

# Effect of Sowing Quantity on Soil Temperature and Yield of Winter Wheat under Straw Strip Mulching in Arid Region of Northwest China

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**Abstract.** In order to explore the characteristics and relationship between soil temperature and yield of winter wheat, under different sowing quantities conditions of straw mulching conventional drilling in Northwest China, this study took Lantian 26 as material, under the whole corn mulching conventional drilling in Changhe town and Pingxiang town, setting up 3 different seeding quantities of 270 kg/ha (SSMC1), 324 kg/ha (SSMC2) and 405 kg/ha (SSMC3), to study the difference of soil temperature during the growth period of winter wheat and its correlation with yield components. Results showed: the average soil temperature of 0~25cm in two ecological zones in the whole growth period have a significant change with the increase of sowing quantities; too much seeding had a sharp drop in soil temperature; the highest temperature of SSMC in Changhe town was the middle quantity of SSMC 2; the highest temperature of SSMC in Pingxiang town was the lowest sowing quantity of SSMC1. Diurnal variation of soil temperature at all growth stages showed: with the increase of SSMC, in the morning it increased with the increase of soil depth, noon and evening reducing with the depth of the soil. The average soil temperature of SSMC2 was higher than that of in all the two ecological zones in the whole growth period of SSMC. The maximum day temperature difference of each treatment was at noon. With the increase of SSMC, the yield increase varied with two ecological zones. SSMC of the local conventional sowing quantity of 270kg/ha SSMC1 yield was the highest in Changhe Town. SSMC of the middle sowing quantity SSMC2 of 324kg/ha yield was the highest in Pingxiang town. The difference of grain number per spike was the main cause of yield difference among these 3 treatments. Correlation analysis showed: the correlation among the yield and yield components, growth index and soil temperature varied with different ecological zones; thousand kernel weight and grain number per ear (.964\*\* and .891\*\*) had a very significant positive correlation with the yields in Changhe Town, but thousand kernel weight and grain number per ear (.708\* and .718\*) had a significant positive correlation with yield in Pingxiang Town. There was a significant positive correlation between harvest index and 10cm soil temperature (.763\*). But in Pingxiang Town grain number



per ear and 15cm soil temperature showed a significant positive correlation (.671\*); 15cm soil temperature and the average temperature of 0~25cm soil layer in the whole growth period (-.687\* and -.698\*) had a significant negative correlation with the number of panicles per unit area; there was a very significant negative correlation between plant height and average temperature of 0~25cm in the whole growth period (-.906\*\*). Thus, the changes of soil temperature under SSMC different sowing quantity have indirect effect on the yield of winter wheat.

## 1. Introduction

Research and development of dry farming technology is the common trend of sustainable development of dry land agriculture<sup>[1]</sup>. The primary food crop wheat producing areas in Northwest China are mainly distributed in the semi-arid areas with adequate illumination, low natural precipitation, cool climate and 250~600mm of annual precipitation<sup>[2]</sup>. It is easy to encounter low temperature and drought in early spring<sup>[3, 4, 5, 6]</sup>, and winter wheat yield is low and unstable. Developing the technology of water use efficiency of dry land agriculture is the key to solve the problem of sustainable development of agriculture and the security of food supply<sup>[7]</sup>. Straw mulching technology is considered to be one of the main techniques to increase grain yield in dry land farming area, which don't only conserve water, but also can improve the structure of soil and prevent soil erosion, reduce straw burning due to pollution and protect the ecological environment<sup>[8, 9, 10]</sup>. But in the production practice, the straw mulching layer hinder the light directly to the ground, so that the soil temperature is low<sup>[11]</sup>; thus, the emergence and growth of wheat are affected, and the yield decreased<sup>[12, 13, 14]</sup>. Coupled with the lack of accumulated temperature in Northwest China, crop growth is more sensitive to temperature. The settlement of the mulching and cooling contradiction is the bottleneck in the Northwest China straw mulching technology promotion.

In view of the existing problems of the practice of straw mulching, in order to solve the contradiction between straw mulching and cooling, from 2012 to 2015 Gansu Agricultural University has made research and developed a "New technology of straw mulching in dry land"<sup>[15]</sup>, which takes the test principle of "Where the planting area are not mulched; where the mulching area is not planted; it don't decrease seeding quantities; it make close planting in parts of area". After more than three years' experiments, this technology can achieve a substantial increase over the open field, and the yield is close to that of plastic film mulching<sup>[15, 16, 17]</sup>. It can effectively solve the contradiction between full straw mulching and water cooling technology, which is a safe and efficient recycling of ecological resources and sustainable development of dry land agricultural technology. But on the basis of this technology, it is necessary to further study and to determine whether it can adjust the seeding mode and seeding quantity to optimize the population structure and further improve the yield.

Suitable sowing rate is one of the important cultivation measures for high yield of crops. Grain number per spike, Ear number per mu and the 1000 grain weight could promote the yield of crops. Existing research has also achieved positive results. Yu Zhenwen's study shows that it is the fundamental way to realize the high yield of crops by making full use of the resources in the field, supplying the conditions of crop growth and coordinating the relations among the components of yield is the fundamental way to achieve high yield of crops<sup>[18]</sup>. Wang Liming et al shows that applying appropriate amount of straw mulching can effectively adjust the soil temperature change and the large sowing amount can save water and increase production<sup>[19]</sup>. Li Xiaohang et al shows that with the increase of sowing amount, the number of panicles per hectare will increase gradually, but the number of grains per ear will decrease gradually, and the 1000 grain weight will not change obviously<sup>[20]</sup>. Wang Xia et al show that the effects of varieties and density on yield are very obvious<sup>[21]</sup>. Jiang Lina study the effects of sowing date and sowing amount on the high yield wheat population and individual growth under the ecological environment in Henan province, it is found that the use of late sowing and small sowing amount pattern is beneficial to the growth development of wheat "Bainong low resistance 58"<sup>[22]</sup>. Hao Youming et al found that through the effective regulation of winter wheat sowing amount and

