特定光輻射延長明期光照對西瓜及胡瓜苗株生長之影響

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摘要

本試驗研究係在位於臺中市霧峰區之行政院農業委員會農業試驗所農場進行，以三種瓜類作物(西瓜-‘新蘭’、’甜美人’，胡瓜-‘夏之輝’)為試驗材料，分別於日出前 2 h 及日落後 2 h 光照處理苗株 4 h 以延長明期，據以探討特定光輻射延長明期光照對西瓜及胡瓜苗株生長之影響。人工光源包括發光二極體(LED; light-emitting diode)(計有 730、660、590、520、500、470 及 405 nm 等 6 種特定波長)和省電燈泡(110-120V、23W、6500K 之 Philips Helix 晝光色)，並以不照光為對照，合計 8 種光源。種子於發根達 1 cm 後移植穴盤生長(計有03/16/2010及04/15/2010兩栽植期)，分別於出土後 14 d 及定植前調查苗株生長性狀，又分別於定植後 7 d 及 14 d 再調查幼株生長情形。由變方分析(ANOVA)發現，三種瓜類作物之兩栽植期各性狀皆無顯著性差異後，即將兩批資料予以合併分析。根據分析結果，胡瓜在出土後 14 d 及定植前之株高、下胚軸長度、下胚軸乾重等在處理間存有差異，顯示苗株生長對延長明期光照產生反應，惟不同光源會造成不等生長差異。胡瓜苗株定植田間後 7 d 之株高與下胚軸長度在處理間亦有差異，定植後 14 d 時僅下胚軸長度存在差異，顯見苗期生長受到延長明期光照之效應可能延續至田間株幼初期生長，尤以對下胚軸伸長的影響最大。若將 730 nm 的數據去除，再以變方分析探究處理間之差異，不同 LED 光源間的差異不大，以藍光(470 nm)和紫光(405 nm)的株高、下胚軸長度和下胚軸乾重較對照組(不照光)佳，顯示兩種光源有促進苗株生長的現象。西瓜‘新蘭’係於出土後 14 d 時之株高和下胚軸長度在處理間存在差異，定植前只有下胚軸長度維持差異存在，定植後則無處理之間差異。若將 730 nm 的數據去除，則在定植前的下胚軸長度在處理間有明顯差異，以綠光 520 nm 的促進生長的效果最佳，此現象維持至定植後 7 d，可知延長明期光照之效應僅及於苗期且以下胚軸具較強反應。西瓜’甜美人’的結果近似於’新蘭’，但是對下胚軸長度之效應可延至定植後 7 d，同樣將 730 nm 的數據去除，亦是在定植前的下胚軸長度在處理間有明顯差異，以綠光 520 nm 和紫光 405 nm 兩種光源有促進生長的效果，此優勢生長也維持到定植後 7 d。經檢視下胚軸長度與株高之關係，無論苗期或幼株生長初期大致呈現直線正相關，惟胡瓜可長達定植後 14 d，可見延長明期光照對下胚軸伸長的促進可以反應在株高。在植株地上部鮮重與株高之關係上，三種瓜類作物概為直線正相關，尤其胡瓜在出土後 14 d 即有此現象，顯示地上部鮮重隨著植株高度的增高而增加。

關鍵詞：特定光輻射、明期光照、西瓜、胡瓜、苗株生長。

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Effects of Extended Day Illumination on the Seedling Growth of Watermelon and Cucumber

