Cucumber accession PI308916, noted for compact plant habit and poor seedling emergence, exhibits poor apical hook formation.

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Cucumber (*Cucumis sativus* L.) accession PI308916 is characterized by very short internodes and vine length resulting in a compact plant habit (Table 1). The compact plant form, which is conferred by a single recessive allele, *cp*, was of interest to breeders as a way to increase planting density, and thereby increase yield per unit land area. Breeding lines derived from PI308916 were shown to have significant yield advantage (Kauffman and Lower, 1976; Edwards and Lower, 1982a). Efforts to produce finished cultivars were curtailed, however, as the PI308916-derived lines exhibited poor seedling emergence which could not be segregated away from the compact plant trait (Edwards and Lower, 1981, 1982b, 1983).

Subsequent studies in our lab, directed toward reducing incidence of *Phytophthora capsici* fruit rot, again led to PI308916 as a potentially useful germplasm (Ando and Grumet, 2006). Cucumber fruit rot, caused by the soil-borne oomycete *P. capsici*, is a significant problem affecting cucumber production in the midwest (Hausbeck and Lamour, 2004). Since screening cucumber germplasm for resistance to *P. capsici* did not yield a reproducible source of resistance useful for breeding efforts (Gevens et al., 2006), we screened cucumber germplasm for architectural types that might reduce disease incidence, either by reduced canopy density to allow for increased air movement (reduced temperature and humidity), increased accessibility of the fruit to chemical sprays, or reduced fruit contact with the soil In these studies PI308916 showed greatly reduced disease occurrence (1% vs. 20% for standard cultivars at the time of harvest (Ando and Grumet, 2006). The short internode length of the PI308916 plants resulted in a tendency to hold young fruit at an upright angle and off the ground. Direct inoculation tests showed that the reduced disease occurrence was not due to resistance of the fruit per se, suggesting that architecture which allows less contact of fruit with the soil led to reduced *P. capsici* infection (Ando and Grumet, 2006).

Given the potential usefulness of this the compact plant habit for both increased yield and reduced *P. capsici* infection, we sought to investigate the cause of the seeding emergence problem. Short internode length can be caused by reduced levels of plant hormones, such as gibberellins or brassinosteroids (BRs) (Clouse and Sasse 1998; Hooley 1994). Gibberellins can be associated with seed germination and BRs are associated with proper formation of the apical hook that allows the tightly folded germinating seedling to push through the soil surface (Li and Chory, 1999). Effects on either germination or apical hook formation could influence seedling emergence.

Tests of seed germination suggest that poor seedling emergence does not result from poor germination, per se, at least in laboratory conditions. Although PI308916 seeds were a bit slower to germinate (2 days instead of 1), all showed 100% radical emergence when germinated on moist filter paper (Table 1). On the other hand, examination of apical hook formation showed a distinct difference between the genotypes (Figure 1, Table 1). With only a few exceptions, Wautoma and Vlaspik seeds showed uniform, 100-180 hook angle, as is typical of a germinating dicot seed. In contrast, PI308916 failed to exhibit a uniform hook. Angles were highly variable, ranging form 0-180, suggesting that poor seedling emergence may result from poor apical hook formation.

Analysis of F_1 and F_2 progeny of reciprocal crosses of PI308916 with cv. Wautoma indicate that the loss of apical hook formation is Inherited as a recessive, single gene trait (Table 2). Almost all F_1 seedlings showed angles of 100-180, and F_2 progeny separated 3:1 for angles of 100-180 vs. random angle size. While it remains to be verified that the short internode and poor apical hook formation co-segregate, a pleiotropic effect of the *cp* gene on apical hook formation would explain the inability to genetically separate the compact plant habit from effects on seedling emergence.

