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Best Sowing Date for Wheat Summer Planting in Kunming

Cheng Jia-sheng[1, 2, 3, †], Wang Zhi-long[1, †], Qiao Xiang-mei[1], Wang Zhi-wei[1], Liu Lie[1], Huang Ge[1], Cui Yong-zhen[1], Yu Ya-xiong[1, *], Wu Yu[3]

[1]Food Crops Research Institute, Yunnan Academy of Agricultural Sciences / National Wheat Improvement Center Yunnan Branch, Kunming, China

[2]University of Chinese Academy of Sciences, Beijing, China

[3]Chengdu Institute of Biology, Chinese Academy of Sciences, Chengdu, China

Email address:

624586835@qq.com (Cheng Jia-sheng), zhilong0316@126.com (Wang Zhi-long), 363880209@qq.com (Qiao Xiang-mei), wzw0903@126.com (Wang Zhi-wei), hangge998@163.com (Huang Ge), cuiyongzhen137@126.com (Cui Yong-zhen), yyx582@163.com (Yu Ya-xiong), wuyugood@126.com (Wu Yu)

[*]Corresponding author

† Cheng Jia-sheng and Wang Zhi-long are co-first authors.

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Abstract: *[Background]* Wheat is the most important food crop, with the largest planting area in the world. However, in the production process, due to the species degradation and the occurrence of new diseases, the antigens of old varieties are lost, resulting in reduced yield and even no harvest. In order to ensure the stable yield and increase of wheat, the varieties need to be updated in time. By using different seasons and different places to carry out additional generation breeding of wheat, two or even three generations can be bred in a year. Accelerate wheat breeding process and accelerate the rate of variety renewal. *[Objective]* Kunming is an ideal place for wheat summer breeding in China due to its special climate. The optimal sowing time of wheat summer sowing in Kunming was studied to provide guidance for wheat planting of double seasons. *[Methods]* Local spring varieties were used as research materials, yield components of wheat were investigated and analyzed at four sowing dates. *[Results]* Agronomic traits data of summer sown wheat were lower than that of winter sown whea except nonbearing tillering numbert. The yield was the highest sowing on June 5. The reproductive coefficient, number of effective tillers, plant height, spike length, number of grains per spike, 100 ear grain weight and biomass decreased with the delay of sowing date. [Conclusion] Wheat summer sowing in Kunming should be no later than June 25 to obtain more breeding seeds.

Keywords: Wheat, Summer Planting, Sowing Date

1. Introduction

Wheat is one of the most important crops and food sources for human beings, with 35% to 40% of the global population taking wheat as the main food [1]. According to the latest forecast of the United Nations, the world population will increase to about 8.5 billion in 2030 and 9.7 billion in 2050, respectively, and reach a peak of about 10.4 billion in the 2080s [2]. In order to meet the needs of the growing population, all research units have made efforts to increase the output per unit area. New variety cultivation is the main method to increase crop yield. For example, in Britain, cultivar improvement alone increased wheat yield by about 40% from 1947 to 1977, among which cultivar contributed the most to increase wheat yield during 1960-1970, and cultivar improvement was the most important factor for increasing wheat yield per unit area in Britain [3]. The same trend has been observed in the evolution of wheat productivity in China. The economic yield of wheat varieties in Guanzhong in 1990 was 33% higher than that in 1940 [4]. If conventional wheat breeding is carried out according to one generation per year, the breeding cycle generally needs 8-10 years, and some distant hybridization or compound

hybridization even needs more than 10 years [5-7]. Shuttle planting and selection of wheat are carried out by taking advantage of the warm and cool climate in different regions with great different latitude or altitude. In order to shorten the breeding process and reduce the breeding cost, many research institutions choose the nearby regions with relatively cool summer for summer propagation [7-14]. Located in central China southwest yunnan-guizhou plateau, kunming dianchi lake in the south, surrounded on three sides by mountains and faces the dianchi lake plain, is a low latitudes north latitude subtropical mountain, plateau monsoon climate, due to the effect of warm moist air flows in the Indian Ocean southwest of, mild climate, no cold winter and summer without the heat, annual rainfall of 1450 mm, with a typical temperate climate characteristics, using the temperature of Kunming climate in summer is not high, Under the specific ecological conditions that do not change much, after the harvest of positive season winter sowing wheat, a summer sowing wheat is added to harvest around the early October, which can be connected with winter sowing, effectively increasing the coefficient of breeding and generation of wheat superior seed, thus accelerating the breeding of wheat superior seed [15]. Since the founding of the People's Republic of China, due to the special climate in Kunming, It has become an ideal place for summer propagation and generation in all wheat breeding units in China [14-16]. Therefore, this paper used local research materials on spring varieties to study the best sowing date of summer sowing wheat in Kunming, so as to provide reference for future breeders to study summer propagation and generation of wheat.

