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Full Length Research Paper

Physiological basis for allelopathic potential of different wheat cultivars in heading period on the Loess Plateau of China

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The relationship between fluorescence kinetics and allelopathic expression of four winter-wheat ecotypes in heading period was discussed. With the breeding history from No. 1 Bima, No. 3 Fengchan, No. 1 Ningdong to No 22 Xiaoyan and agronomic properties of winter wheat like thousand seed weight and yield, etc increased gradually. Meanwhile, allelopathic potential was also enhanced. It was explained well by physiological basis of fluorescence kinetics. Fm' and F was induced to increase, furthermore, photosynthesis system PSII would be expressed superiorly under arid press. Significant relationship among growth traits, florescence kinetics and allelopathic potential was discovered. Three kinds of parameters like yield, chlorophyll and allelopathic potential of winter wheat in heading period formed a complex network system. So, allelopathy variation was mainly determined and regulated by the presumed net system in plants. It is important in screening and breeding of allelopathic crops cultivars, including development of sustainable agriculture.

Key words: Allelopathy trait, fluorescence kinetics, *Triticum aestivum* L., dryland farming, network system.

INTRODUCTION

Chlorophyll fluorescence from the plant adhered closely to response process in photosynthesis effect. Chlorophyll a in the plant will reveal more information related to plant photosynthesis, especially under environmental press (Van and Snel, 1990). Chlorophyll fluorescence is applied widely in more fields such as crops, forestry and fruits, among which artificial breeding, planting and physiological ecology in wheat study were correlated (Lichtenthaler et al., 1986). In recent years, a great deal of researches on the mechanism of photosynthesis effect and the forecast of enhancing crop yield were conducted by utilizing chlorophyll fluorescence technique all over the world. Some study on different wheat cultivars suggested that under stronger light press at noon the most efficiency of PSII photo-chemistry of wheat variety with high protein decreased, but the rate of photo respiration enhanced significantly, meanwhile, photosynthesis rate falls (Lu and Zhang, 1998). Photosynthesis efficiency in crops from dryland farming ecosystem was determined mainly by both interior genetic factors and exterior environmental circumstance, for example, field water and fertilizer condition. However, the variation of chlorophyll fluorescence parameters was caused mostly by the differences in crops genotype (Slapakauskas and Ruzgas, 2005). Water is one of the necessary factors affecting the growth and development of plant. Soil drought would result in the decline of photosynthesis efficiency. If nitrogen fertilizer was supplemented in time and in definitive scale so as to compensate for photosynthesis response by water deficit, which will increase leaves area to improve and enhance photosynthesis capacity. Therefore, water, nitrogen and their interaction were crucial to the function of plant photo-system (Shangguan

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et al., 2000).

Vernalization, photoperiod and precocious property, as three important characteristics influencing wheat growth and development in heading period, would regulate growth stages to deal with different environmental press by their function and interaction (Sourdille et al., 2000). With genetic control in heading period, wheat will resist and adapt to different presses from the environment. So in view of the evolution, wheat has enhanced its adaptive ability with the time. The adaptability was directly related to growth characteristics of wheat in heading period. In heading stage of wheat the differentiation of young tassel determined the establishment of wheat ears and seeds per tassel, which was affected by genotype feature and living environment like terrain, soil water and climate etc. The time of heading period of wheat would determine grouting efficiency and affect seeds weight. But to stabilize and increase sees weight would be the future direction of improving yield of wheat (Erickson and Fernandez, 2006). So it was necessary to conduct physiological ecology of wheat in heading period so as to naturally screen useful genetic variation adapting widely and culture reasonable genotype complying with the nature.

At present, plant allelopathy has gradually become a hot technology in modern agriculture field. It was applied widely in agricultural production and scientific research. It shows most especially the application potential in the improvement of agricultural measurements, the adjustment of tillage systems and the sustainable agriculture. However, up to today, studies on allelopathy in wheat focused mainly on isolation and identification of allelochemicals and scientific assessment of allelopathic potential of crop resources, etc (Wu et al., 2000, 2001). In China, wheat covered a large area of planting. Based on growth zones and cultivars ecotype, Chinese wheat regions would be divided into 3 main districts and 10 sub-districts. In the Loess Plateau, as significant wheat production area in China, belongs typical drought climate of continental feature and cultures high yield and better quality crops, with artificial irrigation of crops, low precipitation, plentiful sunlight and abundant heat for specific regional characteristics. The trait of temperature-light effects and relative growth and development has been studied concretely for wheat accessions in different ecotypes (Koa et al., 2010).

However, there was no report for the biological basis on chlorophyll fluorescence kinetics of typical wheat varieties from different allelopathic ecotypes. So, four typically allelopathic wheat cultivars were introduced to deeply study and compared with their chlorophyll fluorescence as the mechanism of allelopathic variation of different wheat ecotypes in heading period and further analyze variation law of allelopathic ecotypes and obtain their physiological basis. In this way, the whole synergic mechanism of different allelopathic wheat ecotypes will be exposed, which was helpful for enhancing photosynthesis productivity, improving and breeding high resistant and yield wheat, which provide valuable theory reference for ecological breeding and sustainable agriculture.

