A-5.2.1 Interactive effects of increased UV-B and global warming on crop growth

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Abstract A greenhouse experiment was carried out to investigate the effects of UV-B on wheat (*Triticum aestivum* L.) growth and yield and its interactive effects with other environmental factors, according to the fractional (1/2) factorial design of 6 factors (UV-B, CO_2, temperature, soil fertility, wheat cultivar and block) with the orthogonal array table (L_{32}).

Results were, 1) Seed yield was not affected by increased UV-B irradiation (induced by 20-30% ozone depression) alone nor interactively. 2) CO_2 concentration and cultivar differences may modify effects of UV-B on tiller numbers. 3) Increased UV-B irradiation promoted the increase of tiller numbers in the early growth period, but final tiller number fell off under ambient CO_2 concentration compare with high CO_2 concentration. 4) Sensitiveness differed among wheat cultivars; Kitakamikomugi was not affected by UV-B, while UV-B increased tiller numbers or inhibited plant height for Norin 61.

Key Words UV-B, Global warming, CO_2, Interactive effects, Wheat

1.Introduction

Depletion of the stratospheric ozone layer has resulted in an increase in the UV flux, especially UV-B radiation (280-320nm) reaching surface of the earth. Many UV-B supplemental studies suggest that enhanced UV-B cause detrimental effect on plant. But majority of these information has been obtained in growth chamber or greenhouse experiment with "square wave" pattern UV-B irradiation throughout the daily treatment period. Such a constant lamp output may cause unrealistic balance of UV-B and UV-A or PAR. These experiments are under suspicion of overestimating the effects of UV-B

because of relative lower UV-A or PAR which has been found to have photo-repair function against UV-B induced injuries in the plant tissue[2].

Modulated UV-B supplemental systems have been developed to escape such a suspicion. In this study we arranged UV-B irradiation system with modulated lamp output [3] for grass-room experiment. Using this system we investigated the effects of UV-B on wheat growth and yield and its interactive effects with other environmental factors such as CO_2, temperature and so on.

2.Research method

A greenhouse experiment was carried out to investigate the effects of UV-B on wheat growth and yield included interactive effects with other environmental factors concerned to global warming, according to the fractional (1/2) factorial design of 6 factors (UV-B, CO_2, temperature, soil fertility, wheat cultivar and block)(Table 1) with the orthogonal array table(L_{32}).

UV-B were supplemented by fluorescent sunlamps (UVB313 Q-panel) covered with a 0.13mm thick cellulose diacetate (CDA) film for a supplemental UV-B treatment or with double 0.13mm thick CDA films for a control treatment. Lamp output was adjusted to 1.6 times of ambient $UV\text{-}B_{BE}$ [1] for supplement treatment.

2.Result and Discussion

Changes of $UV\text{-}B_{BE}$ through growing seasons were shown in Fig.2. Seasonal change caused by solar zenith angle and daily changes caused by clouds were significant.

Seed yield was not affected by enhanced UV-B irradiation (induced by 20-30% ozone depression) alone nor interactively (Table2). In growing processes we found that CO_2 concentration and cultivar differences may modify effects of UV-B on tiller numbers. Enhanced UV-B increased tiller numbers in 350ppm, but in 700ppm UV-B didn't modify tiller numbers in both UV-B levels tiller numbers were high during early growth period. And final tiller numbers UV-B increased final tiller numbers in 700ppm, otherwise UV-B decreased them in 350ppm (Fig.3).

We also found that the sensitiveness differed among wheat cultivars; Kitakamikomugi was not affected by UV-B, while UV-B increased tiller numbers in early growth period (Fig.4) or inhibited plant height for Norin61.

In replicate experiment carried in 1998-1999, we got similar tendency in tiller numbers, but that was not significant interaction. The interactive effects between UV-B and another factor (for example CO_2) may be exist, but they are changeable affected by the other environmental factors.

3.Reference

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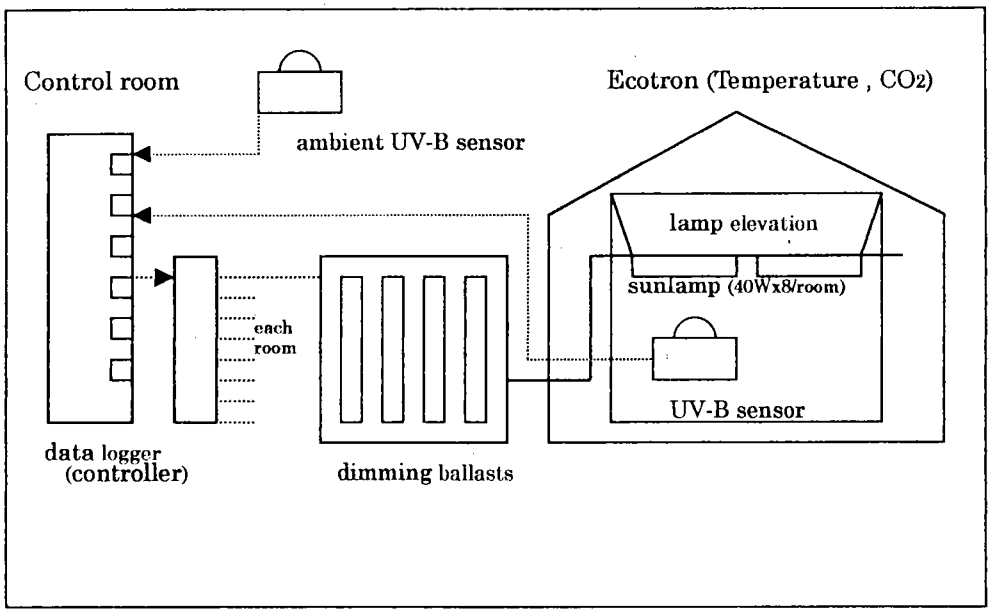