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ABSTRACT

Field experiments were conducted in the experimental farm of Taiwan Agricultural Research Institute to study the effects of extended day illumination (4 h, i.e., 2 h before dawn and 2 h after sunset) on the seedling growth of watermelon (*Citrullus vulgaris* Schrad. ex Eckkl. & Zeyh) and cucumber (*Cucumis sativus* Linn) before and after transplanting. Artificial light sources were adopted to provide additional lighting, including light-emitting diodes (LEDs,) at 730, 660, 590, 520, 500, 470 and 405 nm and light bulb (LB) (110-120V, 23W, 6500K; Philips Helix white color) with no light treatment (CK) in comparison. Seeds of watermelon and cucumber were planted twice in cropping season of 2010. Samplings were made at fourteen days after seedling emergence (14 DAE), day before transplanting (BTP), 7 days after transplanting (7 DATP), and 14 days after transplanting (14 DATP). Based on results of analysis of variance (ANOVA), experimental data from both plantings were pooled for further study hereafter. There were significant differences in growth traits between light treatments of cucumber, including plant height (PH), hypocotyls length (HL), and hypocotyl dry weight (HDW) at 14 DAE and BTP, while significant difference of PH and HL was found at 7 DATP and only HL at 14 DATP. Variations existed among treatments of different light sources. By excluding data of 730 nm, there was no significant difference between light treatments. However, the increments of PH, HL and HDW by 470 nm and 405 nm were better than those of CK. Significant differences of PH and HL between treated seedlings were found in variety 'Hsin-Lan' of watermelon at 14 DAE, only HL at BTP, and no different after transplanting. By excluding data of 730 nm, there was a difference in HL at BTP, and 520 nm-treated seedlings had better growth than others till 7 DATP. The results of variety 'Tien-Mei-Zen' of watermelon were similar to those of 'Hsin-Lan', but lighting effect on HL extended to 7 DATP. Without data of 730 nm, difference between light treatments was found only in HL at BTP, especially at 520 nm and 405 nm. The relationship between PH and HL was linearly correlated in a positive fashion, and could extend to 14 DATP for cucumber. PH and aboveground plant fresh weight of treated plants was also positively correlated linearly in the examined varieties of cucumber and watermelon. Such relationship appeared at 14 DAE for cucumber.

Key words: Specific waveband, Day illumination, *Citrullus vulgaris* Schrad. ex Eckkl. & Zeyh., *Cucumis sativus* Linn., Seedling growth.

前言

國內在上半年春作期間進行瓜類育苗時，常逢連續陰雨及寒流冷氣團來襲，形成低溫與低光照環境。相對的在下半年秋季期間進行育苗時，亦常有冷鋒侵襲帶來的低溫與弱光環境，這些情境將嚴重干擾健康活力種苗之生產。然而，關於強化種苗活力於此等環境生長之研究卻闕如，限制了瓜類種苗生產的季節。植物行光合作用時必須要有充足的光照，尤以波長在 400-700 nm 範圍的可見光為最重要的光波段，再進一步言之，不同波長的光輻射對於光合作用具有不等貢獻。通常以 400-520 nm 的紫光至藍光波段及 610-720 nm 的橙光至紅光波段對於光合作用的效率較高，而 520-610 nm 的綠光至黃光波段的植物色素吸收效率較低(Bula *et al.* 1991, Fan and Jao 2004)。植物體的一些重要反應，大多是由於特定的色素系統所進行的光化學反應，例如光合作用由葉綠素(體)進行，葉綠素吸收紅光和藍光最多，也就是說紅光和藍光對光合作用效果最大，而綠光吸收最少，所以我們看到的植物就呈綠色。藍色光源(400-500 nm)對植物的分化與氣孔的調節十分重要。如果藍光不足，遠紅光的比例太多，莖部將過度成長，而容易造成葉片黃化。紅光波段(655-665 nm)能量與遠紅光波段(725-735 nm)能量的比例在 1.0 與 1.2 之間，植物的發育將是正長(Kendrick and Kronenberg 1986, Okamoto *et al*. 1996, Yanagi *et al.* 1996, Fan and Jao 2004)。但是，每種植物對於這些波段比例的敏感性也不同，若能提供較高效率的光波段照射來取代連續性波段光輻射，或許可以得到較佳的光合效能，然此一推論仍需要試驗求證。