MATERIALS AND METHODS

Trial location and natural circumstance

Test field, located in trial base of Institute of Soil and Water Conservation, belongs to the upland of Guanzhong region of gully hilly area of the Loess Plateau with the height of 1200 m. The area was subordinate to semi-wet and arid climate of warm temperate zone with annual mean precipitation of 584 mm, annual mean temperature of 9.1°C and frost-free period of 171 days.

Field test was designed in drought tillage farming without any irrigation and dependant on precipitation in green house, which maintained arid circumstance for about 35% soil water of field water capacity. The test location was in plain, accumulated deeper loess with the soil of Chinese Lou soil for more years' tilling. Before the trial, the tillage layer of 0 to 20 cm soil contained organic matter of 10.4 $g·kg^{-1}$, total nitrogrn of 0.60 $g·kg^{-1}$, base dissolving N of 37.0 $mg·kg^{-1}$, available phosphorus of 3.0 $mg·kg^{-1}$, available potassium of 129 $mg·kg^{-1}$ and pH 8.3. The rotation system of winter wheat and summer corn dominated the region, whose area possesses 70 to 80% of the total area with the rest for other crops (Zuo et al., 2010).

The measurement of growth and allelopathic potential

Four typical common wheat genotypes expressing certain allelopathic potential were selected by the present allelopathy laboratory in institute of Soil and Water Conservation, Chinese Academy of Sciences and Ministry of Water Resources, named as No. 1 Bima, No. 3 Fengchan, No. 1 Ningdong and No. 22 Xiaoyan (Zuo and Ma, 2006). On 5 April 2006 of heading period of winter wheat in field trial, growth parameters like plant height, the area of flag leaf, the length of the spike and the diameter of main stem was measured respectively by the tape ruler, leaf area measurer, general ruler and vernier caliper. While wheat has heading period in field test, after the mentioned earlier growth investigation was finished, 10 wheat plants samples were collected. The roots about 0 to 20 cm and aerials parts were cleansed and shattered respectively to powder after their freezing dry in low temperature, which was saved in refrigeration for further utilization. At maturity, wheat was harvested and dried at room temperature. Agronomic traits like plant height, thousand seed weight and net productivity per hectare, etc, were calculated based on the mean of the earlier stated parameters of 10 wheat plants.

In this study, modified genetic potato introduced by CuZnSOD and APX genes and the control without introducing exotic genes (Figure 1), presented by Dr. Kim from Gyeongsang National University in Korea in 2004, was assayed as mode acceptor to wheat allelopathy (Kim et al., 2003).

The young stem of 1.5 to 2 cm from seedling top was cut down in sterilized test worktable and put into solid culture medium followed as 3/2MS with 3 ml/l of NAA, 3% of sucrose, 0.75% of agar in PH 5.8 as a inducement medium for callus tissue under 2000 Lx of light for photoperiod of 12/12 h in 25±1°C.

Each treatment was replicated for six times at least, each time three explants of stem tips were collected in a 200 ml Erlenmeyer flasks containing 50 ml medium, among which wheat powder were added for 20 mg/ml with the control for no wheat powder. After 30 days culturing, under the concentration, some relative index such as the maximum root length, root number, plant height, mean stem diameter, branch number, leaves number per plant, maximum leaf area and stem and root fresh weight were investigated. Allelopathic

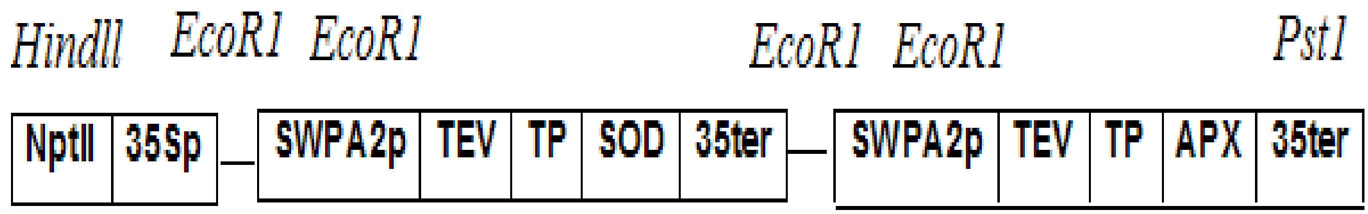

Figure 1. The SSA mode of expression vector in modified genetic potato introduced by CuZnSOD and APX genes.

potential as response index for all inhibitive effect in this study came from mean values of tested relative parameters calculated by Zuo (2005).

The survey of fluorescence kinetics

To four typical wheat ecotypes in heading period, 3 to 5 active leaves including flag leaf were screened randomly. After dark adaptation of 30 min, chlorophyll fluorescence imaging system as imaging PAM made in Walz Germany was adopted to investigate relative parameters in fluorescence kinetics and then the analysis software of fluorescence images as Imagingwin Walz were used to analyze the indices. Imaging PAM showed the following standard.

MAG-MIN/B was blue of 450 nm, room temperature for 25 ± 2°C, light strength for 300 μmol·m^{-2}·s^{-1}, fluorescence kinetics parameters were read out directly, concluding the maximum fluorescence output as Fm', the instant fluorescence yield as F, the concrete quanta photon yield as Y(II), the regulated and non-regulated energy dissipation as Y(NPQ) and Y(NO). Non-photochemical and photochemical quenching of chlorophyll fluorescence as qN and NPQ and both coefficients as qP and qL and apparent photosynthetic electron transport rate as ETR. With the help of the imaging win software, selected areas of inters can be further analyzed with respect to induction curves for 5 min interval (Ralph et al., 2005).