2. Research Methods

2.1. Research Materials

Spring varieties Yunmai 68 and Yunmai 80, which were bred by Food Crops Research Institute of Yunnan Academy of Agricultural Sciences, were planted in Songming Experimental base of Yunnan Academy of Agricultural Sciences.

2.2. Test Method

Four sowing dates were set, which were June 11 (period I), June 25 (period II), July 12 (period III), and July 25 (period IV). Fifteen rows of each variety were sown at each period by 1 meter plot length, 25 cm row spacing. and 45 hand-selected seeds were sown in each row (the germination rate was 100%). After fertilizing urea 15 kg/667m^2, manual weeding in the field.

The number of effective tillers, plant height, ear length, number of bearing spikelets, number of degenerated spikelets, number of grains per spike and 1000-grain weight were investigated. 100 spikelets were randomly cut, manually threshed, and weighed after drying in oven at 45°C to constant weight. biomass of 100 stems with leaves were randomly removed from 100 plants sampled, roots were removed, dried in an oven to constant weight, and then measured the weight.

$$\text{Effective panicles in plot} = \frac{\text{effective panicles in } \textit{the second row of positive numbers} + \text{effective panicles in the second line from the bottom}}{2\times 15 \text{ rows}}$$

$$\text{Effective ear in } 667.67\text{m}^2 = \frac{\text{effective ear of plot}}{\text{1m line length} \times \text{row spacing } 0.25\text{m}\times 15 \text{ rows} a} \times 667.67\text{m}^2$$

$$Propagation\ coefficients = \frac{667.67m^2 \text{ effective panicle} \times \text{number of grains per panicle}}{667.67m^2 \text{ sowing amount}}$$

2.3. Data Processing

Germination index was figured out Excel 2010. Analysis of variance (single factor) was made on agronomic traits by DPS7.05 software using Duncan's new complex range method). The level of significance was set at α=0.05 for all analyses. Winter sowing (WS) data were collected using the two-year average of variety comparison tests in Songming experimental base in 2021-2022 planting season. Mu represents an area of 666.67m^2.

3. Test Results

3.1. Differences in Agronomic Traits Among Summer Sowing Wheat Varieties

The number of effective tillers, plant height, ear length, number of bearing spikelet, number of grains per spike, 1000-grain weight, 100 spikelet weight and biomass of Yunmai 80 were higher than those of Yunmai 68 in winter sowing (WS) and summer sowing, while the number of degraded spikelet was opposite. The 100 spikelet weight and biomass of Yunmai 80 were significantly higher than those of Yunmai 68. No significant differences of other traits were found among the tow cultivars. It can be seen that the differences of traits among cultivars are controlled by genetic factors.

3.2. Differences in Agronomic Traits of Summer Sown Wheat at Different Sowing Dates

Effective tiller number, plant height, spike length, spike grain number, biomass, effective ears, propagation coefficient with overall decreases with the delay of sowing date, The 1000-grain weight increased with the delay of sowing date, Spikelet number phase I > III period > IV period > II period, degenerated spikelet of II period significantly lower than that of other sowing date, the rest traits of sowing date as the delay of sowing date. As can be seen from Table 2, The number of effective tillers, the number of grains per panicle, the number of effective panicle and the reproduction coefficient were all higher

with the earlier sowing. Therefore, summer planting wheat should be sown as early as possible for higher yield.

Table 1. *Differences of agronomic traits of summer sown wheat varieties.*

Variety	Effective division of evil (spikes per plant)	Pant height (cm)(cm)	Spike length (cm)	Spikelet number	nonbearing tillering number
Yunmai80	2.16[a]	59.77[a]	4.97[a]	12.44[a]	4.47[a]
WS	3.83	83.3	11.27	20.65	3.35
Yunmai68	2.21[a]	57.53[a]	4.92[a]	11.64[a]	4.66[a]
WS	3.98	90.7	8.7	18.32	3.4

Table 1. *Continued.*

Variety	grain number per spike (seeds)	1000 grain weight (g)	Effective panicle per mu (Ten thousand per mu)	biomass (g)	Growth period (d)	Reproduction coefficient %
Yunmai80	27.24[a]	33.01[a]	22.10[a]	165.05[a]	80.5	546.37[a]
WS	49.5	35	28.7	423.53	167	1183.82
Yunmai68	25.82[a]	33.92[a]	23.23[a]	153.78[b]	75.5	524.23[a]
WS	46	42	24.8	396.40	170	950.62

Different small letters in the same column meant significant difference at 0.05 level among treatments.