sowing date, the yield can be increased<sup>[23]</sup>. Li Suzhen et al found that the effects of sowing quantities on wheat are all below 5%, and the yield of medium and high density is relatively high yield<sup>[24]</sup>. Cui Lina et al found that with the increase of seeding rate, wheat Tainong 18's and Jimai 22's grain number per ear and thousand kernel weight decrease gradually<sup>[25]</sup>. However, it is rare to discuss the sowing quantities to the soil temperature and wheat yield under straw strip mulching in dryland farming area. This study is based on two winter wheat experimental stations in the northwest dry land about the research and development of "New technology of straw mulching in dry land" as well as on straw strip mulching planting mode of conventional drilling, to discuss the relationship between sowing quantities and soil temperature and yield of winter wheat in wry land, and then find the optimal seeding mode under straw mulching conventional drilling.

## 2. Material and methods

### 2.1. Overview of experimental station

The experiment was conducted at Gansu Agricultural University Experimental Base from September 2014 to July 2015 at Changhe Town and Pingxiang Town in Tongwei County of Gansu Province, China.

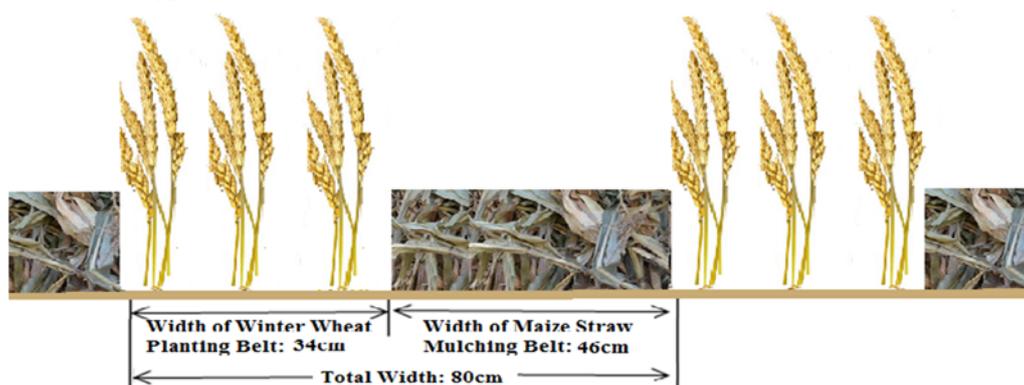
The test base is the typical area of dry land farming area in the northwest of China; it is semi-arid temperate monsoon climate; the soil is loessialsoil; precipitation of winter wheat in growth period ( $\geq 5$ mm) in Changhe Town and Pingxiang Town are respectively 307.5mm and 301.6mm. The average climatological data of the test base for years are shown in table 1. Preceding crop is open field flax.

**Table 1.** Climatic data at two experimental stations

Experimental Station	Altitude /m	Annual sunshine duration /h	Mean annual temperature /°C	Annual evaporation /mm	Average rainfall over the years/mm	Free frost days
Changhe Town	1590	2100~2430	7.4	1350	390.7	120~170
Pingxiang Town	1760	2100~2350	6.6	1500	380.2	120~170

### 2.2. Experimental design

The randomized block design was used in the study. Plot area was 45 m<sup>2</sup> (5 m×9 m), with 3 repeats, randomized block arrangement. The conventional drilling of SSMC was set 3 sowing treatments: 270 kg/ha(SSMC1), 324 kg/ha(SSMC2), 405 kg/ha(SSMC3). The minimum sowing rate of 270 kg/ha was consistent with the local conventional seeding; the winter wheat variety for experiment was Lantian 26. The specific experimental design was as follows:



**Figure 1.** The Illustration of Maize Straw Strip Mulching

Straw strip mulching conventional drilling (SSMC): As can be seen from figure 1, the width of maize straw mulching belt and wheat planting belt was 80 cm; planting belt with ordinary drill row planting 3 rows of wheat, the total row width 34 cm, planting width of each row about 3 cm; set aside 46 cm wide maize straw mulching belt next to each planting belt at the sowing stage, at the winter wheat's 3 leaf stage (before the winter), the whole maize stalk was placed on the straw mulching belt;

Winter wheat sowing date was on September 25, 2014. Straw mulching time was on November 8, 2014. Dry maize stalk mulching amount was 9000 kg/ha. The sowing and fertilization amount was the same in each plot. The winter wheat variety was Lantian 26. Before sowing N 150 kg/ha and P<sub>2</sub>O<sub>5</sub> 120 kg/ha combining with rotary tillage were put into as basal fertilizer only once. There was no fertilization in growth period. The fertilization put into all treatment was nitrogen as urea and diammonium phosphate. During the growth period of winter wheat in the early stage of filling the foliar fertilizer, insecticides and fungicides mixed were sprayed to prevent plant diseases and insect pests, the late dry hot wind and winter wheat plant senescence.

### 2.3. Soil temperature measurement

After sowing the seeds, 5 different length metal curved ground thermometers were respectively buried in 5 cm, 10 cm, and 15 cm, 20 cm, and 25 cm soil layers in the middle of each planting belt of each plot. Each growth stage of each plot was divided into five layers of 5 cm, 10 cm, 15 cm, 20 cm and 25 cm to be measured. The measurement of determination of each growth period were chosen in the sunny day, in the morning (6:00~8:00), noon (12:00~14:00) and evening (17:00~18:30) three times. Daily temperature was determined by the average value in the early, noon and evening.