Statistic analysis

ANOVA analysis by LSD or T-test was introduced for all calculated parameters in 3 replications. Data treatment including cluster analysis was conducted by SPSS10.0. While comparing both strains, significant level for 5 and 1% was displayed as * and **, or small letter and capital letter, respectively.

RESULTS

Growth characteristics of wheat ecotypes in heading period

In comparison of growth property of four wheat ecotypes in heading period, with the breeding from cv. No 1 Bima, cv No 3 Fengchan, cv No 1 Nindong and cv No 22 Xiaoyan, plant height and spike length declined gradually (Figure 2a and b), which implied that both decreased by 15.1 and 39.4% and 3 and 22.1%, respectively. Differing from the upper, stem diameter of wheat main stem increased by mean of 11.5 to 23.5% except for decline trend of stem diameter cv No 1 Ningdong (Figure 2d). However, there was no significant change of flag leaf area in four wheat ecotypes as seen from Figure 2c. In sight of Figure 1, the mean ranges in theory of growth parameters like plant height, spike length, flag leaf area and stem diameter in four wheat ecotypes should be about 88cm, 8.0cm, 7.6cm^2 and 3.5 mm, respectively.

Allelopathic potential of four wheat ecotypes with different genetic background

In germination and seedling stages, wheat was apt to produce and exude allelochemicals like hydroxylamine and phenolic acids, which lead to allelopathic effect and further suppress weed growth such as annual ryegrass, etc (Huang et al., 2000). However, in heading period, four wheat ecotypes showed prominent allelopathic potential, as seen in Figure 3. In view of half inhibition, aerial parts of wheat materials displayed stronger allelopathic suppression of non-transgenic potato than that of roots, but to transgenic potato, in contrast, roots exhibited stronger allelopathic potential (Figure 4). Wheat ecotypes plants showed significant difference in allelopathic inhibition on relative growth parameters (Figure 3). For allelopathic effect of wheat plants on transgenic potato, aerial parts showed the following declined order based on allelopathic rank like total fresh weight of seedling> main stem diameter> branches per plant> root number>the maximal leaf area> shoot weight of seedling>plant height>leaves number per plant>the maximal root length (Figure 3a). Differing from allelopathic effect of aerial parts, roots displayed another order of strongest allelopathic effect on shoot fresh weight of seedling>the maximal leaf area>main stem diameter>root number>branches per plant> total fresh weight of seedling (Figure 3b). Meanwhile, there was significant difference in allelopathic effect on transgene and non-transgene potato by wheat ecotypes. The aerial parts of wheat ecotypes showed declined trend of allelopathic effect on non-transgenic potato as in total fresh weight of seedlings, plant height, root number, maximal leaf area, main stem diameter, stem fresh weight of seedling, leaves number per plant, branches per plant and maximal root length (Figure 3c). However, roots showed different allelopathy order comparing with aerial parts to non-transgenic potato, whose increased with was in root number, maximal leaf area, leaf number per plant, total fresh weight of seedling, branches per plant, main stem

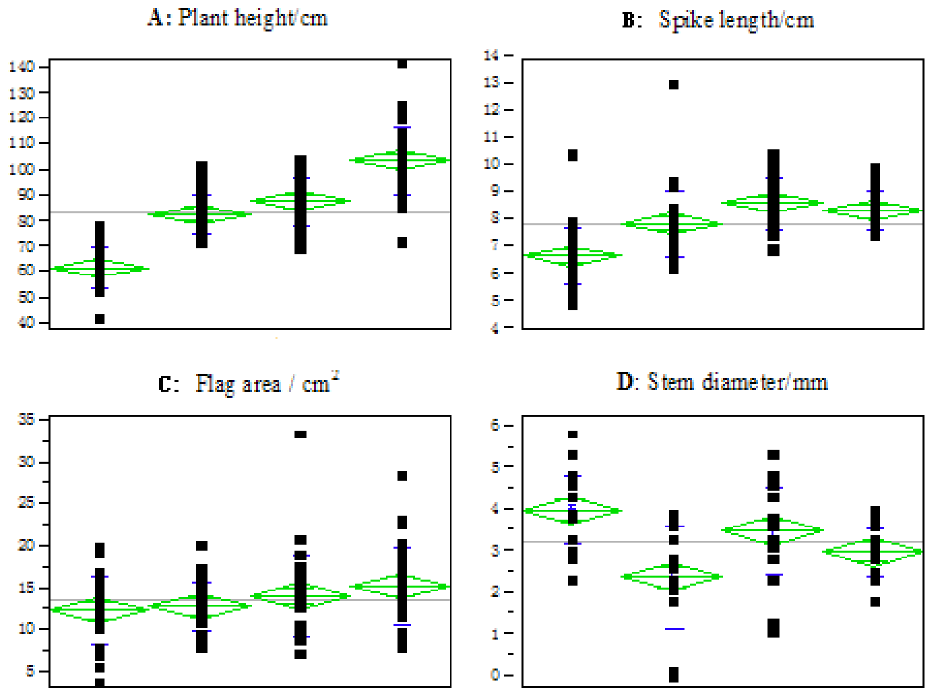

Figure 2. Partial growth parameters of four wheat ecotypes in heading period.

