Effects of Different Sowing Dates on Growth and Yield of Proso Millet (*Panicum miliaceum* L.) in Baicheng

Han Guo-jun[1], Han Yue-ming[2], Xie Zhi-ming[1,*]

[1]School of Life Sciences, Baicheng Normal College, Baicheng, Jilin,137000

[2] San Chazi Forestry Bureau in Jilin Province, Baishan, Jilin, 134702

*Corresponding author

Keywords: Proso Millet; Sowing Date; Characteristics; Growth Period

Abstract: Sowing dates can affect the morphological and agronomic characteristics, yield of proso millet (*Panicum miliaceum* L.) greatly. Treatments of B1 with the sowing date of May 8, B2 with the sowing date of May 18, B3 with the sowing date of May 28, B4 with the sowing date of June 7, B5 with the sowing date of June 17 were designed as different sowing dates for proso millet, Ningmi-15. The different growth periods, morpholofical and agronomic characteristics, yield-related traits and yield of Ningmi-15 were studied under the treatments of the 5 sowing dates. Results showed that sowing dates can significantly affect the indexes of growth, development and yield greatly. The yield of proso millet planted at May 18 was the highest one of the 5 sowing date treatments, which was 5232.33 kg/hm^2. The proper sowing dates were from May 18 to May 28 for proso millet in Baicheng.

1. Introduction

Proso millet (*Panicum miliaceum* L.) is one of the most important cultivating crops of with a long history, there was proso millet under the condition of artificial cultivation 7700-8000 years ago according to archeological study. It was recorded by local chronicles of West Xia, Ming and Qing Dynasty, when there were many types of proso millet with different seed colors of white, red, yellow and black. Proso millet can survive in dry area and it has the characteristics of drought resistance, wide adaptability, barren tolerance and a short growth period about 90-105 days[1]. The grains of proso millet is nutritious and have medicinal values, and can be developed into health food for people with the problems of obesity, diabetes and cardiovascular disease. There are plenty of proteins, fat, reducing carbohydrates, syrup and maltose,vitamins, and 8 types of essential amino acids in the grain. Proso millet can be processed into various kinds of products, such as maltose and Chinese liquor. Proso millet is good material which can be used in wine brewing for a long history. It is recorded in some ancient books, for example, “Proso millet can be used to make alcohol,”

  DOI: 10.25236/isafb.2019.049

during the Spring and Autumn Period. The “Golden Proso Millet Wine” of Ningxia is brewed by proso millet, which has pure and mild flavor and has been one of special local products of Guyuan and Ningxia.

The correlations of proso millet sowing date, varieties and ecological environment are significant[2]. Proso millet can make good use of the environmental factors of temperature, light and water, which provides proper growing conditions to proso millet to grow and develop well, and get high yield by utilizing the limited hydrothermal resources of local climate. Research has shown that sowing date can affect the growth, development and yield greatly[3]. It was report that the yield of proso millet decreased with the postponing of sowing date[4]. The needing time of reproductive growth can be satisfied by means of early sowing dates, which can effectively promote the quality of flowering and yield of proso millet. The values of the plant length, stem diameter, leaf area per plant, the effective tillers per plant, main ear length, weight of ear and grain yield of proso millet had a reducing trend with the putting off of sowing dates[2]. Sowing dates are affected by the regional and climatic environment of different geographic area, similar study about sowing dates of proso millet is rare in Baiching, it is very important to study the optimal sowing dates of proso millet to ensuring the quality and quantity of proso millet in Baicheng.

The aims of this study are that for one thing, by using the variety of Ningmi-15 introduced from Guyuan District of Ningxia Hui Autonomous Region is aimed to solving the problems that restrict the production of proso millet in Baicheng, for example, intermixing, low yield, low-quality and low-benefit of local varieties; for another, sowing dates is studied to find the proper sowing methods and time to improve the quality of agronomic characteristics and yield of proso millet in Bacheng, Jilin Province.

