

Maize Flowering Obsolete

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Allegany, New York, USA

Karl, J

jrk36@cornell.edu

MAIZE FLOWERING

Maize **flowering** determines internode (leaf) number and possibly (plant) height. It is formulated by quantitative load, night (day) length, transgenics, mutations, background, and outdoor cultivation (specifically UV suggested). **Indeterminacy** was questionably named in the past, but is nothing less than repeated in this study, and is also newly alleged in a partially dominant form (Muszynski 2014: *Ftt - Fails to transition*). **id1** (chromosome 1) offers 9 internodes (MNL 88:e14), 3 more from synergy with nightlength, 20 more from background, and outdoor indeterminacy (non-dwarf Neuffer allele). **Lfy1** (chromosome 3) offers from 8 to outdoor indeterminacy (MNL 87:2). Highly night-length-reactive **teosintes** (chromosome 10 etc.) appear to offer long-night obligacy (JJ Colasanti, personal communication). No internode quantity to-date (or description of otherwise morphological normalcy) accompanied the claim of **Ftt**. In spite of being published with contact information, communication (or supplying the claimed material for broader or even restricted analysis) is refused, like with **ZmCCT10-BSV** (chromosome 10 etc.), a transgenic that allegedly adds 50 internodes (MGC 57:189 and Patent 20150252377). The **short-night reaction** (chromosome 10 etc.) can add 25 etc. internodes below the ear (MNL 86:4) and perhaps 15 above (MNL 89:e4). **Quantitative** addition ostensibly totals 18 internodes (e.g. long-night Gaspé 6 vs. Tehua 24). **dlf1** (chromosome 7) offers 4 internodes (MNL 89:e2) and likely more from synergy with nightlength and background (background ostensibly 12-18). It is important to note the finding that when **id1** and **dlf1** are **combined**, only the effect of **id1** is seen (Plant Physiol 142:1523). **Glossy15** (chromosome 9 etc.) adds 5-10 internodes and sometimes height (SP Moose, personal communication 2010-2013). **OCL1** (chromosome 3 etc.) adds 6 internodes (J Exp Bot 62:293). **ZmRap2.7** (chromosome 8 etc.) adds up to 5 internodes (PNAS 104:11376). **ZCN5** (chromosome 10 etc.) adds 4.5 (Plant Phys 153:238). The **zmm22** (chromosome 3 etc.) / **zagII** (chromosome 1 etc.) quantity is unknown (SM Kaeppeler, personal communication; Patent 20140366213).

Chromosome

- 1 - **id1** (Maize Genome Database, Maize Mutant Stock Center)
- internodes **above ear** / qLA1-1 (New Phytologist 210:256)
- some night-length reaction distal to **id1** (JB Holland, personal communication)
- 2
- 3 - **Lfy1** (HW Cai, personal communication 2007)
- 4 - **Ts5** (Maize Genome Database)
- 5

- 6 - orange kernel (cf MM Sachs, personal communication)
- 7 - **dlf1** (Maize Genome Database, MG Neuffer)
- 8 - *elm1* (Maize Genome Database; MM Sachs and PS Stinard identified as elongating normal internodes)
- night-length reaction / long night obligacy **2°** (JF Doebley, personal communication),
- 9
- 10 - **night-length** reaction / long night obligacy **1°** - highly reactive teosinte
(cf JF Doebley, personal communication)
and maize (cf JB Holland, personal communication)
- ZmCCT10

TEOSINTE OBLIGACY

Colasanti asserted Balsas obligacy from an absence of differentiation at 12 months (personal communication; *parviglumis*) with Ames 21785 (MJ Millard, personal communication). The question remained as to the facility with which the species obligacy could be **transferred** to maize for public use (consider Proc Natl Acad Sci USA 109:1913, gratitude JF Doebley).

An **F2** plant of the cross Chiapas 234 maize x Huehuetenango teosinte grown in a tall short-night greenhouse had an indeterminate meristem *31 ft from the ground*, that stopped growing. There were *57 separate nodes*, and the 57th spiraled (with developing leaves) to the meristem, such that the total of readily visible *leaves exceeded 70*. Internode lengths were normal, ranging up to 15 inches (internode 21 at 11 ft). The plant indicated no deviation from the architectural uniformity of vegetative growth until 5 ft higher than regular Chiapas 234 (33 vs 28 ft). Before culling, roots developed to node 45 at 29 ft. This suggests that transferring the obligacy is a **ready** phenomenon from independently assorting chromosomes and co-inheritance from linkage.