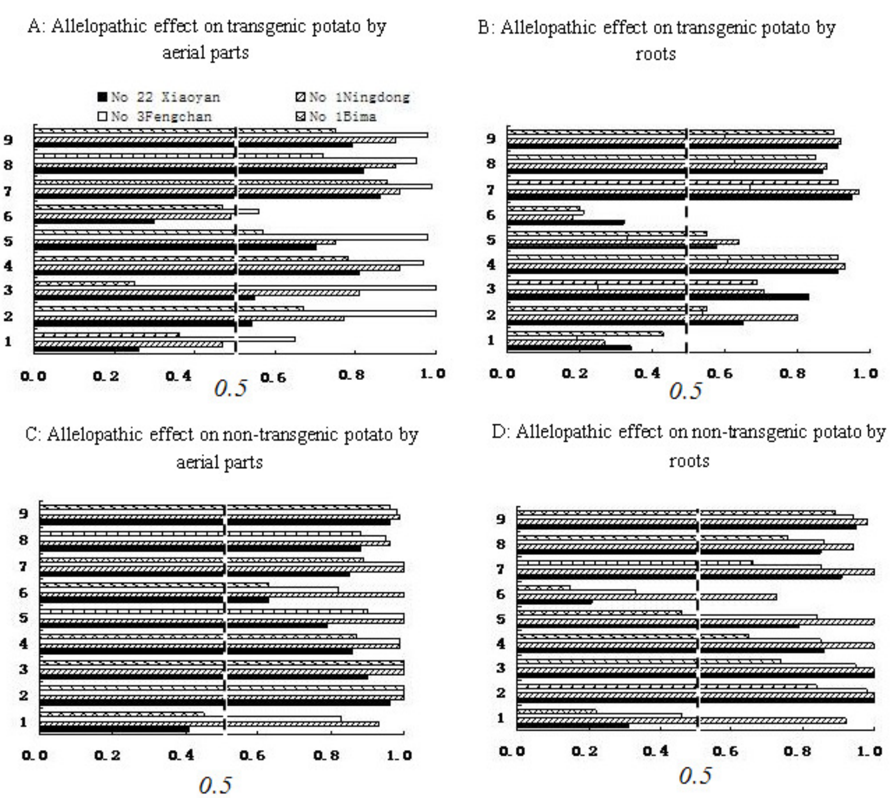

Figure 3. Allelopathic inhibition of four wheat ecotypes in heading period to potato (1plant height/cm ; 2 root number ; 3 the maximal root length/cm ; 4 leaf number per plant ; 5 the maximal leaf area/mm2 ;6 main stem diameter/mm ;7 branches per plant ;8 shoot fresh weight

of seedling/g ; 9 total fresh weight of seedling/g)

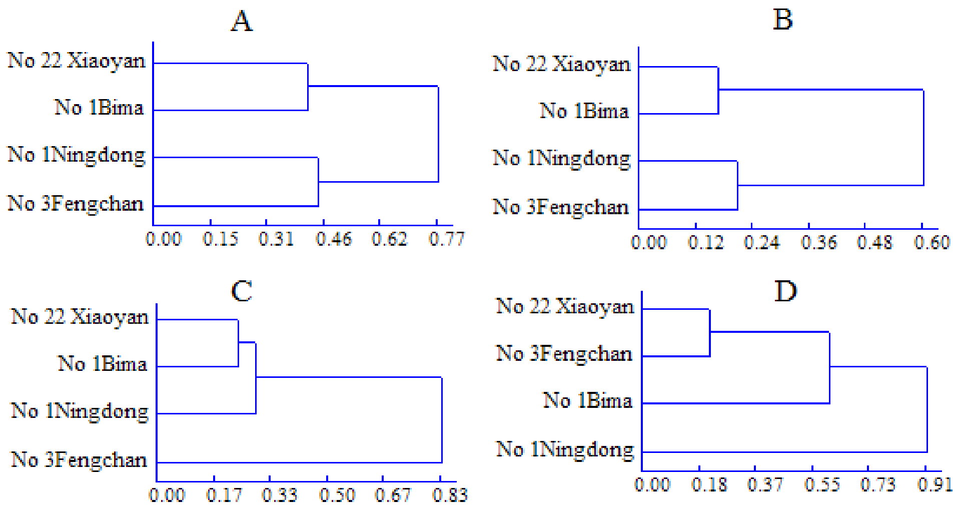

Figure 4. Mean allelopathic potential of four wheat ecotypes in relation to potato in heading period (A to D: as in Figure 3).

Table 1. Typical parameters of fluorescence kinetics of four wheat ecotypes in heading period.

Fluorescence parameter	No 1 Bima	No 3 Fengchan	No 1 Ningdong	No 22 Xiaoyan
Fm'	0.19^{bB}	0.21^{aA}	0.17^{cC}	0.22^{aA}
F	0.12^{aA}	0.13^{aA}	0.10^{bB}	0.14^{aA}
Y(II)	0.34^{cC}	0.40^{aA}	0.39^{bAB}	0.37^{bB}
Y(NPQ)	0.32^{aA}	0.25^{cC}	0.28^{bB}	0.26^{cC}
Y(NO)	0.34^{bAB}	0.34^{bAB}	0.33^{bB}	0.37^{aA}
NPQ	0.20^{aA}	0.16^{bcB}	0.17^{bB}	0.15^{cB}
qN	0.56^{aA}	0.48^{cB}	0.53^{bA}	0.48^{cB}
qP	0.58^{bB}	0.60^{bB}	0.66^{aA}	0.57^{bB}
qL	0.36^{bB}	0.33^{cB}	0.45^{aA}	0.35^{bcB}
ETR	29.25^{cC}	34.70^{aA}	33.13^{bAB}	31.52^{bB}