Fig.1. UV-B irradiation system in the Grass room (Ecotron, Tsukuba Ibaraki, Japan)

Table1.Facters in experiments

factors	Exp.1 level 1	Exp.1 level 2	Exp. 2,3 level 1	Exp. 2,3 level 2
Block	R1	R2	R1	R2
CO_2	700ppm	350ppm	700ppm	350ppm
Temperature	average+2degrees	average	ambient+2degrees	ambient
UV-B	ambient UV-B_{BE}×1.6	ambient UV-B_{BE}×0.8	ambient UV-B_{BE}×1.6	ambient UV-B_{BE}×0.8
Fertility	N:12kg/10a	N:6kg/10a	N:18kg/10a	N:6kg/10a
Irrigation	1l/pot/week	0.5l/pot/week	—	—
Cultivar	Norin61	Kitakamikomugi	Norin61	Kitakamikomugi

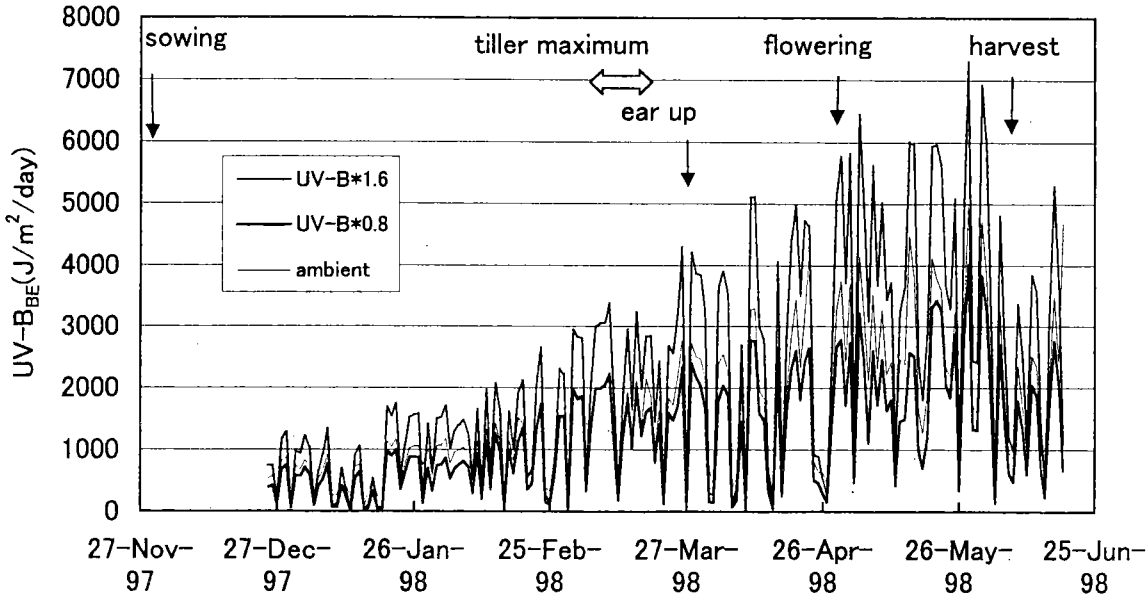

Fig.2.Changes of UV-B_{BE} through the growing seasons.