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Literature Cited

1. Ando K, Grumet R. 2006. Evaluation of altered plant architecture as a means to reduce *Phytophthora capsici* disease incidence on cucumber fruit. J. Amer. Soc. Hort. Sci. 131:491-498.
2. Gevens, AJ, Ando K, Lamour K, Grumet R, Hausbeck MK. 2006. Development of a detached cucumber fruit assay to screen for resistance and effect of fruit age on susceptibility to infection by *Phytophthora capsici*. Plant Dis. 90:1276-1282.
3. Hausbeck M, Lamour K. 2004. *Phytophthora capsici* on vegetable crops: research progress and management challenges. Plant Dis. 88:1292-1302.
4. Clouse SD, Sasse JM. 1998. Brassinosteroids: essential regulators of plant growth and development. Annu. Rev Plant Physiol Plant Mol Biol 49:427-451.
5. Edwards MD, Lower RL. 1981. Investigations into the characteristics of seeds from compact plants. Cucurb Genet Coop 4:2-3.
6. Edwards MD, Lower RL. 1982a. Comparative yields of compact and vining plant type isolines in cucumber at four densities. Cucurb Genet Coop 5:6-7
7. Edwards MD, Lower RL. 1982b. The genetic regulation of several seed traits in compact (*cpcp*) cucumbers - maternal vs. embryonic control. Cucurb Genet Coop 5:8-9.
8. Edwards MD, Lower RL. 1983. Effect of inbreeding on seed traits for compact cucumber. Cucurb Genet Coop 6:5-7.
9. Hooley R. 1994. Gibberellins: perception, transduction and responses. Plant Molec Biol 26:1529-1555.
10. Kauffman CS, Lower RL. 1976. Inheritance of an extreme dwarf plant type in the cucumber. J Amer Soc Hort Sci 101:150-151.
11. Li J, Chory J. 1999. Brassinosteroid action in plants. J Exp Bot 50:275-282.

Table 1. Internode and vine length, germination rate, and apical hook formation for PI308916 and cultivar Wautoma.

	Internode length (node 4-5) cm ± S.E.	Vince length (at 6 weeks) cm ± S.E.	Time to 100% germination	Apical hook angle (at 5 days)	
				Mean angle (± S.E.)	Range
PI 308916	1.1±0.3 n=62	8.3+4.6 n=58	2 days	95+19.7 n=132	20-180
Wautoma	3.3±0.7 n=98	55.1±8.6 n=44	1 day	130±15.5 n=120	65-180

Data are pooled from two (vine length) or three (internode, apical hook) experiments. Seedlings were germinated in the growth room in the dark for five days, then transferred to soil in the greenhouse after apical hook measurement.

Table 2. Observed and expected ratios for apical hook angle of 5-day old seedlings for Wautoma, PI308916 and their F_1 and F_2 progeny.

Genotype	Observed		Expected ration[1]		Chi square
	0-100	101-180	0-94	95-180	
Wautoma (W)	7	113			
PI308916 (PI)	66	63			
F1 (W x PI, PI x W)	21	165	10	90	0.21 ns
F1 (W x PI)	7	97			0.90 ns
F1 (PI x W)	14	68			3.81 ns
F2 (W x PI, PI x W)	150	680	20	80	1.80 ns
F2 (W x PI)	68	341			2.70 ns
F2 (PI x W)	82	339			0.04 ns

The expected ratios for segregating populations in a single recessive gene model, were calculated based on hook angle distributions of the parental phenotypes where approximately 10% of W and 50% of PI have angles <100. In the F_2 generation, it is expected that 25% will resemble PI and 75% W. With a segregation ratio of 3:1, 10% of 75% (7.5%) and 50% of 25% (12.5%), or 20%, will have hook angles less than 100.

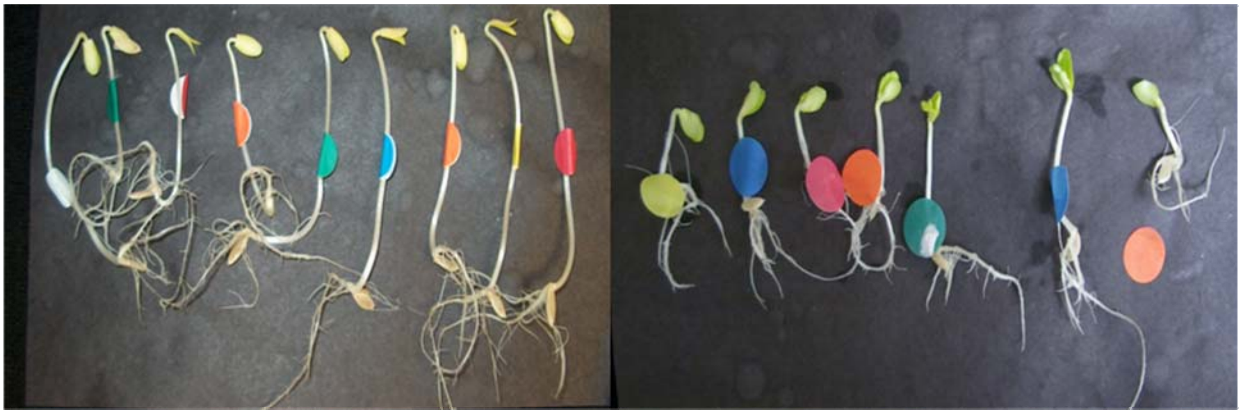

Figure 1. Apical hook formation for Wautoma and PI308916. Seedlings were germinated for five days in the dark on moist filter paper.