Fm', Maximum fluorescence output; F, instant fluorescence yield; Y(II), concrete quanta photon yield; Y(NPQ), regulated energy dissipations; Y(NO), non-regulated energy dissipations; NPQ, photochemical quenching of chlorophyll fluorescence; qN, non-photochemical quenching of chlorophyll fluorescence; qP and qL, coefficients; ETR, apparent photosynthetic electron transport rate. Small letter and capital letter, significant at at 5% and 1% respectively.

diameter, maximal root length, plant height and stem fresh weight of seedling (Figure 3d).

Based on clustering analyses by mean allelopathic potential of each growth index, four wheat ecotypes plant in heading period exhibited significant difference in comprehensive allelopathic expression (Figure 4). On the whole level, four wheat ecotypes displayed weak allelopathic inhibitive potential to transgenic potato (0.18 to 0.40). Allelopathic inhibition in No 1 Bima and No 22 Xiaoyan was weaker than that of No 3 Fengchan and No 1 Ningdong. But there was no significant difference in both groups (Figure 4a, b). However, four wheat ecotypes showed stronger allelopathic inhibition of non-transgenic potato (0.20 to 0.90), whose aerial declined in allelopathic potential with No 3 Fengchan, No 1 Ningdong, No 1 Bima and No 22 Xiaoyan, and similarly, roots allelopathy increased with No 22 Xiaoyan, No 1 Bima, No 3 Fengchan and No 1 Ningdong (Figure 4a, d). These results imply that both CuZnSOD and APX transgenic and non-transgenic potato responded to allelopathic press inconsistently, among which transgenic potato showed stronger resistance to exotic allelopathy and non-transgenic potato was sensitive to allelopathy pressure.

Variation of fluorescence kinetics of four wheat ecotypes in heading period

Under drought press, T1/2 of wheat flag leaf declined, Fv/Fm and Fv/Fo decreased and with press enhancing, their decreasing degree become more prominent. In

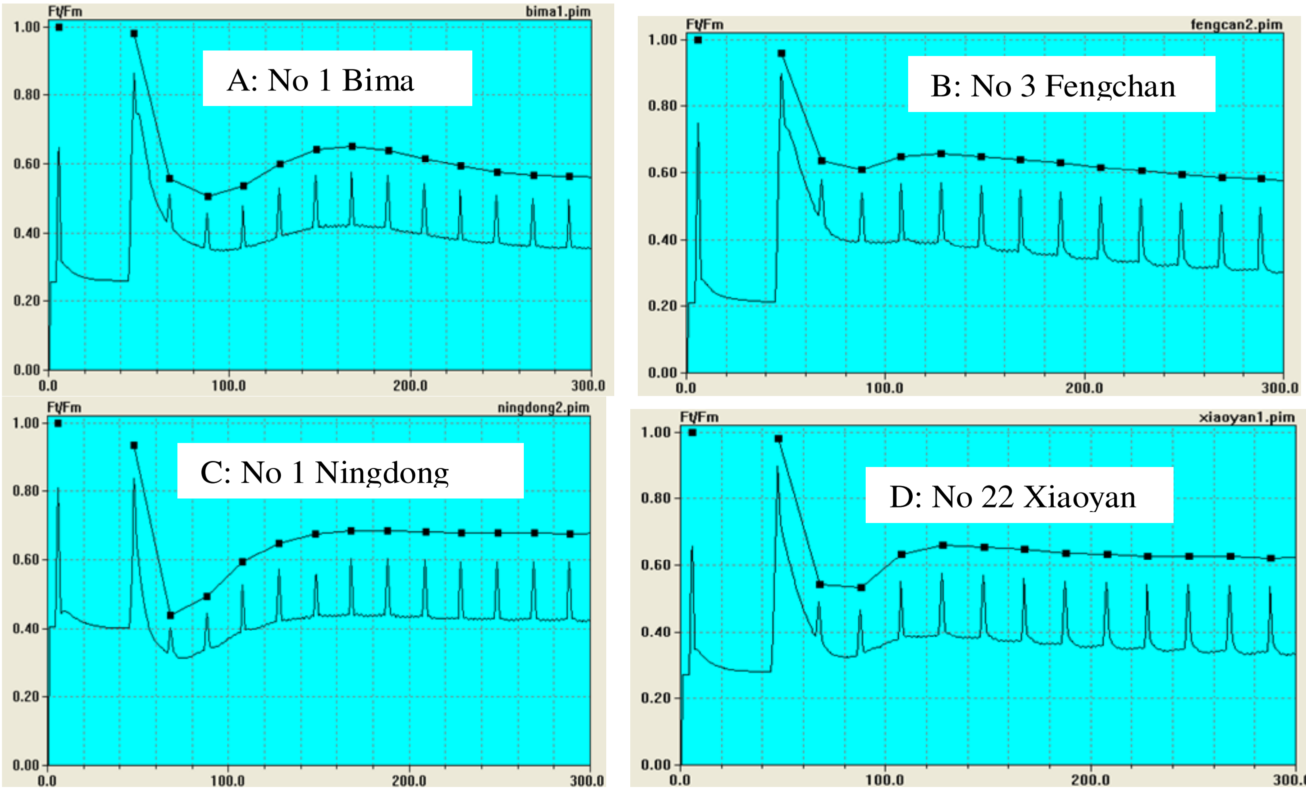

Figure 5. Induction curve of fluorescence kinetics of four wheat ecotypes in heading period.

