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Study on the Effects of Filling Parameters of Wheat Grain by Soil Water Control with Difference Stages

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Abstract. In order to study the character parameter difference of winter wheat grain filling, Logistic equation was used to fit the filling process by different treantments of water control, and wheat was planted in pot and rainless. The result showed that: the treatments of water control brought different effect on grain filling parameters. For days of grain filling, the variation coefficient of Tmax and T1 were relative stabilization, that of T2 was large, and that of T3 was the largest. For filling rate, R was most stable, next was Rmax、R1、R2, then was R3. The treatments of irrigation 1 time in jointing stage and 2 times in jointing stage + booting stage had obvious effect on grain filling parameters; and the other treatments had same effect. The difference of filling parameters was not significant between strong and weak grain, and filling of strong and weak grain tends to synchronize, strong grain slightly faster than the weak grain. Thus under high yield condition of Henan Province, that is advantaged to boosting yellow ripening, increasing grain weight and production, by improving filling rate of slightly increasing stage(R3), relatively prolonging days of slightly increasing stage(T3).

Keywords: winter wheat; water control; grain filling

1. Introduction

Wheat production is affected by many factors, including grain weight, an important affecting factor, and grain-filling stage is critical period of deciding grain weight. In this period, water is an important impact for wheat grain filling process and grain weight, except their own biological characteristics of wheat varieties effects[1,2,3]. In recent years, soil moisture for winter wheat grain yield and grain filling characteristics is more studied. Generally believed that, under drought conditions, winter wheat, the average filling time is relatively shorter, the average filling rate increase[4]; while researchers believe that grain weight, was positively correlated with grain filling rate, and no significant correlation with grain filling duration[5,6]; there research were more limited dry weight, fresh weight, volume change during grain filling and a certain mathematical model describes, or different varieties of types, different strains[7,8,9,10], but the cultivation factor was rare studies, especially cultivation practices. Based on the previous works, this paper attempts to providing a scientific basis for high-quality water-saving cultivation, by fitting with different water-control wheat grain filling process by Logistic equation, exploring characteristics of grain filling by analysis of a series of sub-parameters.

2. Materials and methods

The study was tested in experimental drought shed for wheat, in Xinyang agricultural college of Henan Province on 2003-2004. The test conditions: clay, medium fertility, upland rice of preceding crop, soil moisture 11.48%, maximum water holding capacity of 27.92%. Dry pool is 1.9 meters long, 0.87 meters wide, 2 meters deep, and encountered rain and snow cover during full growth period. Wheat cultivar Yu-mai 34. Fertilization pure N 12.6 kg / 667m^2, P2O5 10 kg / 667m^2, K2O 10 kg / 667m^2, then sowed in October 26th, with water pouring after sowing.

Experiment with six treatments and three repeated, (1) no irrigation with whole growth period (CK); (2) once irrigation on jointing stage, 60mm; (3) once on booting stage, 60mm; (4) twice with jointing stage 60mm and booting stage 60mm; (5) three times with jointing stage 60mm, booting stage 60mm and post-flowering 45mm; (6) four times with jointing stage 60mm, booting stage 60mm, post-flowering 45mm and 25 days of post-flowering 45mm. Other managed routine high-yield field.

Wheat stems with blossom period consistent, no pests and diseases, were marked at wheat blossom period. Sampling began from fourth days of post-flowering, once every 4 days, and 10 spike were backed to indoor every treatment each sampled. 10 wheat groats from the first and second floret of 5 central spikelet in every sample, that is 100 groats for the strong grain; the rest floret of 5 central spikelet for weak grain, and count to 1000-grain weight. 105℃ for 15 minutes to green removing, 80℃ dried to constant weighing, then weighing.

The days post-flowering (T) as independent variables, the 1000-grain weight (y) as the dependent variable, grain growth process was used Logistic equation $y = k/(1+ a\ e^{-bt})$ fitting. Where k is the maximum growth limit; a, b are constant. At the same time there grain filling parameters were derived: mean grain filling rate R (g/1000G • d); T for continuous days of filling process; maximum filling rate Rmax (g/1000G•d); Tmax (d) for the Rmax time. Grain filling process was divided into three stages: slowly increasing stage, quickly increasing stage, slightly increasing stage. T1, R1, T2, R2, T3, R3 were three stage grain filling duration (d) and grain filling rate (g/1000G•d).

