trial showed an average yield of Longyundou 10 over the two years of 2946.3 kg/ha². The yield was 26.8% higher than that of the control Longyundou 3 (2323.6 kg/ha²).

The variety comparison trial was carried out from 2009 to 2010 in the experimental field of the Heilongjiang Academy of Agricultural Sciences. The control variety was Longyundou 3, an open field planting design was used, and 150 varieties were planted in the trial. Plot area was 10.05 m² with a randomized design and three rows; each row was 5 m long, with a row spacing of 0.67 m and a plant spacing of 0.20 m.

The results of the variety comparison trial showed that the average yield of Longyundou 10 was 3024.6 kg/ha², which was an increase in yield of 25.4% over that of the control Longyundou 3 (2412.0 kg/ha²).

The regional trials were carried out from 2011 to 2012 in five areas of Heilongjiang Province, namely, Harbin, Baoqing, Yinlonghe, Jianshanjiang state farm, and Keshan. Six varieties were grown in each area, and the control variety was Longyundou 3. The trial was randomized and had three replications. Plot area was 10.05 m² with three rows. Each row was 5-m long, with a row

spacing of 0.67 m and a plant spacing of 0.20 m. The planting density of the plot area was 156. The results of the regional trials showed that the average yield of Longyundou 10 was 2599.0 kg/ha², which increased in each of the five areas over the two years. The yield increase was 20.1% over that of the control Longyundou 3 (2164.0 kg/ha²). The yield of Longyundou 10 was ranked first in comparison with other varieties (Table 1).

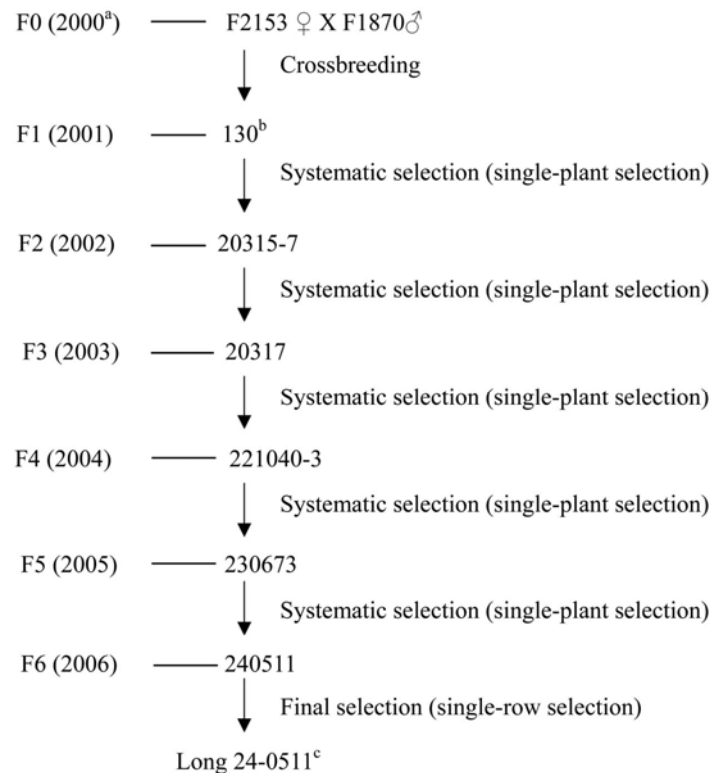


Fig. 1. The breeding process.

^a breeding year; ^b field planting number of each generation; ^c the number of final selection.

The large area production trials were carried out in 2013 in five experiment areas of Heilongjiang Province. Four varieties were planted in each area, and the control variety was Longyundou 3. The trial was randomized. The planting area of each variety was approximately 333.3 m², and the planting density of the plot area was 5000.

The results of the production trials showed that the average yield of Longyundou 10 was 2555.6 kg/ha², which increased in each of the five areas. The yield increase was 21.8% over that of the control (2098.2 kg/ha²) (Table 2).

The quality analysis was carried out from 2012 to 2013 by the Grain Quality Testing Center of the Ministry of Agriculture in Harbin. The crude protein content ranged from 22.50 to 24.38%, the crude fat content ranged from 1.04 to 1.86%, and the crude starch content ranged from 40.37 to 40.60%. The quality requirements for Heilongjiang common bean varieties were achieved.

The disease resistant individuals were selected from the F₄ grown in the field of Plant Protection Institute of Heilongjiang Academy of Agricultural Sciences in 2013. No anthrax, blight, root rot, or leaf spot were found during the growth of Longyundou 10, which shows that the variety has strong disease resistance.