Table 2. *Differences of agronomic characters of summer sown wheat at different sowing period.*

Sowing date	Effective division of evil (spikes per plant)	Pant height (cm) (cm)	Spike length (cm)	Spikelet number	nonbearing tillering number	grain number per spike (seeds)
I	3.62[a]	72.62[a]	6.08[a]	15.73[a]	4.44[bc]	33.19[a]
II	3.10[a]	59.45[b]	5.35[b]	9.53[c]	3.88[c]	27.20[b]
III	1.01[b]	54.81[bc]	4.79[b]	12.93[ab]	4.78[ab]	27.27[b]
IV	1.02[b]	47.72[c]	3.56[c]	9.96[bc]	5.16[a]	18.46[c]

Table 2. *Continued.*

Sowing date	1000 grain weight (g)	Effective panicle per mu (Ten thousand per mu)	biomass (g)	Growth period (d)	(Reproduction coefficient %)
I	32.14[b]	34.80[a]	228.89[a]	81	958.60[a]
II	32.55[b]	32.87[a]	182.68[b]	81	744.99[b]
III	33.36[b]	11.47[b]	138.73[c]	74	260.21[c]
IV	35.80[a]	11.53[b]	87.37[d]	76	177.39[d]

Different small letters in the same column meant significant difference at 0.05 level among treatments.

3.3. Differences in Agronomic Traits Among Cultivars at Different Sowing Dates

The number of effective tillers, plant height, panicle length, number of bearing spikelets, number of grains per spike, 1000-grain weight, effective panicle and reproduction coefficient of winter sown wheat Yunmai 80 and Yunmai 68 were higher than those of summer sown wheat, and the growth period was significantly longer than that of summer sown wheat, while it was vice versa for the number of degraded spikelets.

All the effective sowing periods decreased with the delay of sowing date and no significant difference was found among them. The plant height difference during each sowing period was significant or extremely significant. The plant height of Yunmai 80 is period I>period III> period II> period IV, while Yunmai 68 was reduced with the delay of sowing date. Panicle length was significantly different in each sowing period, and shortened with the delay of sowing date. Except for the first period of Yunmai 80, there was no significant difference in the other sowing periods. Yunmai 68 of Yunmai 80 had period I>period III>period II>periodIV. The spikelets of Yunmai 80 and Yunmai degenerate were period IV> period III > period I> period II. The difference of grain number per spike was significant or extremely significant in each sowing period of Yunmai 80, and decreased with the delay of sowing date. There was no significant difference in the second and third sowing periods of Yunmai 68, and the difference of grain number per spike was extremely significantly lower than that of other sowing dates, and the change of grain number per spike was I> period III>period II> period IV. The 1000-grain weight of Yunmai 80 in period IV was significantly higher than that of other sowing dates, the change was period IV> period II> period I> period III, and the change of Yunmai 68 was period III > period IV > period I> period II. The grain weight per hundred panicle of Yunmai 80 at period I was significantly higher than that of other sowing dates, and the change was period I> period III> period II> period IV. The grain weight per hundred panicle of Yunmai 68 at period Iwas significantly higher than that of other sowing dates, and the change was period II>period I> period III> period IV. The effective panicle per mu, biomass and reproductive coefficient were significantly different during each sowing period, and they all decreased with the delay of sowing date. The above

results suggesting that the agronomic traits of the varieties were greatly affected by the environment.

Table 3. *Differences of wheat variety agronomic characters at different sowing periods in summer.*