2. Materials and Methods

2.1 Experimental Site and Soil Condition.

During May to October, 2018, field experiments were conducted at the Teaching and Research Farm of the Baicheng Normal University, the location information is that Latitude is 44°13′55″-46°18′ N, longitude is 121°38′-124°22′ E, and altitude is 130-600 m above sea level in the western Jilin Province, which is characterized by a temperate continental monsoon climate, under which there is big temperature difference between day and night, the mean annual sunshine duration is 2919.4 h, the accumulated temperature above 10 ℃ is 2933.4 ℃, annual average air temperature is 4.9 ℃, the frost-free period is 157 d, annual precipitation is about 400 mm. The

climatic characteristics of Baicheng are long and chilling winter, for which the local farming system is a year one ripe for crops under such climate, arid early spring, hot summer, cool and little rain autumn, simultaneous heat and moisture.

The basic properties of 0-20 cm deep soil , which is Light chernozem soil, of which it contains organic matter 20.2 $g \cdot kg^{-1}$, available nitrogen 130.6 mg. kg^{-1}, available phosphorus 12.66 $mg \cdot kg^{-1}$, available potassium 132.39 $mg \cdot kg^{-1}$, pH value is about 7.8.

2.2 Experimental Design.

The field experiment was designed in randomized complete block design, 3 replications in a 4 × 5 m^2 net plot size. Proso millet variety, Ningmi-15 was used as the studying cultivar, the density of proso millet was 65 000 plants· hm^{-2}. Chemical fertilizers were applied together with the organic fertilizer of farmyard manure, under the condition of appropriate scale of soil moisture, at the doses of nitrogen (N) 200 kg· hm^{-2}, phosphorus (P_2O_5) 100 kg· hm^{-2} and potassium (K_2O) 80 kg· hm^{-2}, respectively. Treatments were 5 sowing dates of proso millets: B1 with the sowing date of May 8, B2 with the sowing date of May 18, B3 with the sowing date of May 28, B4 with the sowing date of June 7, B5 with the sowing date of June 17. The sowing methods, management and weed control were operated uniformly during all the growing stages of the 5 treatments in the field.

2.3 Indexes to Determine

The characteristics of growth, development, agronomy and yield of proso millet being treated under different sowing dates were measured and determined by selecting 10 plants of Ningmi-15 randomly in each plot. These parameters were growth period, number of stem nodes, tillers per plant, stem diameter, ear length, plant height, grain weight per ear, 1000-grain weight, yield of each plot and the total yield

2.4 Statistical Analysis

All the data were analyzed by means of SPSS Version 17.0 for Windows, with one-way analysis of variance procedures. The differences among treatments were compared at 0.05 significance level by Duncan’s test .

3. Results

3.1 The Procedures of Growth Periods of Proso Millet under Different Sowing Dates

According to the data of Table 1, the earliest sowing date was B1, which was conducted at May, 8, 2018, the total growing days was 120 days during growth period of proso millet, Ningmi-15; the

latest sowing date was B5, which was planted at June, 17, 2018, the growing days was 86 days, during which the proso millet, Ningmi-15 grew from emergence date to mature date. The differences between the B1, May, 8 and B5, June, 17, were 40 days, with the delay of sowing dates, the growing days shortened significantly in this experiment, which were 120 days of B1 and 82 days of B5. Studies show that the vegetative growth stage is shortened significantly by the late sowing date, with the putting of of sowing dates, the values of air temperature, soil temperature and precipitation increase remarkably[5].

Table 1 The growth period of proso millet under different sowing dates

Treatments	Sowing date	Emergence date	Jointing date	Heading date	Mature date	Ripening date	Days planting to maturity
B1	8 May	21 May	28 Jun.	6 Aug.	18 Sep.	21 Sep.	120
B2	18 May	28 May	2 Jul.	3 Aug.	16 Sep.	19 Sep.	113
B3	28 May	7 Jun.	10 Jul.	12 Aug.	16 Sep.	19 Sep.	103
B4	7 Jun.	16 Jun.	19. Jul	15 Aug.	19 Sep.	22 Sep.	93
B5	17 Jun.	26 Jun.	25 Jul.	20 Aug.	20 Sep.	23 Sep.	86

3.2 The Interval days of Growth Periods of Different Sowing Dates

Table 2 The interval days of growth periods by sowing dates

Treatments	Sowing date	Interval days from sowing to seedling emergence	Interval days from seedling emergence to Jointing	Interval days from Jointing to heading
B1	8 May	13 days	38 days	38 days
B2	18 May	10 days	36 days	32 days
B3	28 May	10 days	33 days	31 days
B4	7 Jun.	9 days	31 days	27 days
B5	17 Jun.	9 days	29 days	26 days