目前已有利用單一波段或混合波段進行作物栽培試驗案例(Fan and Jao 2004)，有關紅光的發光二極體 LED 會影響莖節的伸長、葉片的生長、葉綠素的形成(Tripathy and Brown 1995)、光合成速率(Tennessen *et al*. 1994)和形態的改變(Hoenecke *et al*. 1992, Robin *et al*. 1994)。Hoeneck *et al*. (1992)使用超高亮度紅光 LED 配合藍光燈管，可以成功栽培萵苣種苗。此外，Okamoto *et al*. (1996)使用超高亮度紅光 LED 與藍光 LED，在一定的比例下(B/R=1:2)可以培育出正常萵苣。若改以純藍光 LED 環境中，仍可促進植株分化生長，但是其乾物重小於純紅光或紅藍光並存下的植物，使得純藍光下的植物顯得更矮壯而健康。Jao and Fang (2004a, 2004b)的研究則發現，間歇性的給予馬鈴薯組織培養苗照射有機發光二極體 OLED (organic light-emitting diode)的紅光和藍光，能增加種苗的生長速率，而組合不同波長的 OLED 光照射，還可抑制某些植物的病原菌。Jao *et al*. (2003)以自行研發的超高亮度紅光與藍光 LED 燈具為人工光源，試驗結果顯示兩者在鮮重、乾重、葉片數、葉寬、根數及根長上並無差異，但在葉長上則以 LED 為光源者較長。由此證實，LED 可用來栽培蝴蝶蘭組培苗，亦適用於作為光型態發生基礎研究之人工光源。Wang *et al*. (2006)以不同光源下育苗後對洋桔梗切花品質之影響，結果顯示冷陰極管的綠光和白光育苗的株高最佳，LED 的綠光苗株較矮且花朵數減少，另光源與品種間在株高及盛花期性狀上有交感效應存在。

國內目前尚無試驗利用特定波段光輻射於瓜類種苗之生長與活力探討，特別在低光照環境下(如日出、日落時段)以人工光源提供不足的光輻射，在節能減碳重要性日益提升的現在，其可行性與應用潛力值得探究。本文研究以歸屬於綠色光源發光二極體 LED 來提供特定波段光輻射於瓜類種苗(如胡瓜、西瓜等)生長用途，利用日出前 2 小時加上日落後 2 小時之光照處理苗株，釐清特定光輻射延長明期光照對西瓜及胡瓜苗株生長之效應。

材料與方法

本試驗研究係在位於臺中市霧峰區之行政院農業委員會農業試驗所農場進行，以農業試驗所作物組蔬菜研究室提供之西瓜(*Citrullus vulgaris* Schrad. ex Eckkl. & Zeyh.)‘甜美人(Tien-Mei-Zen)’和’新蘭(Hsin-Lan)’兩栽培種，以及胡瓜(*Cucumis sativus* Linn) ‘夏之輝(Hsia-zi-Huei)’栽培種為試驗材料，以綠色能源發光二極體 LED 及省電燈泡(LB)來提供特定波段光輻射於瓜類種苗生長影響探討。光照時間分別於日出前 2 h 及日落後 2 h，即以延長明期光照 4 h 來處理苗株，光源包括 LED 之 730、660、590、520、500、470 及 405 nm 等 6 種波長和省電燈泡(110-120V、23W、6500K 之 Philips Helix 晝光色)連續波段，並以不照光(no light treatment; CK)為對照，合計 8 種光源。

種子育苗前以殺菌劑“免賴得”(benomyl, 可濕性粉劑 50%，1000×)進行種子消毒，經逆滲透水清洗 5 次之後，置於室內暗處發芽。種子於發根達 1 cm 後移植穴盤生長，計有 03/16/2010 及 04/15/2010 兩栽種(植)期，再分別於出土後 14 d (14 DAE)及定植前(BTP)調查苗株生長性狀，調查項目有苗株高度(PH)、下胚軸長度(HL)、下胚軸鮮重與乾重(HFW、HDW)及地上部鮮重與乾重(AFW、ADW)。苗株於第七位葉長出後定植於田間，又分別於定植田區後 7 d (・7 DATP 及 14 d (14 DATP)，再調查田間幼株生長情形。田間生長的植株以殺菌劑“三泰隆”(triadimenol, 23%水分散性乳劑，3000×)防治白粉病，以“撲克拉錳”(prochlorate manganese, 50%可濕性粉劑，4000×)防治炭疽病，以除蟲劑“納乃得”(methomyl, 90%可濕性粉劑，1000×)防治蟲害。