3. Results and analysis

3.1. Curve of grain filling characteristics fitting

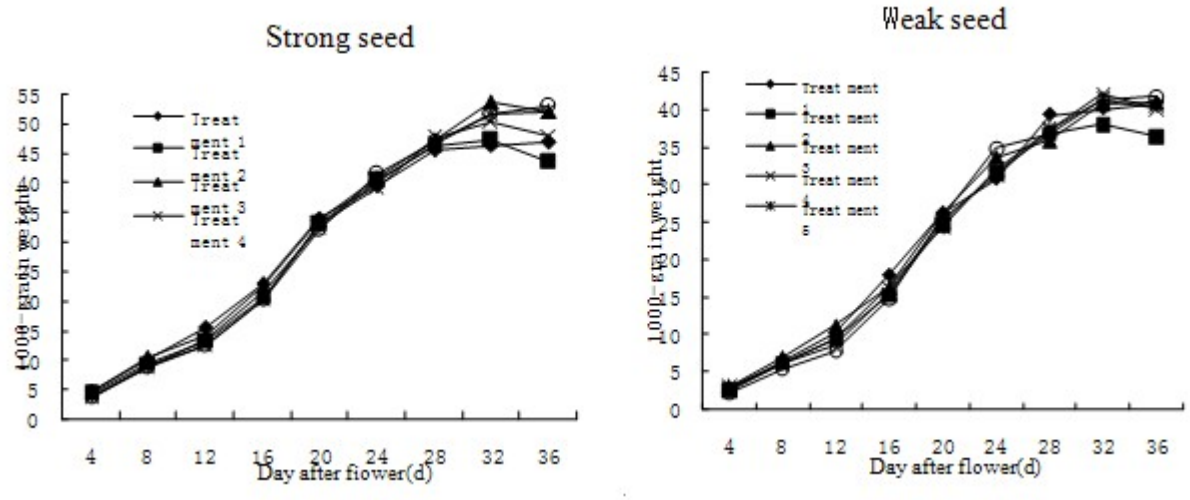

Fig. 1: Growth curve of dry weight of wheat grain under different treatments

Different parts grain of filling process from the same treatment can be seen (Fig. 1), the dry matter accumulation appear "slow-fast-slow", and suitable for Logistic growth curve fitting. The equation parameters are shown in table 1. By chi-square test [9], all the equations have reached very significant level, Logistic equation reflects the grain filling process.

Under high yield condition in Henan Province, the slowly increasing stage lasted 8.88~12.26d, grain filling rate was 0.7542~1.1591 g/1000G•d; the quickly increasing stage lasted 12.03 ~ 16.39d, grain filling rate was 1.5270 ~ 2.5770 g/1000G•d; the slightly increasing stage lasted 7.35 ~ 15.73d and grain filling rate was 0.3789 ~ 0.7366 g/1000G•d filling rate.

Table 1. Logistic equation and secondary parameter of wheat grain filling

Item	strong grain						weak grain					
	1	2	3	4	5	6	1	2	3	4	5	6

k	47.61	50.12	53.69	54.62	53.60	54.61	41.83	40.88	42.10	46.45	42.04	42.78
a	23.30	16.23	33.98	20.93	28.48	30.32	29.00	23.66	30.09	26.74	35.68	48.73
b	0.2062	0.1608	0.2190	0.1610	0.1918	0.1891	0.1924	0.1704	0.1967	0.1607	0.2052	0.2144
r	0.7670	2.3063	2.9397	6.4339	2.0642	3.4877	4.2702	3.2481	4.3589	0.5059	5.2422	3.5862
Tmax	15.27	17.33	16.10	18.89	17.47	18.04	17.51	18.56	17.30	20.45	17.42	18.13
Rmax	2.4525	2.0144	2.9362	2.1970	2.5676	2.5802	2.0102	1.7406	2.0689	1.8649	2.1546	2.2903
T	35	36	36	36	38	40	35	36	36	36	38	40
R	1.3391	1.3081	1.4870	1.3961	1.3637	1.3205	1.1668	1.0552	1.1369	1.1659	1.0884	1.0452
T1	8.88	9.14	10.09	10.71	10.60	11.07	10.66	10.84	10.61	12.26	11.00	11.98
R1	1.1329	1.1591	1.1247	1.0778	1.0688	1.0420	0.8294	0.7972	0.8386	0.8009	0.8074	0.7542
T2	12.77	16.38	12.03	16.36	13.74	13.93	13.69	15.46	13.39	16.39	12.84	12.29
R2	2.1522	1.7671	2.5770	1.9274	2.2530	2.2640	1.7639	1.5270	1.8155	1.6360	1.8908	2.0101
T3	13.35	10.48	13.88	8.93	13.67	15.00	10.65	9.71	12.00	7.35	14.16	15.73
R3	0.6980	0.3789	0.6952	0.5500	0.6987	0.6503	0.7366	0.4257	0.6436	0.4726	0.5122	0.5131
grain weight	45.34	42.86	48.30	46.56	49.29	49.29	45.34	42.86	48.30	46.56	49.29	49.29