### 2.4. Wheat yield and its components

Each plot was fully mature at maturity, individual threshing calculates yield. The plant height, number of kernels per ear and thousand kernel weights per plant were randomly selected in each plot of 20 plants.

### 2.5. Data processing

The data were drawn by Microsoft Excel 2010, and the SPSS22.0 software was used for statistical analysis. The Duncan method was used to test the significance of difference, and the significant level was  $\alpha=0.05$ .

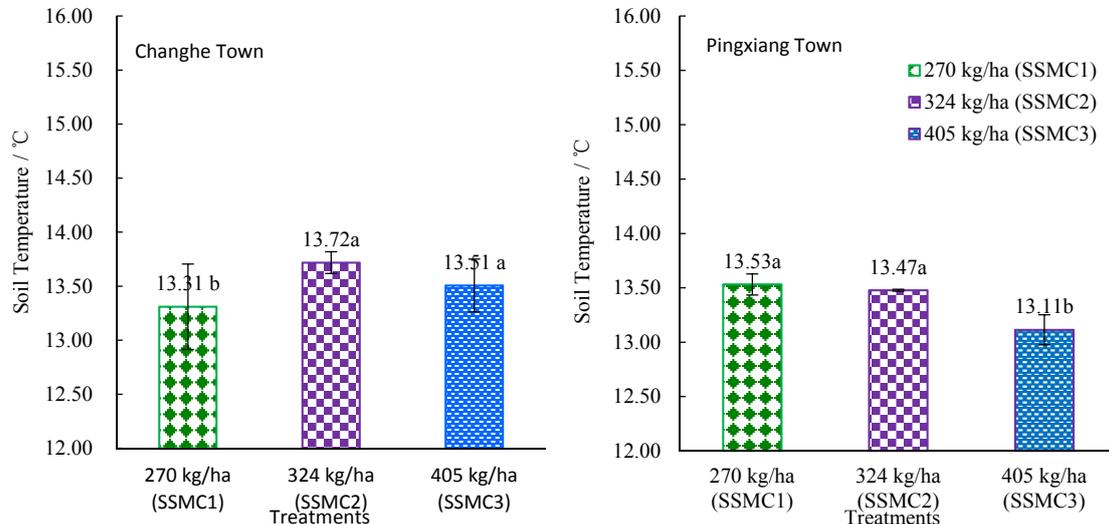
## 3. Results and analysis

### 3.1. The difference of mean soil temperature in 0~25 cm soil layers during the whole growth period of winter wheat under the different sowing quantities

As can be seen from figure 2, at the different ecological regions, the mean soil temperature in 0~25 cm soil layers during the whole growth period have a significant differences along with the increase of sowing quantities under straw strip mulching conventional drilling (SSMC). Too much sowing quantities had a sharp drop in soil temperature. The highest temperature of SSMC in Changhe town was the middle sowing quantities of SSMC2, which was respectively higher than SSMC1 about 0.41 °C and SSMC3 0.21 °C. The highest temperature of SSMC in Pingxiang town was the lowest sowing quantity SSMC1, which was higher than SSMC2 0.06 °C and SSMC3 0.43 °C.

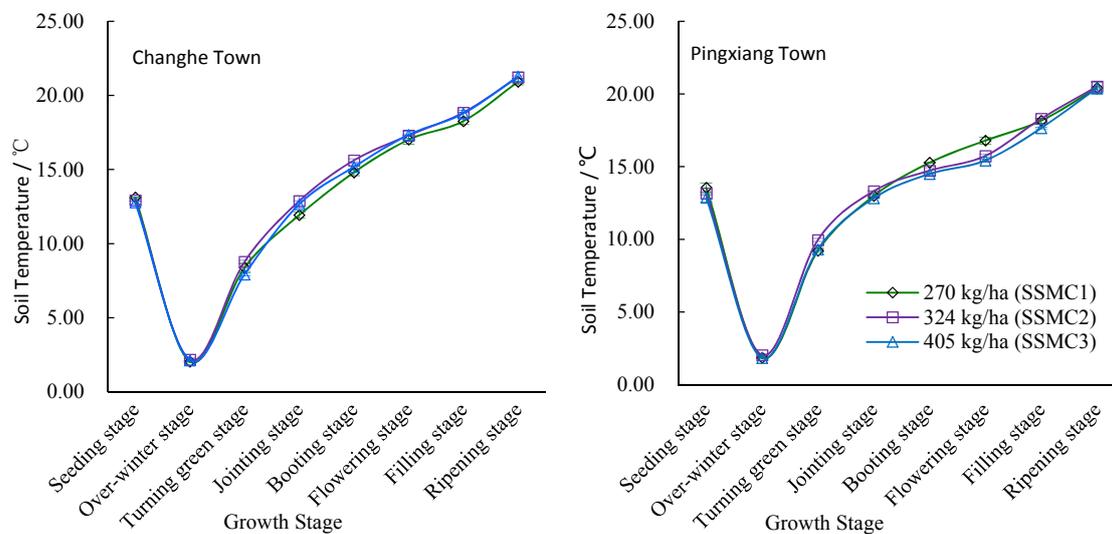
The effect of different treatments on soil temperature was different (Figure 3). With the advance of the growth process, the trend of soil layers temperature in 0~25 cm was consistent with the atmospheric temperature, showing a high-low-high trend, and the lowest was in over-winter stage. With the increase of sowing amount under in SSMC condition, the differences of soil layer temperature among treatments were related to the air temperature in different ecological zones. The over-winter stage was the largest, amplitude was 3.32%~5.47%. The difference after winter (0.27~5.15%) was greater than that before winter (1.32%~2.62%). The difference between the range values of the two different ecological zones in the period of treatment was inconsistent, which may be related to environmental factors. Changhe Town had the maximum range value in the jointing stage of 0.96 °C and the minimum was 0.14 °C in

over-winter stage; Pingxiang Town had the maximum of 1.37 °C in the flowering period and the minimum was 0.10 °C in ripening stage.