試驗資料分析以 SAS 統計軟體(SAS

Institute 1998)進行變方分析(ANOVA; analysis of variance)檢定，使用最小顯著差異性測驗(LSD; least significance difference test)來判定處理間的差異是否達到顯著。

結果與討論

由變方分析 ANOVA 發現三種瓜類作物之兩栽植期各性狀皆無顯著性差異後，即將兩批資料予以合併分析。根據試驗分析結果(Table 1)，胡瓜在出土後 14 d 及定植前之株高、下胚軸長度、下胚軸乾重等在處理間存有差異，其中以 730 nm 光照苗株的生長值最高，檢視其增加的株高和下胚軸的幅度，相較於下胚軸乾重增加的比值，似乎有促進苗株生長的趨勢。顯示苗株生長對延長明期光照產生反應，惟不同光源會造成不等生長差異。胡瓜苗株定植田間後 7 d 之株高與下胚軸長度在處理間亦有差異，定植後 14 d 時僅下胚軸長度存在差異。顯見在無劇烈天氣變化前提下，胡瓜苗期生長受到延長明期光照之效應，可能延續至田間株幼初期生長，而此一效應以對下胚軸伸長的影響最大。

此一結果因為紅外光 730 nm 的株高和下胚軸都顯著高於其他光照處理，因而在變方分析結果處理間有顯著性差異。若將 730 nm 的數據去除，再以變方分析探究處理間之差異，則不同 LED 光源間的差異不大。以藍光(470 nm)和紫光(405 nm)的株高、下胚軸長

Table 1. Effect of day illumination with LEDs (light-emitting diodes) and light bulb (LB) on growth traits of *Cucumis sativus* Linn in two planting/growing seasons of 2010.

	14 DAE[x]			BTP[y]			7 DATP[z]		14 DATP
	PH	HL	HDW	PH	HL	HDW	PH	HL	HL
03/16/2010	-------cm-------		10^{-1}g	-------cm-------		10^{-1}g	-------cm-------		cm
LB	15.8	6.0	0.35	17.5	6.3	0.55	18.0	5.4	5.5
730 nm	21.5	11.6	0.53	24.1	11.9	0.84	23.3	10.3	10.9
660 nm	17.2	7.0	0.32	18.4	7.2	0.50	18.6	5.5	6.4
590 nm	16.3	6.2	0.34	17.8	6.5	0.59	19.9	6.5	6.4
520 nm	16.9	6.5	0.34	17.6	6.6	0.60	18.3	6.4	6.3
500 nm	16.6	6.9	0.33	17.0	5.9	0.60	18.8	6.4	5.9
470 nm	17.2	7.4	0.36	18.1	6.8	0.62	20.7	8.0	7.3
405 nm	17.1	7.8	0.41	19.0	7.7	0.67	20.0	6.8	8.1
CK[w]	14.7	5.5	0.27	18.0	6.3	0.56	18.0	5.9	5.4
Mean	17.0	7.2	0.36	18.6	7.2	0.62	19.5	6.8	6.9
$LSD^{0.05}$	2.8	1.8	0.09	3.0	1.2	0.13	2.9	1.2	2.1
F	4.54	10.41	7.02	21.5	24.46	5.96	3.52	16.69	7.07
$t^{0.05}$	2.62								
	14 DAE[x]			BTP[y]			7 DATP[z]		14 DATP
	PH	HL	HDW	PH	HL	HDW	PH	HL	HL
04/15/2010	-------cm-------		10^{-1}g	-------cm-------		10^{-1}g	-------cm-------		cm
LB	15.8	6.0ab	0.35ab	17.5	6.3bc	0.55ab	18.0	5.4c	5.5b
660 nm	17.2	7.0ab	0.32bc	18.4	7.2ab	0.50b	18.6	5.5bc	6.4ab
590 nm	16.3	6.2ab	0.34abc	17.8	6.5bc	0.59ab	19.9	6.5bc	6.4ab
520 nm	16.9	6.5ab	0.34bc	17.6	6.6abc	0.60ab	18.3	6.4bc	6.3ab
500 nm	16.6	6.9ab	0.32bc	17.0	5.9c	0.60ab	18.8	6.4bc	5.9b
470 nm	17.2	7.4a	0.36ab	18.1	6.8abc	0.62ab	20.7	8.0a	7.3ab
405 nm	17.1	7.8a	0.41a	19.0	7.7a	0.67a	20.0	6.8ab	8.1a
CK	14.7	5.5b	0.27c	18.0	6.3bc	0.56ab	18.0	5.9bc	5.4b
Mean	16.5	6.7	0.34	17.9	6.7	0.59	19.5	6.3	6.4
$LSD^{0.05}$	3.0	1.9	0.07	3.0	1.2	0.13	2.9	1.3	2.1
F	0.9	1.73	3.23	0.4	2.5	1.67	3.52	4.43	1.97
$t^{0.05}$	2.31								

