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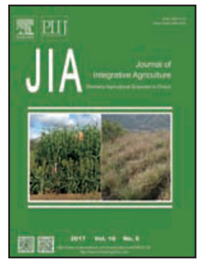

RESEARCH ARTICLE

# The effects of sowing date on cottonseed properties at different fruiting-branch positions

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**Abstract**

A two-year field experiment was conducted to illustrate the effects of sowing date on cottonseed properties at different fruiting-branch positions (FBPs). Two cotton cultivars (Kemian 1 and Sumian 15) were sowed on 25 April, 25 May, and 10 June in 2010 and 2011, respectively. The boll maturation period increased with the delaying of sowing date. Normal sowing treatment (25 April) had higher seed weight, embryo weight, embryo oil content and protein content than late sowing treatments (25 May and 10 June). The flowering date, seed weight, embryo weight, embryo oil and protein contents, and the dynamic changes of embryo oil and protein contents were altered by different FBPs. A significant interaction of sowing date×FBP was observed on embryo weight, embryo oil content, embryo protein content and the dynamic changes of embryo oil and protein contents, but was not observed on seed weight. Seed weight, embryo weight, embryo oil and protein content had significant positive correlations with the mean daily temperature (MDT), mean daily maximum temperature ($MDT_{max}$), mean daily minimum temperature ($MDT_{min}$), and mean daily solar radiation (MDSR), indicating that temperature and light resources were the main reasons for different sowing dates affecting the cottonseed properties at different FBPs. Moreover, the difference in MDT was the main difference in climatic factors among different sowing dates.

**Keywords:** sowing date, fruiting-branch position, cottonseed properties

## 1. Introduction

Cotton is the fifth largest oil crop and the second important potential source of plant protein in the world. Cottonseed is an important source of oil and protein. Cottonseed is the principal byproduct of fiber production, and large-scale production of cottonseeds is continuous because of the on-going demand of fiber in the textile industry. In 2013, the total cottonseed yield reached 1 100 million tons in China, so the reasonable development and utilization of cottonseed is beneficial for the vegetable oil and protein industry. However, the quality of cottonseed is relatively neglected, because the producers usually focus on the fiber yield and quality in cotton production.

As cotton is an indeterminate crop, the bolls at different fruiting-branch positions (FBPs) grew in different environmental conditions (Liu *et al*. 2015a). Thus, boll weights at different FBPs were observed to be significantly different (Zhao and Oosterhuis 2000). The positions of fruiting-branch also significantly affected boll formation and fiber strength (Zhao *et al*. 2010, 2011). In addition, biomass and non-structural

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carbohydrate contents of the leaves collected from different FBPs were significantly different (Zhao and Oosterhuis 2000; Liu *et al*. 2014). Therefore, previous studies have measured the differences in boll weight, fiber quality and leaf growth among different FBPs. However, the studies of cottonseed growth and development at different FBPs were lacking.

The oil content in cottonseed ranged from 28.44 to 44.05% and the protein content ranged from 27.83 to 45.60% (Sun *et al*. 1987). The variations in oil and protein contents were attributed to genetype (Singh *et al*. 1985; Dani 1989; Ye *et al*. 2003) and environmental factors (Kohel and Cherry 1983; Singh *et al*. 1985; Dani 1993; Ye *et al*. 2003). Previous studies showed that the daily minimum temperature of 22–23°C was optimum for oil and protein accumulations in cottonseed, and the oil and dry matter accumulations would be restrained when the daily minimum temperature was lower than 15°C (Zhou *et al*. 1992; Li *et al*. 2009). High canopy light could promote the oil accumulation, while too high or too low canopy light would limit the protein accumulation (Zhu *et al*. 2010; Lü *et al*. 2013). Sowing date could affect temperature and light, which were the main ecological factors influencing cotton growth and development (Chen *et al*. 2014). Delayed sowing date caused the cotton growing at lower temperature and light, which resulted in decreased sucrose export in cotton leaves (Liu *et al*. 2013), indicating that less photosynthate was transferred to fiber and cottonseed (Zhou *et al*. 1998). Thus, the growth of fiber and cottonseed would be affected by late planting. In addition, Liu *et al*. (2015b) reported that the differences of environmental condition between late planting date and normal planting date were primarily on temperature, and late planting significantly decreased fiber strength relative to normal planting date. However, the effects of different sowing dates on cottonseed properties were not well understood.