According to Table 2, the longest interval days from sowing to seedling emergence was B1, the second one was B2; the shortest interval days was B3; the interval days of B4 and B5 was same, which was 9 days. All the interval days in each stage of B1, sowing date at May, 8, were longer than those of the rest ones, B2, B3, B4 and B5. The interval days of each stage by B5 at June, 17, were the shortest one of the 5 sowing dates, of which the interval days from sowing to seedling emergence was 9 days, the interval days from seedling emergence to jointing was 29

days and the interval days from jointing to heading was 26 days. Results in this field research showed that the seedlings of proso millet came out evenly, which were planted before May, 28, and the seedlings grew well; the plant of proso millet matured late under the treatment of B5, sowing date at June, 17.

3.3 The Morphological and Agronomic Characteristics of Proso Millet

According to the results of comparing morphological and agronomic characteristics of the 5 sowing dates treatments on Ningmi-15 in 2018 (Table 3), with the delay of sowing dates, there was downtrend in the values of plant height, stem diameter, main ear length, the number of stem nodes and the tillers per plant. The values of plant height from higher to lower were the treatments of B1, B2, B3, B4 and B5, there was no remarkably difference among B1, B2, B3 ($p<0.05$); there was no significant difference between B4 and B5 ($p<0.05$); the values of the plant height under the treatments of the former 3 sowing dates were obviously higher than those of the latter ones. The values of stem diameter ordered high to low were of B1, B3, B2, B4 and B5; the stem diameter values of B1, B2 and B3 were significantly higher than those of B4 and B5 ($p<0.05$). The values of ear length from high to low were of B2, B3, B1, B4 and B5; the values of under the treatments of B1, B2 and B3 were significantly higher than those of the rest 2 treatments ($p<0.05$). The values of number of stem nodes from high to low were of B3, B2, B1, B5 and B4; the values of B1, B2 and B3 were significantly higher than those of B4 and B5 ($p<0.05$). The values of tillers per plant from high to low were of B2, B3, B1, B5 and B4; there was no remarkable difference of the values under the treatments of B1, B2 and B3; there were no significant difference between the treatments of B4 and B5 ($p<0.05$).

Table 3 The characteristics of proso millet under different sowing dates

Treatments	Plant height (cm)	Stem diameter (mm)	Main ear length (cm)	Number of stem nodes	Tillers per plant
B1	160.25±1.21a	9.12±0.51a	40.76±1.33a	8.81±0.43a	2.10±0.14a
B2	156.49±3.65ab	8.62±0.55a	41.73±2.42a	8.95±0.46a	2.42±0.12a
B3	153.20±2.36b	8.78±0.67a	40.92±3.41a	9.10±0.52a	2.28±0.25a
B4	141.61±1.48c	7.65±0.54b	36.83±2.57b	7.23±0.63b	1.21±0.33b
B5	132.16±4.27d	6.33±0.46c	30.35±2.77c	7.36±0.33b	1.30±0.28b

Means (±SD) labeled with different letters within each column are significantly different ($P < 0.05$) by Duncan's test, n = 10.

3.4 Yield and Yield-related Characteristics under Different Sowing Dates

According to table 4, the values of weight of ear from high to low were of B3, B2, B1, B4 and B5; the values of weight of ear under the treatment of B3 was significantly higher than those of other 4 treatments ($p<0.05$); the value under the treatment of B5 was significantly lower than those of others ($p<0.05$). There was no significant difference among the values of 1000-grain weight under the treatments of B1, B2, B3, B4 and B5 ($p<0.05$), which means the index of 1000-grain weight was affected much by variety not by the treatments of sowing dates. The values of yield per plot from high to low were of B3, B2, B1, B4 and B5; the values under the treatments of B2 and B3 were significantly higher than those of the rest ones ($p<0.05$); the values of B1 treatments was remarkably higher than those of the treatments under B4 and B5, of which there was no significant difference ($p<0.05$). The values of yield from high to low were of B2, B3, B1, B5 and B4; the values of yield under the treatment of B2 and B3 were significantly higher than that of B1, which was significantly higher than those of B4 and B5, of which there was no remarkable difference between the yields ($p<0.05$).