Different small letters mean significant difference ( $P < 0.05$ ) between treatments under the same factor.

**Figure 2.** The change of mean soil temperature during the whole growth period under different treatments



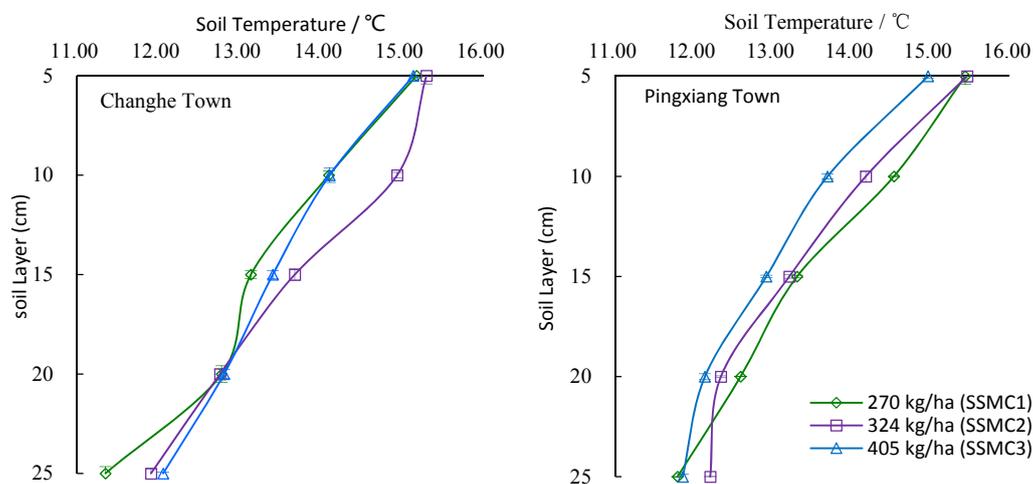
SSMC1: Conventional drilling of straw strip mulching by sowing quantity 270 kg/ha; SSMC2: Conventional drilling of straw strip mulching by sowing quantity 324 kg/ha; SSMC3: Conventional drilling of straw strip mulching by sowing quantity 405 kg/ha. The same is as below.

**Figure 3.** The change of mean soil temperature in 0~25cm at different growth stages  
The change of mean soil temperature in 0~25cm during the whole growth period

3.2. The difference of mean soil temperature of different soil layers during the whole growth period of winter wheat under the different sowing quantities

As can be seen from figure 4, in the two ecological zones, the mean soil temperature of winter wheat in the whole growth stage was decreased with the increase of soil depth, but with the increase of sowing quantities the average soil temperature of each soil layer in the whole growth stage was different. Maybe

it was related to the straw strip mulching as conventional drilling to the effect of water and heat conditions under different sowing quantities at two different ecological regions. The coefficient variation of SSMC1 and SSMC2 was similar, which was higher than SSMC3, and CV was about 10.11%~10.83% at two different ecological. In the view of difference of soil layer under different sowing quantities, the 25cm soil layer in Changhe town had the maximum at 0.7°C; The maximum difference rate was 6.17%; the variation coefficient CV was 3.12%. The layer of 10cm in Pingxiang town had the maximum at 0.84 °C; The maximum difference rate was 6.15% and the variation coefficient CV was 2.99%. The difference of soil layers of different sowing quantities was not consistent, which indicated that the change of soil temperature was affected by sowing quantities and production area. The maximum decreasing temperature amplitude of the soil layers was SSMC1 with 3.64~3.83°C, and the maximum sowing quantity of SSMC3 had the minimum of 3.08~3.10 C. The variation coefficient of soil layers was 8.75%~10.83% among the treatments; the variation coefficient of treatments was 0.04%~3.12% among the layers.