[x] DAE: days after seedling emergence.
[y] BTP: before transplanting.
[z] DATP: days after transplanting.
[w] CK: no light treatment.

度和下胚軸乾重較對照組 CK (即不照光)佳，顯示此兩種光源有促進苗株生長的現象。Lian *et al.* (2002)的百合鱗莖 LED 光照試驗顯示，螢光燈和紅、藍光的 LED 可能促進小鱗莖的形成；植株在紅光 LED 的照射下，莖桿較細長且葉片易呈黃色，顯示如似葉綠素含量偏低之外觀，而光合成速率、頂端和根部的鮮重低於同時照射紅藍光的植株。由此可知，只照射單一紅光波段植株的生長，似皆低於以兩種 LED 波段的光照處理結果，呈現正面生長促進之現象。西瓜新蘭栽培種係於出土後 14 d 時之株高和下胚軸長度在處理間存在差異(Table 2)，定植前只有下胚軸維持差異存在，定植後則無處理之間差異。據此顯示，延長明期光照對於該種西瓜之效應僅及於苗期，且以下胚軸具較強反應。若將 730 nm 的數據去除，則在定植前的下胚軸長度在處理間有明顯差異，以綠光 520 nm 的促進生長的效果最佳，此現象維持至定植後一週。西瓜甜美人栽培種的試驗結果(Table 3)近似於新蘭，但是對下胚軸長度之效應可延至定植後 7 d。同樣將 730 nm 的數據去除，

Table 2. Effect of day illumination with LEDs (light-emitting diodes) and light bulb (LB) on growth traits of *Citrullus vulgaris* Schrad. ex Zeyh (variety 'Hsin-Lan') in the two planting/growing seasons in 2010.

Treatment	14DAE[x]			BTP[y]	7DATP[z]
	PH	HL	PH-HL	HL	HL
03/16/2010	----------cm-----------			cm	cm
LB	14.0	8.2	5.8	8.3	8.8
730 nm	17.7	11.2	6.5	10.8	10.7
660 nm	15.2	9.1	6.2	8.7	8.7
590 nm	17.2	9.4	7.8	8.1	8.3
520 nm	15.8	9.1	6.7	10.6	9.8
500 nm	14.4	9.0	5.4	9.7	9.2
470 nm	14.7	8.7	5.9	8.9	8.6
405 nm	14.5	8.6	5.9	8.7	9.4
CK[w]	13.3	8.0	5.4	7.6	7.6
Mean	15.2	9.0	6.2	9.1	9.0
$LSD_{0.05}$	2.3	1.5	2.2	1.0	1.9
F	4.18	4.13	1.2	11.92	2.37
$t_{0.05}$	2.62				
	14DAE			BTP	7DATP
	PH	HL	PH-HL	HL	HL
04/15/2010	----------cm-----------			cm	cm
LB	14.0^{c}	8.2	5.8^{ab}	8.3^{cd}	8.8^{ab}
660 nm	15.2^{abc}	9.1	6.2^{ab}	8.7^{bcd}	8.7^{ab}
590 nm	17.2^{a}	9.4	7.8^{a}	8.1^{cd}	8.3^{ab}
520 nm	15.8^{ab}	9.1	6.7^{ab}	10.6^{a}	9.8^{a}
500 nm	14.4^{bc}	9.0	5.4^{ab}	9.7^{ab}	9.2^{ab}
470 nm	14.7^{bc}	8.7	5.9^{ab}	8.9^{bc}	8.6^{ab}
405 nm	14.5^{bc}	8.6	5.9^{ab}	8.7^{bcd}	9.4^{ab}
CK	13.3^{c}	8.0	5.4^{b}	7.6^{d}	7.6^{b}
Mean	14.9	8.8	6.1	8.8	8.8
$LSD_{0.05}$	2.4	1.6	2.3	1.1	1.8
F	2.68	1.1	1.2	7.89	1.46
$t_{0.05}$	2.31				