Therefore, there was a need to study the effects of different sowing dates on cottonseed growth and development at different FBPs. The objective of this study was to elucidate the effects of sowing date on cottonseed properties (seed weight, embryo weight, embryo oil content and embryo protein content, etc.) at different FBPs. The results may guide further research on the optimal time for sowing to improve cottonseed quality.

## 2. Materials and methods

### 2.1. Experimental design

A two-year experiment was carried out at the Pailou Experimental Station, Nanjing, Jiangsu Province, China (118°50´E, 32°02´N) in 2010 and 2011. The soil type at the experimental site was clay, mixed, thermic, typic alfisols (udalfs; FAO luvisol) in 20 cm depth of the soil profil, and the soil nutrient contents before sowing were listed in Table 1. In this experiment, two cotton cultivars (Sumian 15 and Kemian 1) were sowed on three different dates (25 April, 25 May, and 10 June) at a row spacing of 0.8 m and plant spacing of 0.25 m. Each plot was 6 m×10.5 m. Cottonseeds were planted in nutrition pots in a nursery bed, and the seedlings with three true leaves were transplanted into the field. The experiment was arranged in a split-plot design with three replications. Main plots were sowing dates and subplots were varieties (Sumian 15 and Kemian 1). Furrow-irrigation was applied as needed to minimize the moisture stress during each season. Conventional weed and insect control measures were utilized as needed.

### 2.2. Measurements and methods

Ten plants were collected randomly from the two central rows of each plot for measuring the flowering date, boll opening date, number of fruiting branch, and 100-seed weight. The white flowers at the 1st node (nearest the stem) of the 2nd–3rd (fruiting branch$_{2–3}$ (FB$_{2–3}$)), 6th–7th (FB$_{6–7}$), and 10th–11th (FB$_{10–11}$) fruiting branches were tagged for all the remaining plants in each plot. The total time for tagging flowering date at each part (FB$_{2–3}$, FB$_{6–7}$ or FB$_{10–11}$) was no more than 3 days to ensure that the tagged flowers had similar biological ages. 15–20 tagged bolls were collected once every 7 days from 17 days post anthesis (DPA) until the bolls opening. Cotton bolls in the 2 center rows of each plot were hand-harvested according to the positions of fruiting branchs (FB$_{2–3}$, FB$_{6–7}$, and FB$_{10–11}$) when the bolls opened. The harvested boll was divided into capsule wall, cottonseed and fiber. The cottonseeds of 17 DPA were not decorticated because of small size, but the cottonseeds collected from other days were decorticated. Cottonseed hull was slightly cracked with a nutcracker before being manually removed and separated from the embryo. The embryos were dried at 105°C for 30 min, and then dried at 60°C to constant weight.

Cottonseed weight (biomass per 100 seeds), embryo weight (biomass per 100 embryos), embryo oil and protein contents were determined. Embryo oil content was measured with Soxhlet extraction (Luque and Garcia 1998). The N concentration of embryo was measured with Kjeldahl method (Feil *et al*. 2005), and embryo protein content was calculated as 6.25×N concentration.

### 2.3. Environmental conditions

Weather data were collected from the Nanjing Weather Station, China. Microclimate factors including air temperature and solar radiation were measured. The air temperature was measured with a Hygro-Thermometer Psychrometer (DT-8892, CEM, Shenzhen, China) at the positions of FB$_{2–3}$,