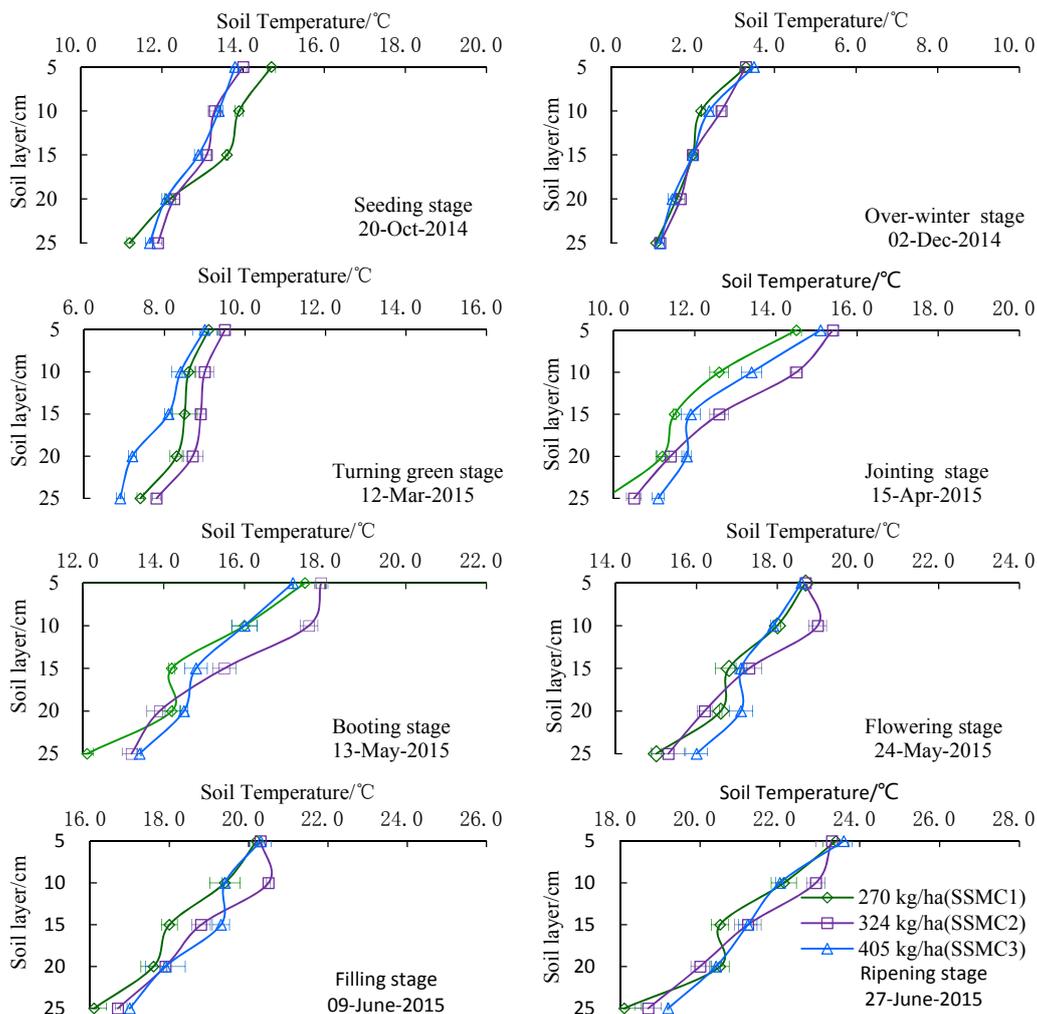


**Figure 4.** The change of mean soil temperature of different soil layer during the whole growth period

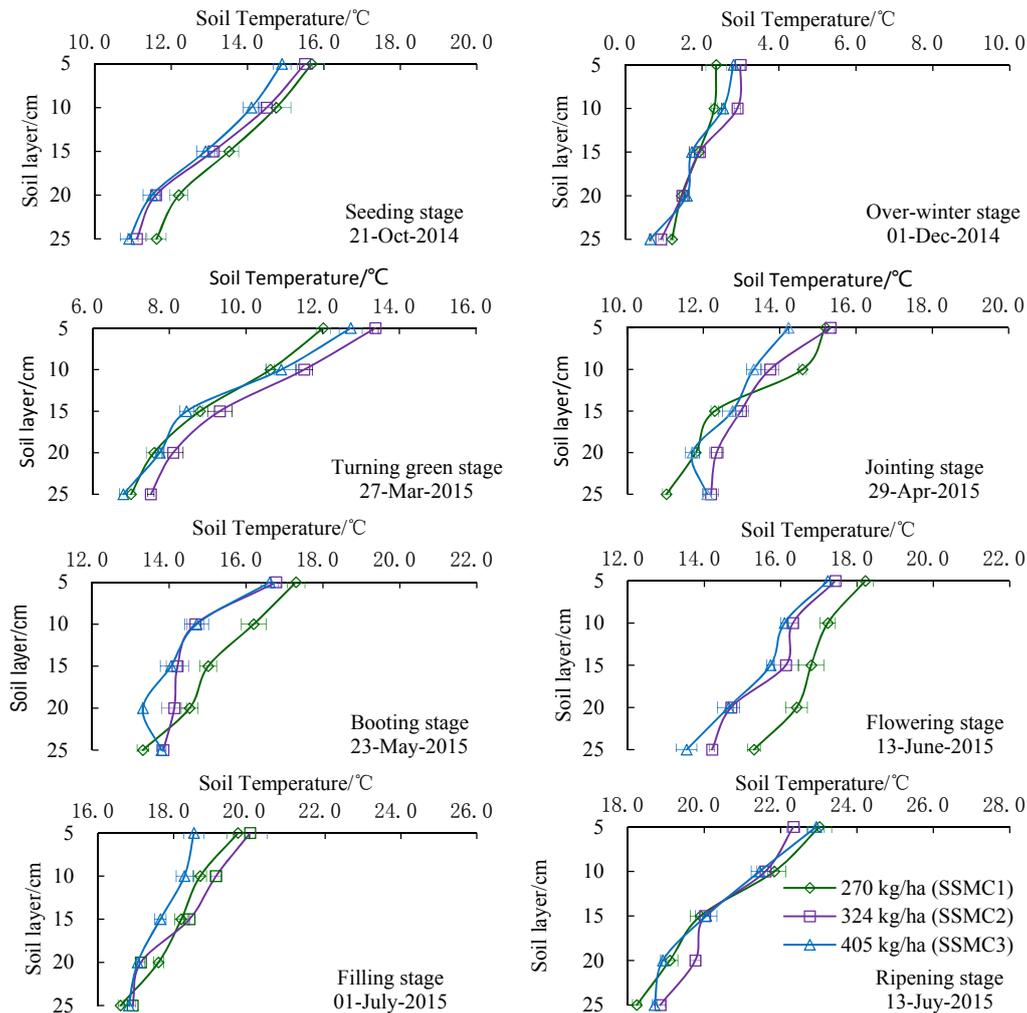
### 3.3. Changes of soil temperature at different soil layers in different growth stages under different sowing quantities