[x] DAE: days after seedling emergence.
[y] BTP: before transplanting.
[z] DATP: days after transplanting.
[w] CK: no light treatment.

Table 3. Effect of day illumination with LEDs (light-emitting diodes) and light bulb (LB) on growth traits of *Citrullus vulgaris* Schrad. ex Eckkl (variety 'Tien-Mei-Zen') in the two planting/growing seasons in 2010.

Treatment	14DAE[x]		BTP[y]		7DATP[z]
	PH	HL	PH	HL	HL
03/16/2010	-----cm-----		-----cm-----		Cm
LB	12.6	6.8	16.1	6.4	7.0
730 nm	15.8	8.3	20.1	8.8	8.8
660 nm	13.2	7.1	16.8	6.6	7.7
590 nm	14.0	7.4	17.2	7.4	7.4
520 nm	14.5	7.9	17.9	8.1	7.9
500 nm	13.6	7.1	16.2	6.7	7.4
470 nm	13.4	7.9	17.0	7.6	7.5
405 nm	13.2	7.3	18.3	8.5	7.6
CK[w]	12.2	6.5	15.1	6.6	6.4
Mean	13.6	7.4	17.2	7.4	7.5
$LSD_{0.05}$	1.7	1.2	5.1	1.2	1.1
F	4.02	2.43	0.83	5.41	3.79
$t_{0.05}$	2.62				
	14DAE		BTP		7DATP
	PH	HL	PH	HL	HL
04/15/2010	-----cm-----		-----cm-----		Cm
LB	12.6^{b}	6.8^{ab}	16.1	6.4^{c}	7.0^{ab}
660 nm	13.2^{ab}	7.1^{ab}	16.8	6.6^{bc}	7.7^{a}
590 nm	14.0^{ab}	7.4^{ab}	17.2	7.4^{abc}	7.4^{ab}
520 nm	14.5^{a}	7.9^{a}	17.9	8.1^{a}	7.9^{a}
500 nm	13.6^{ab}	7.1^{ab}	16.2	6.7^{bc}	7.4^{ab}
470 nm	13.4^{ab}	7.9^{a}	17.0	7.6^{bc}	7.5^{ab}
405 nm	13.2^{ab}	7.3^{ab}	18.3	8.5^{a}	7.6^{a}
CK	12.2^{b}	6.5^{b}	15.1	6.6^{bc}	6.4^{b}
Mean	13.4	7.2	16.8	7.4	7.4
$LSD_{0.05}$	1.8	1.2	5.0	1.2	1.1
F	1.68	1.84	0.84	4.28	1.72
$t_{0.05}$	2.31				

[x] DAE: days after seedling emergence.
[y] BTP: before transplanting.
[z] DATP: days after transplanting.
[w] CK: no light treatment.