Table 4 Yield and yield-related characteristics under different sowing dates

Treatments	Weight of ear (g)	1000-grain weight (g)	Yield per plot ($kg/20m^2$)	Yield (kg/hm^2)
B1	15.56±2.25b	7.52±.035a	96.47±8.61b	4856.43±12.34b
B2	15.69±1.12b	7.65±0.16a	108.73±7.63a	5232.33±20.81a
B3	17.66±1.63a	7.85±0.31a	112.62±5.16a	5186.17±23.53a
B4	9.16±0.40c	7.43±0.24a	82.33±6.60c	3225.26±21.35c
B5	7.36±0.65d	7.56±0.18a	79.50±6.82c	3189.78±20.00c

Means (±SD) labeled with different letters within each column are significantly different ($P < 0.05$) by Duncan's test, $n = 10$.

4 Conclusions and Discussion

According to the results of the research, sowing dates can significantly affect the emergence quality, interval days of growth periods, morphological and agronomic characteristics and yield. Sowing dates affect the agronomic traits greatly. Late sowing dates play an important role in shortening the growth period, which cause the limited light for proso millet growth, and proso millet can't mature because of the limited light and decrease the yield[5]. Research showed that

there is a positive correlation between proso millet physiological stages[6] and the environmental factors of daily mean temperature[7], effective accumulated temperature[8], and duration of sunshine[9][10]. When the proso millet was sowed early, the temperature was low, the nutrient absorption rate was low, the seedlings were strong, the days from planting to maturity can be lengthened greatly, and the mature dates put off. The yield under treatment of May 18 was the highest one among the 5 sowing date treatments, which was 5232.33 kg/hm^2, the yield under treatment of May 28 was the second highest one, which means that the optimal sowing dates were during May 18 to May 28 for proso millet in Baicheng. The yield under treatments of June 17 was the lowest, the yield of proso millet was 3189.78 kg/hm^2, which significantly lower than those of the rest treatments. In order to get high yield of proso millet, the optimum sowing dates were from May 18 to May 28, by which the proso millet can get high yield; the yield can be decreased greatly by delaying the sowing date to June 7 in Baicheng.

Acknowledgements

This dissertation is a part of Science and Technology Project (No. 421 Jijiao kehe[2015]) supported by the Education Department of Jilin Province; the Doctoral Scientific Fund Project sponsored by Baicheng Normal University.

References

[1] Zhang Panpan, Li Jianyi, Li bing, , et al. Effects of sowing date on yield traits of the imported broomcorn millet varieties[J]. Heilongjian Agricultural Sciences, 2017(6):17-20.

[2] Jing Xiaolan, Li Zhihua, Dong Xun. Effects of different sowing dates on growth and yield of different millet varieaties[J]. Crops, 2019(1): 146-151.

[3] Wang Yuxian, Li Qingquan, Liu Yutao, et al. The effect of sowing date on yield and growing development of *Panicum miliaceum* L.. Heilongjian Agricultural Sciences, 2013(9): 22-24.

[4] Wang Dehui, Sheng Jinhua, Zhang Xiongjie, et al. Effects of sowing dates on growth, development and yield of proso millet[J]. Chinese Seed Industry, 2013(4):61-64.

[5] Luo Shiwu, Zhang Shangpei, Yang Xuejun, et al. Effects of different sowing dates on growth, development and yield of proso millet in drought area[J]. Shaanxi Journal of Agricultural Sciences, 2015, 61(3): 1-3.

[6] Lin Xiaoyan, Zhang Shuangding. Introduction of nine new varieties (lines) of proso millet in

Longxi County[J]. Gansu Agricultural Science and Technology, 2017(10): 55-58.

[7] Yang Ying. Introduction of four new proso millet varieties (lines) in Lingtai County[J]. Gansu Agricultural Science and Technology, 2018(2): 36-39.

[8] Han Qiliang, Wang Wenying, Han Meishan, et al. Introduction Experiment and Application Assessment of Broom Corn Millet in Northwest Shanxi[J]. Journal of Shanxi Agricultural Sciences, 2010, 38(4): 33-36.

[9] Li Bin. Trials on New Introduced Millet Varieties (Liners) in Yuzhong County, Gansu Province[J]. Gansu Agricultural Science and Technology, 2004(10): 18-19.

[10] Li Faming, Liu Shizeng, Guo Chunxiu. Cultivation of introduced alfalfa varieties in an arid area of Minqin county[J]. Acta Prataculturae Sinica, 2009, 18(6): 248-253.