Table 1, significant difference in partial parameters in fluorescence kinetics fully reflected that wheat in different regions and in various time breeding formed their specific ecotypes under long term evolution and screen-breeding history. From Table 1, when imaging Pam began to work, the maximal fluorescence yield increased from No 1 Bima, No 3 Fengchan to No 22 Xiaoyan as well as Fm', F and Y(NO) gradually.

Contrarily, NPQ and qN decreased significantly. But Y(II), Qp, qL and ETR enhanced firstly and then declined, Y(NPQ) first decreased and then increased. In the variation order, relative parameters of fluorescence kinetics in No 1 Ningdong ranged in the series.

These documentation meant that under artificial breeding and environmental induction, with the breeding and popularized history, light energy transition efficiency of PS II system of four wheat ecotypes in heading period and its potential activity enhanced, of course, inner energy consumption decreased, furthermore, which assured normal pass of photosynthesis electron. The earlier mentioned change came from helpful induction of artificial breeding and interaction of environment and gene, which was opposite to variation of fluorescence kinetics from adverse environment under exotic press. For example, Fv/Fm, Fv/Fo, yield and Rfd of sugarcane in seedling stage fell within gradually increasing water press (Luo et al., 2004). Similarly, under salt pressure, Fv/Fm and Fv/Fo of maize leaves significantly decreased (Guo and Zhao, 2001). For artificial enhancement of wheat breeding and natural decreased of some plants under environmental press in fluorescence kinetics parameters, it implied that PSII system change directly affected variation of fluorescence kinetics. However, the variation can be regulated appropriately by artificial management.

Induction curve of fluorescence kinetics of four wheat ecotypes in heading period

Induction curve of fluorescence kinetics of four wheat ecotypes in heading period contained great deal of information of primary photochemistry response of PSII system (Figures 5, Fm' and Ft curves). Based on specific type of induction curve of fluorescence kinetics, it was known that with the breeding press combined with inductive effect from specific environment of the Loess Plateau like drought and more ultraviolet, four wheat ecotypes showed an adaptive change in photosynthesis organ and its photo effects. Four wheat ecotypes reflected four typical types of induction curve of fluorescence kinetics, which implied four pathways of photo electron pass from donor nearby of PSII system to donor side and oxidation and reduction change of electron vectors like QA, QB and PQ bank.

Based on Imaging PAM, after dark adaptation for some

long term, environmental factors as limit condition of crop yield, genetic traits would determine the increase of crop yield. Genetic mode, specific evolution and artificial breeding in wheat led to different ecotypes (Singh et al., 2000). In this study, the similarity and difference of agronomic property, allelopathic potential and fluorescence kinetics in wheat ecotypes was investigated based on arid land farming of the Loess Plateau of china.

term, active leaves of wheat ecotypes in heading period were exposed to strong light (300 $\mu E/m^2s$), and then fluorescence kinetics was induced and chlorophyll molecular would emit weak near-ultra-red (K ≈ 685 nm) whose change strength show certain law. The above response meant the change of photosynthesis process from the beginning open to the stable status, which depends on wheat ecotype. In Figure 4, there was significant difference in induction curve of fluorescence kinetics of four wheat ecotypes in heading period. No 1 Bima fluorescence induction curve strictly complied with the inductive kinetics process by Kautsky and Hirsch (1931) and Papageorgiou in midst term of 1970s, it concluded such a course from O (the origin) →É (the deflexion) →D (the delve) or PL (the stage) →P (the peak) →S (semi-stable status)→M (the hypo-peak) →T (the end) (Figure 5A).

Similarly, No 3 Fengchan basically accorded with the typical process of inductive curve except for persisting decline from M to T point, which implied that photosynthesis system would waste partial energy as heat and fluorescence dissipation, while transporting photo electrons after trapping light energy (Figure 5B) . Differing from the above two forms, No 1 ningdong and No 22 Xiaoyan showed another types, although, consisting with Kautsky and Papageorgiou curve. The former expressed stable process from M to T, but the latter showed first decreasing and then reaching stable status (Figure 5C and D).

This description suggested that in energy flowage the energy antenna pigment (Ch1) absorbing (ABS) would lost part energy for heat and fluorescence (F), the rest energy would be trapped and activated to transform as reductive energy in response center (RC) in JIP measurement. Q_A was deoxidized as Q_A^-, the latter was reoxidized and kept overall energy stable so as to assure normal electron transport (ET) and stabilize CO_2 by flowing electron (Slapakauskas and Ruzgas, 2005; Sourdille, 2000).

DISCUSSION

Growth characteristics, allelopathic potential and fluorescence kinetics of four wheat ecotypes in heading period under artificial screening pressure

To propel crops growth and enhance its yield and quality was one of the important objects in artificial breeding update (Foulkes et al., 2011). In breeding history for a

With the breeding from cv. No 1 Bima, cv No 3 Fengchan, cv No 1 Nindong and cv No 22 Xiaoyan, yield factors like spikelet number per plant, grains per spike, thousand seeds weight, and yield increased, but plant height decreased, which implied that to regulate matters and energy transform and distribution between crops and environment would control growth and development of crops and determine the final yield, that is to say, it was the process of matter allocation, accumulation balance in both canopy and roots under certain environment. These obeyed to the terminal aims of crop artificial breeding.