亦是在定植前的下胚軸長度在處理間有明顯差異，相較於對照組以綠光 520 nm 和紫光 405 nm 兩種光源有促進生長的效果，此優勢生長也維持到定植後一週。

經檢視參試三種瓜類作物的下胚軸長度與株高之關係(Fig. 1A)，無論苗期或幼株生長初期大致呈現直線正相關，惟胡瓜可長達定植後 14 d，可見天氣良好情況下延長明期光照對下胚軸伸長的促進可以反應在株高。若將顯示出徒長現象之 730 nm 的數據去除，三種瓜類作物的下胚軸長度與株高之關係如 Fig. 1B 所示，苗期和定植前的下胚軸長度與株高仍維持直線正相關，除胡瓜苗株在定植後一週可維持顯著正相關外，兩個西瓜品種則無顯著相關，可能是受到定植後田間環境的影響。另在植株地上部鮮重與株高之關係方面，三種瓜類作物概為直線正相關(Fig. 2A)，尤其胡瓜在出土後 14 d 即有此現象，顯示地上部鮮重隨著植株高度的增高而增加。如同下胚軸和株高的關係圖。去除 730 nm 的數據(Fig. 2B)，結果與未去除的相關圖類似，仍維持兩者顯著直線正相關。至於三種瓜類苗株在田間的長時間生長及未來生殖生長是否受到苗期光照的影響，仍需較多期作的試驗及更多生育參數來驗證和解釋。

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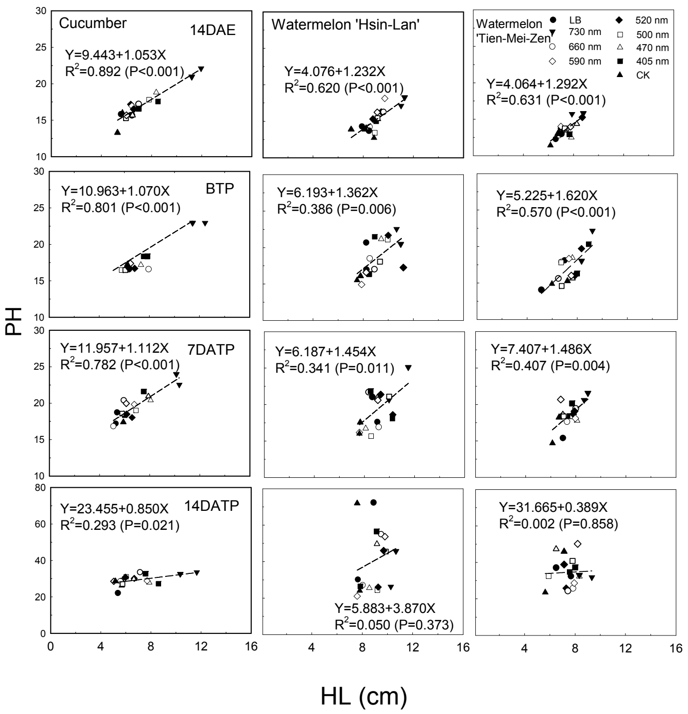

Fig. 1A.Changes in plant height (PH) to hypocotyls length (HL) of treated plants with LEDs (light-emitting diodes; with 730 nm), LB (light bulb) and no light (CK) in varieties of cucumber and watermelon in two planting/growing seasons of 2010.

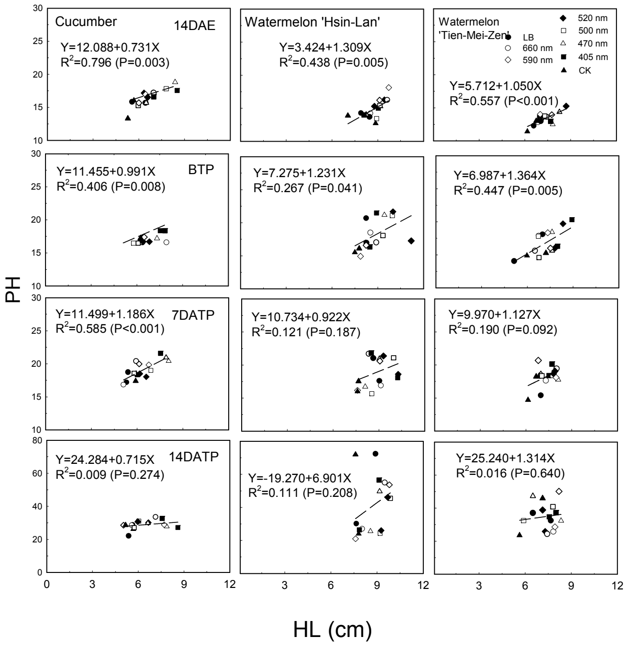

Fig. 1B. **Changes in plant height (PH) to hypocotyls length (HL) of treated plants with LEDs (light-emitting diodes; without 730 nm), LB (light bulb) and no light (CK) in varieties of cucumber and watermelon in two planting/growing seasons of 2010.**