Table 1. The results of the regional trials.

Year	Trial region	Yield of Longyundou 10 (kg/hm ²)	Yield of Longyundou 3, the control (kg/hm ²)	Yield increase (%)
2011	Harbin, Heilongjiang	3023.8	2356.8	28.3
2011	Baoqing, Heilongjiang	1774.4	1487.3	19.3
2011	Yinlonghe state farm, Heilongjiang	2769.6	2184.2	26.8
2011	Jianshanjiang state farm, Heilongjiang	2957.1	2356.3	25.5
2011	Keshan, Heilongjiang	3211.7	2542.9	26.3
Average of 2011	5 regions	2747.3	2194.3	25.2
2012	Harbin, Heilongjiang	2694.9	2133.7	26.3
2012	Baoqing, Heilongjiang	2359.0	2129.1	10.8
2012	Yinlonghe state farm, Heilongjiang	2110.3	1955.8	7.9
2012	Jianshanjiang state farm, Heilongjiang	2942.9	2428.1	21.2
2012	Keshan, Heilongjiang	2146.7	1985.8	8.1
Average of 2012	5 regions	2450.8	2133.0	14.9
Average of 2011 and 2012	10 regions	2599.0	2164.0	20.1

Table 2. The results of the production trials.

Trial region	Yield of Longyundou 10 (kg/hm ²)	Yield of Longyundou 3, the control (kg/hm ²)	Yield increase (%)
Harbin, Heilongjiang	2520.5	2090.0	20.6
Baoqing, Heilongjiang	2966.0	2357.7	25.8
Yinlonghe state farm, Heilongjiang	2640.0	2404.4	9.8
Jianshanjiang state farm, Heilongjiang	2130.0	1709.5	24.6
Keshan, Heilongjiang	2521.6	1966.9	28.2
5 regions	2555.6	2098.2	21.8

The identification of agronomic and grain characteristics of Longyundou 10 in the five experimental regions of Heilongjiang Province show that it is an erect and medium maturity variety. Its growth period ranges from 95 to 103 days after planting, depending on the season and location. It requires 1945°C of active accumulated temperature, and the daily temperature should be ≥10°C. It has a finite pod setting, a compact plant type, and is resistant to lodging. The average plant height is 51.7 cm, the young stem is purple, there are 3 to 4 branches on the main stem and 8 to 11 main

stem nodes, the leaves are heart-shaped, and the flowers are purple. On a single plant, there are approximately 25 to 30 pods, which have a round stick-like shape. The mature pod shell is yellowish-white, there are 5 to 6 seeds in a single pod, the seed is oval, and the seed coat is black. The 100-seed weight ranges from 18 to 22 g. The average yield is 2555.6 kg/hm². The variety has strong disease resistance to anthrax, blight, and other diseases. It is also very marketable and suitable for cultivating in open fields in the northern part of Heilongjiang Province (Figs 2-4).



Figs 2-4: 2. Pods, 3 Seeds and 4. Plant.

The cultivar passed the certification of the Heilongjiang Province Coarse Cereals Committee in 2014 and was given the name Longyundou 10 (Reg. no. HLJ 2014017). At present, it has been grown in different regions, such as Nenjiang, Nehe, Yi'an, Keshan, Baiquan, and Mingshui in Heilongjiang Province; the cumulative growth area of Longyundou 10 has reached 5413 hm².

The breeding process of Longyundou 10 was six years long and reached the target characteristics of both the male and female parent. The multiple yield trials were carried out over seven years in five regions of Heilongjiang Province, after which Longyundou 10 was widely popularized in Heilongjiang as a commercial variety, and the beans sold well all over the world, especially in Europe and the Middle East.

Acknowledgements

This work was supported by the China Agriculture Research System (CARS-08-G05) and the National Infrastructure for Crop Germplasm Resources (NICGR2018-024).

References

- Feng BL, Yu H and Gao XL 2005. Study on brand agriculture of kidney bean in China. *Chinese Agricultural Science Bulletin* **21**(6): 454-457.
- Meng XX, Wang Q, Wei SH, Yang GD and Zhang W 2016. The breeding and cultivation technique of new common bean variety 'Longyundou 9'. *Heilongjiang Agricultural Sciences* **7**: 159.
- Zong XX 2002. High yield cultivation and food processing of food legumes. China Agricultural Science and Technology Press. pp. 227-249.

(Manuscript received on 4 July, 2018; revised on 28 July, 2018)