In sight of allelopathic variation on the whole level, four wheat ecotypes such as cv. No 1 Bima, cv No 3 Fengchan, cv No 1 Nindong and cv No 22 Xiaoyan show stronger allelopathic inhibition of potato of whether transgenic or non-transgenic cultivar, whose allelopathic index was 0.68, 0.77, 0.84 and 0.86 respectively. Therefore, with artificial breeding for perusing higher yield, allelopathic potential was enhanced and then their resistance of exotic press and adaptability to the environment was improved so that it resulted in their wide popularization. These findings of higher allelopathic potential didn't comply with the results in theory from systematic engineering principle, but the allelopathic trend of No 22 xiaoyan> No 1 Ningdong>No 3 fengchan>No 1Biam was consistent. Its possible explanation was the difference of assessment methods and standard. Physiological change of plants like senescence and damange, or under environmental press like Fe deficit, Mn hungry, high or low temperature, salt pressure, and drought etc directly and indirectly affected the function of PSII system (Van and Snel 1990; Fryer et al., 1998). In this study, genotype difference of four wheat ecotypes caused variation of not only allelopathic potential, and but also fluorescence kinetics and its induction curve. With the history of cv. No 1 Bima, cv No 3 Fengchan, cv No 1 Nindong and cv No 22 Xiaoyan, Fm' and F displayed increase trend, contrarily, NPQ and qN decreased. This illumination implied that in breeding pressure, wheat enhanced its capacity of absorbing and transforming light energy in PSII system with less heat dissipation, which also compensate for energy requirement of higher yield and stronger allelopathic potential.

The network of growth characteristics, allelopathic potential and fluorescence kinetics of four wheat

ecotypes based on their correlation

The method of chlorophyll fluorescence kinetics may monitor and analyzed the effects of adverse environment on photosynthesis physiology rapidly and sensitively. But in this study, chlorophyll fluorescence in plants would monitor and assay allelopathic potential of four wheat ecotypes as checking probes because of physiological basis for allelopathic variation, which differed from

Table 2. Regression analyses of allelopathy in wheat ecotypes and agronomic traits and fluorescence kinetics†.

Parmeter	Property	R	P	Parmeter	Property	R	P
Plant height [1]	-	0.9146	0.01**	Fm'	+	0.8785	0.05*
Spike length	-	0.7223	0.05*	F	+	0.9912	0.05*
Stem diameter	+	0.1915	0.56	Y(II)	-	0.4949	0.24
Flag leaf area	+	0.9939	0.01**	Y(NPQ)	+	0.322	0.35
Plant height [2]	-	0.9772	0.01**	Y(NO)	+	0.6832	0.05*
Spikelet s per plant	+	0.7455	0.05*	NPQ	-	0.2398	0.62
Grains per spike	-	0.7455	0.05*	qN	-	0.3843	0.40
Thousand seeds weight	+	0.7872	0.05*	qP	-	0.6449	0.05*
yield	+	0.7285	0.05*	qL	-	0.7240	0.05*
Life cycle	-	0.0773	0.78	ETR	-	0.5198	0.06

†: Positive or negative: + or -; 1: in heading period, 2 : in mature stage. * and **, significant at 5 and 1% respectively

Table 3. Regression analyses of agronomic traits in wheat ecotypes and fluorescence kinetics†.

Parameter	Fm'1	F1	Y(II)	Y(NPQ)	Y(NO)	NPQ	qN	qP	qL	ETR
Plant height [1]	-0.7733*	-0.6547*	0.9875**	-0.1267	-0.8187*	0.7357*	0.7403*	0.7005*	0.6315*	-0.8247*
Spike length	0.9486**	-0.7369*	0.9567*	-0.0589	-0.8995*	0.5906	0.5887	0.7507*	0.6409*	-0.9601*
Stem diameter	-0.8265*	0.7738*	0.0048	-0.4063	-0.7362*	0.5003	0.5005	0.5113	0.0326	0.4732
Flag leaf area	0.7082*	0.8802*	-0.5612	0.6176*	0.7180*	-0.8907*	-0.8897*	-0.9934**	-0.7408*	0.0702
Plant height [2]	-0.6658*	-0.7264*	0.9279*	-0.3687	-0.7097*	0.7356*	0.7407*	0.7215*	0.8711*	-0.9187*
Spikelet s per plant	0.7849*	0.7834*	-0.5456	0.7094*	0.7654*	-0.9207*	-0.9164*	-0.9346*	-0.6225*	0.0795
Grains per spike	0.7233*	0.9369*	-0.7058*	0.5670	0.7087*	-0.9357*	-0.9356*	-0.9346*	-0.6213*	0.2776
Thousand seeds weight	0.8049*	0.8083*	-0.8088*	-0.2897	-0.7456*	-0.2602	-0.2567	-0.9106*	-0.8635*	0.9476*
yield	0.9768**	0.9033*	-0.8725*	-0.2665	-0.9873*	-0.4304	-0.4286	-0.9749**	-0.8909*	0.7780*
Life cycle	-0.8885*	0.9075*	0.0096	-0.3776	-0.7105*	0.4567	0.4606	0.4804	-0.0100	0.5000