As can be seen from Figure 5 and figure 6, there was a great difference in different soil layers temperature in different growth stages under the conditions of different sowing quantities. On the whole, the difference among treatments was the highest in over-winter stage in different growth stages with the increase of sowing quantity in two different ecological areas. 25 cm soil layer of Pingxiang town had the maximum difference in over-winter stage; the variation coefficient was 30.4% and the maximum difference was 0.6°C. The 10 cm soil layer of Changhe town in over-winter stage had the maximum difference; the variation coefficient was 10.3%; the maximum difference was 0.5°C. The difference among 20cm soil layers was the second; the variation coefficient was 6.3%; the maximum difference was 0.2°C. And after the difference among treatments was small and the variation coefficient was 0.3~9.6%; But with the change of the season or the growth period, the maximum difference increased and it was 0.1~1.9°C; 25 cm soil layer of Pingxiang town had the maximum difference in over-winter stage. The variation coefficient was 30.4% and the maximum difference was 0.6°C; The difference in 5~10 cm soil layers among treatments was the second; the variation coefficient was 11.7~11.9%, and the maximum difference was 0.6°C; The differences were small and the variation coefficient was 0.4~6.6%. But with the change of the season or the growth, the maximum difference increased to 0.1~1.8 °C. There were differences in two different ecological regions in different soil layers. 10 cm soil layers among the treatments in Changhe town had the maximum; variation coefficient was 2.2~10.3%;

the minimum was at 5 cm soil layer; the variation coefficient was 0.3~3.4%. The minimum soil temperature variation was in turning green stage; Amplitude was at 1.7~2.1°C; the Maximum was SSMC3; the minimum were SSMC1 and SSMC2; 25 cm soil layers among treatments in Pingxiang town had the maximum; The variation coefficient was 1.0~30.4%; the minimum was 15 cm soil layer; the variation coefficient was 0.4~6.0%. The lowest temperature difference among treatments was in over-winter stage; the amplitude was at 1.2~2.1 °C ; SSMC3 had the maximum; SSMC1 had the minimum. Thus, effects of soil temperature under different sowing quantities of straw mulching conventional drilling was affected by regional and seasonal effects obviously. The average soil temperature of SSMC2 in the whole growth period was the highest in different ecological zones.



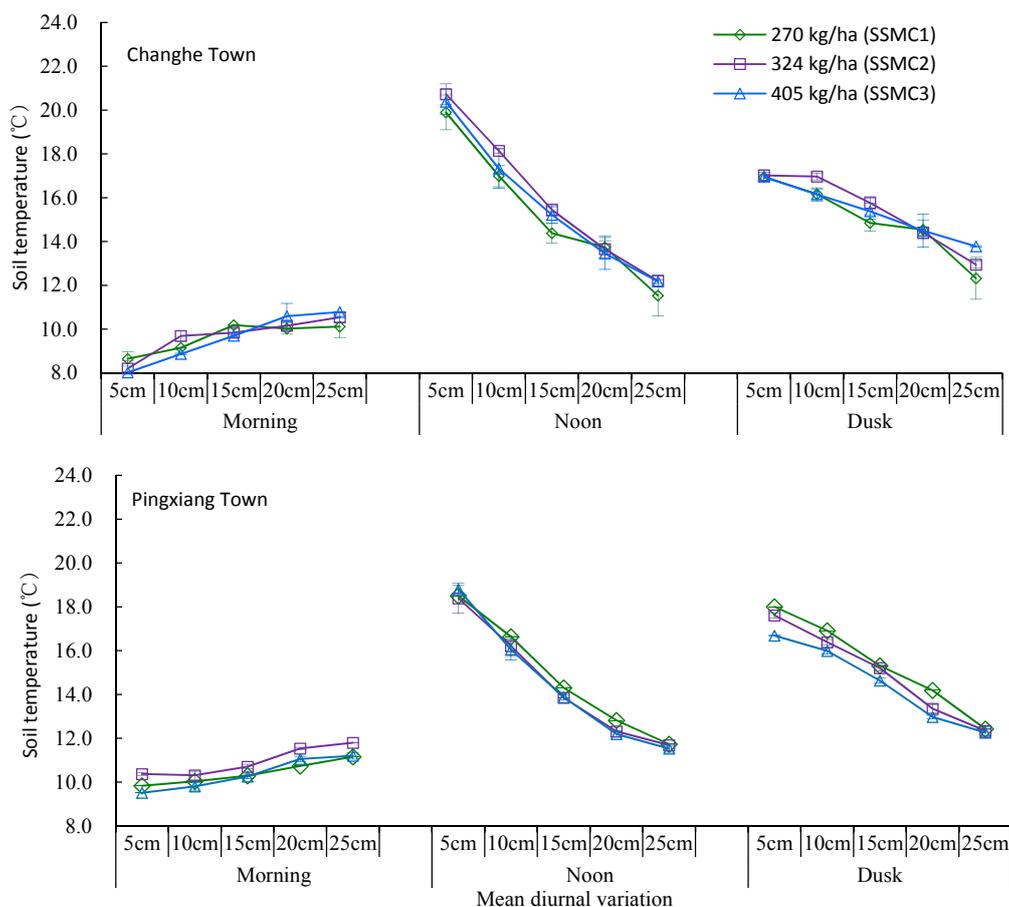
**Figure 5.** Soil temperature at different soil layers at different growth stages in Changhe Town



**Figure 6.** Soil temperature at different soil layers at different growth stages in Pingxiang Town

### 3.4. Diurnal variation of soil temperature at different soil layers in whole growth stage of winter wheat under different sowing quantities

As shown in Figure 7, the diurnal variation trend of soil temperature at different soil layers in whole growth stage at the two different ecological zones showed: with the increase of sowing quantity under the condition of SSMC, in the morning it increased with the increase of soil depth, and noon and evening it reduced with the depth of the soil. But the difference of soil temperature in two different ecological regions was different; Changhe town in the evening had the maximum of 25cm soil layer; variation coefficient was 5.6%. Pingxiang town had the maximum difference of 5cm soil layer in the evening; variation coefficient was 3.9%. The maximum temperature difference of each treatment in day was showed at noon; SSMC2 in Changhe town had the maximum difference of 8.53 °C; CV was 21.42%; SSMC3 in Pingxiang town had the maximum difference of 7.28 °C; CV was 20.55%. Thus, soil temperature of conventional drilling was affected by sowing quantities, different ecological zones and the temperature effect obviously.