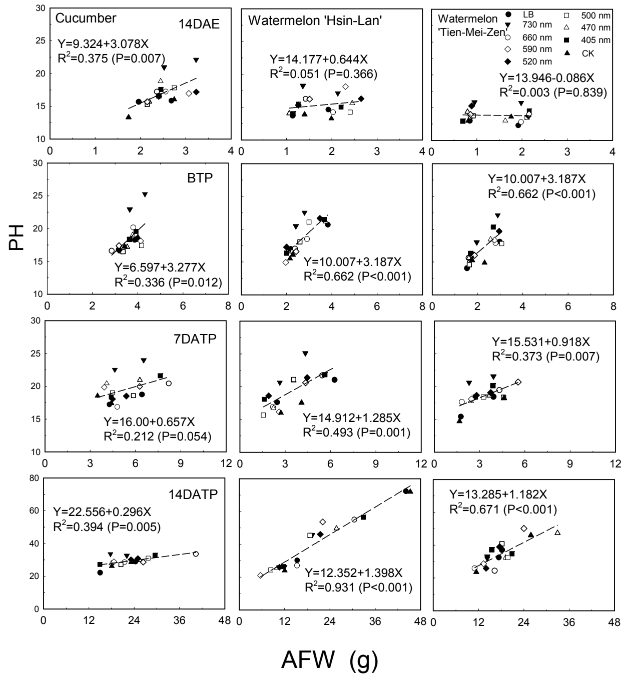

Fig. 2A. **Changes in plant height (PH) to aboveground fresh weight (AFW) of treated plants with LEDs (light-emitting diodes; with 730 nm), LB (light bulb) and no light (CK) in varieties of cucumber and watermelon in two planting/growing seasons of 2010.**

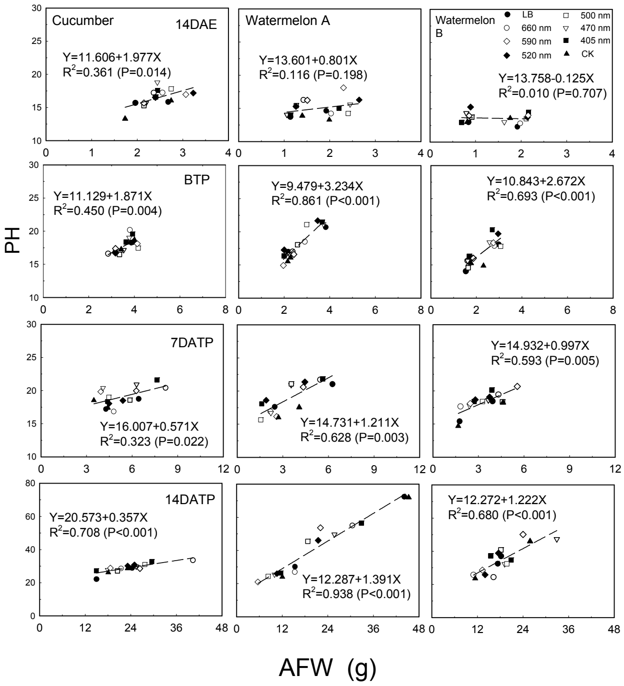

Fig. 2B. Changes in plant height (PH) to aboveground fresh weight (AFW) of treated plants with LEDs (light-emitting diodes; without 730 nm), LB (light bulb) and no light (CK) in varieties of cucumber and watermelon in two planting/growing seasons of 2010.

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