Variety	Treatment	Effective division of evil (spikes per plant)	Pant height (cm)	Spike length (cm)	Spikelet number	nonbearing tillering number	grain number per spike (seeds)
	I	3.38^{a}	76.08^{a}	5.87^{ab}	18.28^{a}	4.31^{ab}	36.91^{a}
	II	3.19^{a}	54.99^{cd}	5.26^{abc}	9.06^{b}	3.36^{b}	27.29^{b}
Yunmai80	III	1.01^{a}	58.02^{bcd}	5.06^{bc}	12.15^{b}	4.93^{a}	25.89^{bc}
	IV	1.04^{a}	49.99^{d}	3.67^{d}	10.25^{b}	5.28^{a}	18.87^{cd}
	WS	3.83	83.3	11.27	20.65	3.35	49.5
	I	3.85^{a}	69.15^{ab}	6.28^{a}	13.18^{ab}	4.57^{a}	29.46^{ab}
	II	3^{a}	63.91^{abc}	5.44^{abc}	10.00^{b}	4.40^{ab}	27.12^{b}
Yunmai68	III	1^{a}	51.59^{cd}	4.51^{cd}	13.70^{ab}	4.62^{a}	28.64^{b}
	IV	1^{a}	45.45^{d}	3.44^{d}	9.66^{b}	5.04^{a}	18.05^{d}
	WS	3.98	90.7	8.7	18.32	3.4	46

Table 3. *Continued.*

Variety	Treatment	1000 grain weight (g)	Effective panicle per mu (Ten thousand per mu)	biomass (g)	Harvest period (month-day)	Growth period (d)	Reproduction coefficient (t%)
	I	31.23^{c}	33.60^{a}	236.17^{a}	September 3	84	1033.43^{a}
	II	32.47^{bc}	31.60^{a}	170.53^{d}	September 18	85	718.60^{b}
Yunmai80	III	31.13^{c}	11.73^{b}	138.64^{e}	September 30	80	253.14^{c}
	IV	37.19^{a}	11.47^{b}	114.85^{f}	October 6	73	180.31^{c}
	WS	35	28.7	423.53		167	1183.82
	I	33.04^{bc}	36.00^{a}	221.60^{b}	August 28	78	883.76^{b}
	II	32.63^{bc}	34.13^{a}	194.82^{c}	September 10	77	771.38^{b}
Yunmai68	III	35.60^{ab}	11.20^{b}	138.82^{e}	September 18	68	267.29^{c}
	IV	34.41^{abc}	11.60^{b}	59.90^{g}	October 12	79	174.48^{c}
	WS	42	24.8	396.40		170	950.62

Different small letters in the same column meant significant difference at 0.05 level among treatments.

4. Discussion

The rainfall in Kunming is mainly in summer and autumn, with drought in winter and spring. The average temperature in summer is 15-26°C and the average temperature in spring is 6-20°C. This climate is very suitable for wheat growth and development. The results of this study showed that the effective tiller number, plant height, panicle length, spikelet number, panicle number and 1000-grain weight of summer planting wheat were lower than those of winter wheat, which may be affected by both temperature and humidity. Water affects the growth and development of wheat. In the vegetative growth period of wheat, water stress affects the number of per panicle and grain number per panicle and seed setting rate. In the reproductive growth period, water stress has a greater impact on 1000-grain weight, and the greater the water stress intensity, the greater impact on yield [17]. Temperature also affects the growth and development of wheat. High temperature leads to short growth period of wheat, high temperature in the differentiation period of young panicle, rapid growth and development, and short differentiation time, so the head of ear is small, the number of grains is small, but the heading is straight, the maturity is early, and the plant height is generally 10 ~ 20 cm lower than that of winter sowing [13]. The delay of sowing date resulted in the decrease of agronomic traits such as effective ear, grain number per ear and 1000-grain weight [15, 16]. The study also showed that with the delay of sowing date, the number of effective tillers, plant height, panicle length, grain number per panicle, 1000-grain weight and biomass were all decreased with the delay of sowing date, while the total number of degenerate spikelet increased with the delay of sowing date. The optimum sowing time for high yield in summer was different from one to another. For example, in Anhui Province, the best time for seed collection is May 20-25, and in Qinghai Province, the best time for summer propagation is May 25-30 [14]. The results of this paper show that there are differences among varieties, but early sowing has more effective ears, relatively more grains per ear, and high reproduction coefficient. Therefore, The summer planting of spring wheat should not be sown later than June 25 in Kunming.

5. Conclusion

All traits except degenerate spikelets of summer planting wheat were lower than those of winter sowing wheat. By comparing two wheat varieties “Yunmai 68” and “Yunmai 80” at four sowing periods for 11 agronomic traits, including effective tiller, plant height, spike length, spikelet, degenerated spikelet, the grain per ear, grain numbers per spike, effective panicle, biomass, and propagation coefficient, it was found that most traits on the first (I) and the second (II) sowing date are obviously better than III and IV sowing date.

These traits include the number of effective tillers, grain per ear, yield and reproduction coefficient. Therefore, the summer planting wheat should be sown as early as possible in Kunming, and the spring varieties are suggested to be sown no later than June 25.

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