**Figure 7.** Diurnal changes of soil temperature at different soil layers under the whole growth stage

### 3.5. Correlation analysis of yield, yield components and soil temperature

As shown in table 2, with the increase of sowing quantity under the condition of SSMC, the yield increase varied was different with different ecological zones; Yield would be reduced due to excessive sowing quantities. Making a comparison of yield between two ecological regions, the yield of SSMC sowing treatments at Pingxiang Town were higher than Changhe town. Making a comparison of suitable sowing quantities between two ecological regions, the suitable sowing quantity of SSMC in different ecological regions was different; the local conventional sowing quantity 270kg/ha under the condition of SSMC at Changhe town had the highest yield; the middle sowing quantity 324kg/ha under the condition of SSMC at Pingxiang town had the highest yield. Specifically, the yield at Changhe town decreased with the increase of sowing quantities; conventional sowing quantities SSMC1 had the highest yield, which was higher than SSMC2 10.2% and SSMC3 20.2% respectively. But in Pingxiang town, the middle sowing quantity of SSMC2 had the highest yield, which was higher than SSMC1 10.1% and SSMC3 12.2% respectively. Under SSMC sowing mode, with the increase of sowing quantities, although the number of panicles per unit area increased, because of the strong self-adjustment ability, the grain number per spike was significantly higher than that of panicle number and thousand seed weight. The variation coefficient of the three elements among SSMC sowing quantities treatments was as follows: the number of grains per ear was 8.1%; Spike number was 4.5%; thousand seed weight was 3.2%. The results showed that the difference of grain number per spike was the main reason for the difference of grain yield. The effect of density on population was mainly reflected in the growth stage before grain formation. With the increase of SSMC in two ecological zones, the variation coefficient of harvest index was similar among treatments, variation coefficient was 1.19%~2.57%, and the plant

height of Pingxiang Town variation coefficient (4.57%) is larger than Changhe Town's variation coefficient (1.31%).

**Table 2.** Differences in yield, yield components, harvest index and plant height of winter wheat in different treatments

Experimental Station	Treatments	Yield (kg/ha)	Thousand Seed Weight(g)	Kernels /Spike	Spike No. of Unit Area (*10 <sup>4</sup> /ha)	Harvest Index (%)	Plant Height (cm)
Changhe Town	270 kg/ha (SSMC1)	4524.4a	48.1a	25.9a	429.0c	37%	82.5b
	324 kg/ha (SSMC2)	4103.8b	46.0b	22.2b	474.0b	38%	84.1a
	405 kg/ha (SSMC3)	3761.5c	43.3c	21.4b	479.2a	36%	84.6a
	Mean	4129.9	45.8	23.2	460.7	0.4	83.7
	CV (%)	9.25	5.25	10.36	5.99	2.57	1.31
Pingxiang Town	270 kg/ha (SSMC1)	5092.8b	45.7b	31.3b	420.1c	44%	78.1b
	324 kg/ha (SSMC2)	5711.7a	46.8a	33.4a	431.6b	43%	78.8b
	405 kg/ha (SSMC3)	5187.6b	46.3ab	29.8b	445.3a	43%	84.8a
	Mean	5330.7	46.3	31.5	432.3	0.4	80.6
	CV (%)	6.25	1.19	5.74	2.92	1.19	4.57

As shown in table 3, the correlation among yield, yield components, growth index and soil temperature varied with different ecological zones. thousand kernel weight and grain number per ear (.964\*\* and .891\*\*) had a very significant positive correlation with the yields in Changhe Town, but thousand kernel weight and grain number per ear (.708\* and .718\*) had a significant positive correlation with yield in Pingxiang Town. There was a significant positive correlation between harvest index and 10cm soil temperature (.763\*). But in Pingxiang Town grain number per ear and 15cm soil temperature showed a significant positive correlation (.671\*); 15cm soil temperature and the average temperature of 0~25cm soil layer in the whole growth period (-.687\* and -.698\*) had a significant negative correlation with the number of panicles per unit area; there was a very significant negative correlation between plant height and average temperature of 0~25cm in the whole growth period (-.906\*\*). Thus, the changes of soil temperature under SSMC different sowing quantity have indirect effect on the yield of winter wheat.

**Table 3.** Correlation analysis of yield, yield components, harvest index, plant height and mean temperature of soil layers