3.2. The analysis of water control on wheat grain filling parameters

3.2.1. Water regulation on grain grouting days and the average rate of grouting effect

Wheat consumes a lot of water furing grain filling period, and in this period grain filling process will be significantly affected, if less precipitation, insufficient soil moisture[3]. The results can be seen from table 1, different irrigation treatments had some influence on the days of grain filling, as with adding irrigation frequency, filling period was prolonged, It was weak and grain all represent the same trend . This reason may be due to irrigation reducing the ground temperature, reducing the senescence of root system, extended the main blade grain grouting time period and function. The table 2 shows, water control had certain effect to mean grain filling rate, but the effect is not so significant (coefficient of variation only 0.119). that water had different effects to different parts of grain, and strong grain was more obvious than weak grains.grain weight with the increase of the irrigation frequency changing trends and grouting for the same number. this shows that under water regulation for days and filling stage grain weight close relationship, after the water grain weight increase mainly depends on filling stage last days of extended (table 1)3.2.2 The effect of water control on the mean grain filling rate.

Table 2. The parametric variation of wheat grain filling

	variation	mean	standard deviation	coefficient of variation
Tmax	5.186	17.705	1.313	0.074
Rmax	1.195	2.239	0.342	0.153
T	5.000	36.833	1.749	0.047
R	0.442	1.239	0.147	0.119
T1	3.375	10.653	0.974	0.091
R1	0.405	0.952	0.158	0.167
T2	4.365	14.105	1.628	0.115
R2	1.050	1.965	0.300	0.153
T3	8.379	12.075	2.629	0.218
R3	0.357	0.581	0.121	0.208

3.2.2. The effect of water control on Tmax and Rmax

The table 2 shows, water control had smaller effect to Tmax (coefficient of variation 0.074), and important effect to Rmax (coefficient of variation 0.153). Tmax (Table 1), strong grain was slower than weak grain, which had a smaller difference by irrigating after flowering, and had big difference between control and jointing stage irrigation 1 time and jointing stage + booting stage 2 times. In strong grains, the water

control of all treatmengs were faster than CK, where that was significantly faster in the jointing stage and booting stage irrigation 2 times than the CK, and the other treatments with no obvious difference with CK. Rmax (Table 1), strong grain was faster than weak grain, which irrigation 1 time in jointing stage and 2 times in jointing stage + booting stage were all slower than that in the CK, other treatments faster than CK, in which the maximum is in booting stage irrigation 1 time for strong grain and the treatments of irrigation 4 times for the weak grain.

3.3. The analysis of water control on different stages of wheat grain filling parameters

3.3.1. The change trend of different stages of wheat grain filling parameters

For filling days, the coefficient of variation of slowly increasing stage (T1) and quickly increasing stage (T2) were small, and that of slightly increasing stage (T3) was big. For filling rate, the coefficient of variation of quickly increasing stage (R2) was small, and those of slowly increasing stage (R1) and slightly increasing stage (R3) were big, which R3 was biggest. Thus, under high yield condition of Henan Province, water control had best obvious effect to days and rate of wheat grain filling in slowly increasing stage, so it should play a very important role for increasing grain weight, that improving the filling days and rate through water control and other cultivation measures to prolong the slowly increasing stage.