Table 2. Main effects and interactive effects in experiment-2 in 1997-1998

Model DF=26 , Error DF=5 **<1% *<5% ・<10%

	Head number	Plant height (cm)	Leaf and stem dry weight	Ear dry weight (g)	Root dry weight (g)	Seed weight (g)	Seed number
Block (B)							
CO_2 (C)		**	**	**	**	**	**
Temperature(T)			**	**	**	**	*
UV (U)							
Ferility (F)	**	**	**	**	**	**	**
Cultivar (Cu)		**	**	**		**	
C×T					*	・	**
C×U	・				*		・
C×F			**	**	*	**	**
C×Cu			**	*			*
T×U		*					
T×F				*	**	・	*
T×Cu		・			・		
U×F		・					・
U×Cu		・					
F×Cu		**	*				

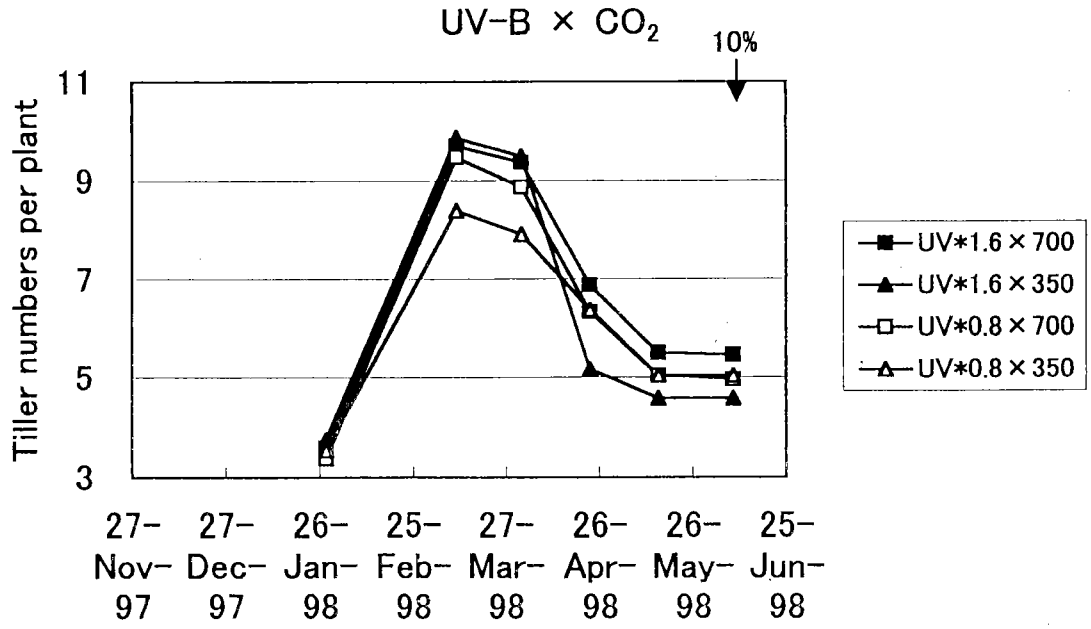

Fig.4.Changes in tiller numbers (UV-B × CO_2 interaction)

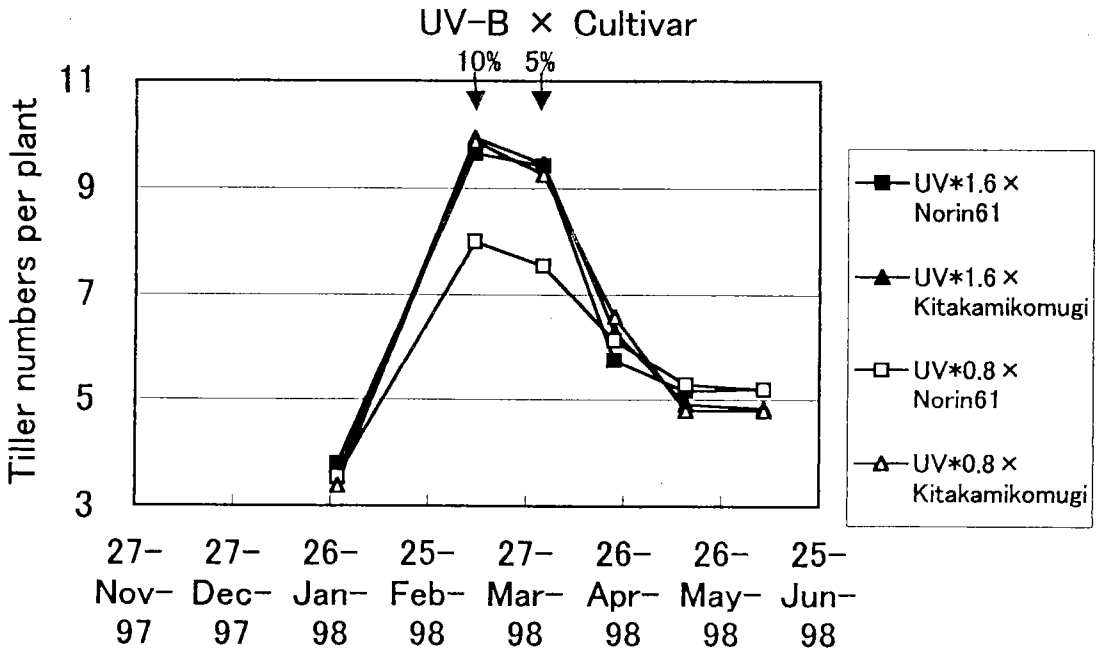

Fig.5. Changes in tiller numbers (UV-B × Cultivar interaction)