Correlation analysis		Yield	Thousand Seed Weight	Kernels / Spike	Spike No. of Unit Area	Harvest Index	Plant Height	
Changhe Town	Yield	1	.964**	.891**	-.892**	0.425	0.019	
	Thousand Seed Weight	.964**	1	.828**	-.832**	0.531	-0.082	
	Kernels / Spike	.891**	.828**	1	-.976**	0.164	-0.063	
	Spike No.of Unit Area	-.892**	-.832**	-.976**	1	-0.094	0.176	
	Harvest Index	0.425	0.531	0.164	-0.094	1	-0.043	
	Plant Height	0.019	-0.082	-0.063	0.176	-0.043	1	
	Mean soil temperature	5cm	-0.194	-0.102	-0.182	0.177	0.292	-0.378
		10cm	-0.022	0.120	-0.261	0.370	.763*	0.075
		15cm	-0.396	-0.264	-0.500	0.568	0.361	-0.051
		20cm	-0.080	-0.023	0.008	0.025	-0.194	-0.157
		25cm	-0.463	-0.420	-0.498	0.578	-0.134	0.426
0~25cm		-0.303	-0.191	-0.403	0.493	0.242	0.136	
Pingxiang Town	Yield	1	.708*	.718*	0.172	-0.074	-0.255	
	Thousand Seed Weight	.708*	1	0.370	0.186	-0.633	0.165	
	Kernels / Spike	.718*	0.370	1	-0.547	0.158	-0.658	
	Spike No.of Unit Area	0.172	0.186	-0.547	1	-0.160	0.582	
	Harvest Index	-0.074	-0.633	0.158	-0.160	1	-0.578	
	Plant Height	-0.255	0.165	-0.658	0.582	-0.578	1	
	Mean soil temperature	5cm	0.204	0.101	0.631	-0.662	0.000	-0.648
		10cm	-0.071	-0.104	0.276	-0.518	0.345	-.782*
		15cm	0.203	-0.083	.671*	-.687*	0.318	-.920**
		20cm	-0.019	-0.280	0.411	-0.583	0.527	-.934**
		25cm	0.440	0.449	0.526	-0.298	-0.212	-0.529
0~25cm		0.184	0.022	0.632	-.698*	0.226	-.906**	

\*: P&lt;0.05, \*\*: P&lt;0.01.

#### 4. Conclusions and discussion

This study shows, under straw mulching conventional drilling in different ecological zones, winter wheat soil temperature of 0~25cm soil depth in the whole growth period are different with the increase of sowing quantities. Too much sowing quantities had a sharp drop in soil temperature. The middle sowing quantity of 324 kg/ha (SSMC2) in Changhe town had the highest temperature, which was higher than conventional sowing quantity of 270 kg/ha (SSMC1) 0.41 °C and the highest sowing quantity of 405 kg/ha (SSMC3) 0.21 °C. The lowest sowing quantity of SSMC 1 in Pingxiang town had the highest temperature, which is respectively higher than SSMC2 0.06 °C and SSMC3 0.43 °C. Diurnal variation of different soil layer temperature in whole growth stages showed: it increases with the increase of soil depth in the morning; it decreases with the depth of the soil at noon and in the evening. The average soil temperature of middle sowing quantity of 324 kg/ha in the whole growth stage of two different ecological zones has the maximum. As a matter of fact, the effect of mulching materials on the soil temperature and yield of Winter Wheat in northwest arid area in China is obvious. With the development of winter wheat and the deepening of soil layer, soil temperature in different soil layers shows a dual effect of increasing temperature and decreasing temperature in different growth stages. It is warming effect from seedling stage to the turning green stage; it is cooling effect from the jointing stage to the end of ripening stage; all the soil layers of straw mulching show cooling effect; It promotes the growth of the crop and ensures the yield<sup>[26]</sup>. Different sowing quantity of winter wheat in northwest dry land under the condition of straw mulching wide drilling has different influence on soil temperature and yield.

Soil temperature as a comprehensive index of soil thermal status can directly or indirectly affect plant growth and development. The increase of panicle number per unit area and the increase and decrease of grain weight has an effect on the temperature of crop growth. This study shows the suitable sowing quantity of SSMC in different ecological areas is different. The local conventional sowing quantity of 270kg/ha in Changhe town has the highest yield; the middle of sowing quantities of 324kg/ha in Pingxiang town has the highest yield. Specifically, grain yield in Changhe town decrease with the increase of sowing quantities. The conventional sowing (SSMC1) has the highest yield, which is respectively higher than SSMC2 10.2% and SSMC3 20.2%. But in Pingxiang town, the middle sowing quantity (SSMC2) has the highest yield, which is respectively higher than SSMC1 10.1% and SSMC3 12.2%. The main reason for the increase of yield is the synergistic growth of its yield components. In Changhe town, straw mulching is suitable to reduce the soil temperature of 0-25 cm soil layer; under sowing quantity of 270 kg/ha, because the suitable soil temperature is favorable for spike differentiation and grain filling, The grain number per spike and thousands kernel weight increase significantly; The yield is significantly higher than other sowing density treatments; In Pingxiang Town, sowing quantity of 324 kg/ha has suitable soil temperature to promote the three elements of production developing the coordinately; The yield is higher than that of other treatments. The reason for the decline of the yield caused by the excessive amount of seeding is the same as that of Li Xiaohang et al. [20], Wang Xia, et al. [21], Jiang Lina et al. [22], Cui Lina [25], etc. Their study showed with the increase of grain yield, grain number per spike and grain weight decreased.

Some scholars showed that, the decrease of sowing quantities was beneficial to the improvement of grain yield and water use efficiency of winter wheat [27,28]. In fact, a lot of water is needed for the growth of winter wheat. Too much or too little water is not conducive to the growth and development of winter wheat; The suitable temperature increase and temperature cooling effect can effectively control the evaporation or absorption of soil water to promote the growth of winter wheat, and then has an indirect impact on yield. On the relations among straw mulching temperature, water content and yield, Cheng Hongbo et al [16] showed straw mulching doesn't only store water and retain soil moisture, but also can insulate temperature [29,30]. This may be the effect of soil temperature and hydrothermal synchronization on the yield of winter wheat. Overall, soil temperature effect caused by different sowing quantity under straw mulching conventional drilling can guarantee seedling establishment and safe wintering, laying the foundation for the increase of winter wheat. On the basis of better utilization of light and hot water resources in winter wheat, because of the effect of straw mulching on soil temperature, the number of panicles per unit area, grain number per spike and thousand kernel weight of winter wheat increase significantly. The technology of straw mulching in dry land can optimize the population structure and increase the yield by adjusting the sowing method and sowing quantity.

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