3.3.2. The effect of water control on different stages of wheat grain filling parameters

The slowly increasing stage, days of were relatively stable, and its coefficient of variation was 0.091; but the filling rate stability was poor, its coefficient of variation was 0.166. Those can be seen from Fig. 3, the days of slowly increasing stage, tha all treatmens were longer than CK, strong grain was shorter than weak grain, the longest of strong grain was the treatments of irrigation water 4 times, but that of weak grain was irrigation water 2 times with jointing stage + booting stage, then was 4 times. Slowly increasing stage was the grain formation stage, and less dry matter accumulated. Fig. 4, with adding irrigation frequency, the mean grain filling rate of strong grain decreased, and that of weak grain was not obvious, but that of strong grain was faster than that of weak grain.

Water control had greatly effect on quickly increasing stage(Table 1). The irrigation of 1 time in jointing stage and 2 times in jointing stage + booting stage prelonged day of quickly increasing stage, 1 time in booting stage shorted it, strong grain with irrigation 1 time post-flowering was longer than that of the CK, and that of weak grains was shorter than the CK. Quickly increasing stage was the key period of grain yield formation, and filling rate quick, grain weight increased rapidly. Water control had great effect on the stage of quickly increasing. The grain filling rate, decreased with the treatments of irrigation 1 time of jointing stage and 2 times of jointing stage + booting stage, and increased with 1 time of booting and 1 time of post-flowering.

At the same time, table 2 shows, water control had greater effect on slightly increasing stage. In addition, water control had same effect on the days of slightly increasing stage with different parts grain, the days were shorted with irrigation 1 time in jointing stage and 2 times in jointing stage + booting stage, and the latter more very; the days were prolonged with irrigation 1 time in booting stage and the treatments of irrigation in post-flowering, and irrigation 4 time more very. In this stsge, grain filling rate had different effects on the grain of different parts, The fillig rate of strong grain was reduced with the treatments of irrigation 1 time in jointing stage and 2 times jointing stage + booting stage, and other treatments had tiny effects; that of weak grain was reduced with all irrigation treatments, which that of 1 time of booting stage was tiny effected and other treatments were significantly effected, and the effect is not significantly different.

4. Discussion

Appropriate extension of filling days and improving the filling rate have important significance to increase grain weight. Although the relation between rate and days of filling and grain weight is in the dispute. This study shows that, under high yield condition of Henan Province, the rate and days of filling were significantly positive correlation with grain weight, and filling days and rate of slightly increasing stage plays a decisive role on the grain weight. Therefore, in production, appropriate extension of filling days and improving the filling rate have important significance to increase grain weight.

Based on the analysis of rice grain filling characteristics, Xie Guang-hui confirmed that strong grain and weak grain of different varieties, the synchronization had differences with the maximum grain filling rate (Rmax), the mean grain filling rate (R) and the time of reaching maximum filling rate (Tmax)[10]. Based on water control, this study showes that the filling of strong and weak grain tends to synchronize, strong grain slightly faster than the weak grain, therefore, in production, water control measures can make strong and weak grain reach the purpose of grain weight improving synchronization.

The grain filling rate and days of quichly increasing stage and the rate of slowly increasing stage were 3 main parameters of influencing grain weight; and the three were closely related. Filling rate and days big coefficient were the main physiological causes of grain weight flabby, which was currently the main direction to increase grain weight. Liu raised that the key to improve grain weigh were increacing rate and prolonging days of slightly increasing stage, especially reduching their volatility, on the basis of increacing filing rate of slowly increasing stage. This study argues that slightly increasing stage is more important with different water control for its more impact from water control, so prolonging filling days and increasing rate of slightly increasing stage can effectively increase grain weight, thus achieve the goal of high yield.

The results show that, different water control had different effects on grain filling parameters. Maximum grain filling rate (Tmax) and days of slowly increasing stage (T1) are stable, maximum grain filling rate (Rmax), mean grain filling rate (R), grain filling rate of slowly increasing stage (R1), days of quichly increasing stage (T2), rate of quichly increasing stage (R2) have poor stability, and days (T3) and rate (R3) of slightly increasing stage are the most unstable, irrigation 1 time in jointing stage and 2 times in jointing stage + booting stage have the same effect on grain filling parameters, other irrigation treatments have the same effect. So under high yield condition of Henan Province, improving filling rate of slightly increasing stage, relatively prolonging days of slightly increasing stage, boosting yellow ripening stag, is advantaged to raise productivity.

5. References

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