†:Positive or negative: + or -; 1:in heading period, 2 : in mature stage. * and **, significant at 5% and 1% respectively

fluorescence phenomena of allelochemicals spectrum (Roshchina et al., 2005). Generally, the strength of environmental press showed significant relationship with the inhibitive degree of Fv/ Fm, Fv/ Fo, ΦPS II, Rfd, qP, qN, fluorescence Yield, which, depending on plant kinds and pressure types, may be considered as resistance index (Van et al., 1990). In China, Kong et al. (2008) discovered that allelopathic traits of some rice accessions weren't related to agronomic properties. Differing from their ideas, in this study, growth characteristics, allelopathic potential and fluorescence kinetics of four wheat ecotypes showed significant relationship, which was a mutual-correlation complex network (Tables 2 and 3).

Regression analyses of agronomic traits, allelopathic potential and fluorescence kinetics parameters suggested that three features correlated well and closely. It implied that some index like plant height, spike length, flag leaf area, spikelet number per plant, grains per spike, thousand seeds weight and yield, and fluorescence indicators such as Fm'、F、Y(NO)、qP、and qL would be considered as appraisal target of allelopathic potential. Allelopathic potential in plants was related to many factors like interior allelochemicals, habitat choice, growth stages and photosynthesis and transpiration etc, so three multiple relationships of agronomic traits, allelopathic potential and fluorescence kinetics parameters was only one part of growth network. At present, besides for heading period, chlorophyll fluorescence kinetics of wheat in life cycle still call for full and novel theory. How does PSII system regulate heat dissipation and energy compensation to maintain normal plant growth and supplement physiological consume in fighting exotic press in allelopathic potential? In addition, is there any correlation in oxygen species and activity loss of PSII response center under long term conventional tillage and drought farming modes? It had better link spectrum of photosynthesis and oxygen responses etc (Rice, 1974).

The whole adaptation and system synergism of wheat ecotypes in evolution and breeding

The whole adaptation and system synergism meant fight against exotic pressure by combining more genes, many

will acquire stable mutation as typical expensive materials for future study and sustainable agriculture (Zuo et al., 2005). For common wheat, the novel cultivars are generated by artificial mutation, hybridization breeding and genetic engineering etc. At present, allelopathic accession culturing was finished by more steps like first bioassay of allelopathic potential in allelochemical identification, and then complex hybridization or allelopathic gene transplanting (Jensen et al., 2001). So under whole adaptation and system synergism from self

traits and great deal factors in the overall life cycle including vegetative and reproductive stages, the harvest, save and dormancy periods of seeds, mainly based on whole resistance of environmental press. For example, allelopathic potential as one of resistant capacity, would reduce the endanger of exotic adverse factors to growth and development, yield establishment and life cycle, which would be embodied on the molecular, cell, tissue and organ, individual and plant, population and community, sub-system ands even the whole ecosystem (Sanchez and Reigosa, 2005) . In this study, as we all know four wheat ecotypes of cv. No 1 Bima, cv No 3 Fengchan, cv No 1 Nindong and cv No 22 Xiaoyan had been popularized widely in different times. They possessed more resistant capacities like anti-drought, anti-salt and alkaline, anti-lodge, anti-weed (allelopathy), and anti-pathogen of bar-rust etc in various growth stages, but still acquire uniquely high yield. Among these resistance, allelopathic potential and expression in plant was regulated and controlled by more genes and QTLs including physiological basis like fluorescence kinetics, biochemical response and molecular operation etc (Wu et al., 2003).

Of course, plant can also express comprehensive resistance capacity. In this study, allelopathic potential in wheat was deduced to correlate well with other press resistance like anti-drought. These resistances would form subsystem to commonly fight against environmental press in more styles like withdrawing, fighting and tolerance. Allelopathic express showed significant time-space series feature, which was determined by gradual program expression of trait gene in life cycle as phase characteristics. So in different growth period, allelopathic potential displayed inconsistently. From Tables 2 and 3, allelopathy expression deal with whole adaptation and system synergism (Zuo et al., 2006). It implied that after whole regulation of plants self, crops could achieve better resistance and higher yield. In the evolution and artificial breeding of crops, allelopathic potential had accumulative effect which fully explains the increased trend of the breeding history of cv. No 1 Bima, cv No 3 Fengchan, cv No 1 Nindong and cv No 22 Xiaoyan.

Wild plants reproduce seeds generation mainly by natural hybridization, but under inductive variation and artificial breeding, they, like wild genotypes (*Triticum boeoticum* and *Triticum dicoccoides*) and cultivated (*Triticum monococcum* and *Triticum dioccum*) genotypes adaptation and breeding improvement excellent wheat variety can be cultured as more resistance like allelopathy, high yield and better quality. In this study, four allelopathic potential in wheat ecotypes was mediated, and intercross coordinated by more levels like configuration establishment (plant height and leaf area etc), vegetative and reproductive age (heading period etc), physio-and biochemical response (fluorescence kinetics etc), metabolism (metabolites like phenolics etc), hormone (NAA etc), and gene (2B QTL etc) (Kong et al., 2002). So it was necessary to discuss the real nature of allelopathic potential in system network view, especially for grain crops.

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