Expectedly, under **long night** and outdoors, no Chiapas 234 x Huehuetenango F2 plants were indeterminate, as such condition is mutually exclusive with the existence of either parent.

When the **F1** of the cross is grown in a tall short-night greenhouse (2008-2011 analyses), it is shorter than the F2. Since obligacy is not seen in maize, its absence in the F1 indicates that it needs to be homozygous.

In a tall, shady short-night greenhouse, a **Huehuetenango** plant grew 9 ft (meristem 6 ft 9 inches) in 10 months (Jan15-Nov 15), when it decided to simply die like all other literally indeterminate *mays* plants. It had 70-75 leaves at its indeterminate meristem (internode length almost nonexistent; basically 1 inch, peak <3), with root initials at all visible nodes, the most recent growing from the 49th, 14 inches below the meristem. *The continuous rooting might suggest that the obligacy is below the earing region* (very similar to the massive dose of internodes below the ear in *Lfy1+* Chiapas 234 with ear shoots going to the top of the 45 ft plant).

This short-night result with Huehuetenango is a slight failure to repeat the results of Modena (MNL 57:38) and Colasanti, yet is a windfall hardening the evidence of long-night **obligacy**, not to mention providing the grossly missing leaf quantity and rooting references.

Likewise, with the short-night development of Huehuetenango under the stressed circumstances of shade, jeopardized night light intensity, and missing one or two short nights due to experimental glitches, it is stunning how **tenacious** the short-night response is, considering all other material (except *id1* and occasional *Lfy1* plants outdoors, with certain sun intensity or background).

ID1 INDETERMINACY

It is understood that the internode quantities listed in this article are in the absence of the **short-night reaction** unless expressly noted. Claims that *id1* creates 25 etc. internodes (Plant Physiol 142:1523; J Colasanti, personal communication) are categorically unreproducible without specific or late **background**. On the other hand, neither source reports literal indeterminacy from **outdoor** growths of their backgrounds. The author's segregating tropical materials (with the non-dwarf Neuffer allele) have more than 55 internodes under the long night of 10 degree latitude, whether in the field or greenhouse, whereas 30 internodes is an extremely high quantity in wild type (Table 1, 2, 3).

A **greenhouse** mutant (68% tall tropical background) was 14 ft (from 55 internodes) at the base of the tassel area where 6 shoots began growing upward among tassel branches enveloped with small leaves. This was 9 months after planting (Dec 6 - Sep 1) compared to 2.5 months for pollen in wild type (Table 1, 2). The branches were totipotent, producing no pollen by a few weeks after protrusion. Roots protruded from nodes up to number 36, which was 7 ft from the ground.

Of 3 (75% tall tropical background) **field** segregants, all were dwarf (extremely brachytic, 1-2 inch internodes, peaking 2.5). Sixty internodes were counted on one plant, succumbed to apparent infection, that had an (naked eye) indeterminate meristem (cf Table 3). On a second plant with apparently stopped growth (9 ft at 11 mo from their Jan 7 planting) were many more than 70 internodes to the indeterminate meristem, with *rooting* long completed (dried up) at node 34. The parent (F1) of this generation produced pollen in 3 mo 1 wk in greenhouse.

Literal indeterminacy therefore exists in maize, from *id1*. This establishes the fact, or affirms the assertions by Shaver. It happens only **outdoors** (even if Shaver's assertion was based on plants with more growth than 30 internodes, unlike the ridiculous criterium of all other reports). All of the present growths were at 10° latitude, so short night is still not involved; and if decreasing night length was involved then the plants would have been expected to induce by some month after June, which they did not. The only other predominant explanation in this event is the marginal difference in background percentage or identity, which is not particularly likely. The strange difference in behavior (internode quantity) between the 68% material in greenhouse vs. outdoors (Table 1, 2) speaks to the strange indeterminate behavior of the 75% material outdoors. Curiously,

rooting ends at the same place (node 36 indoors vs node 34 outdoors) independently of whether indeterminance happens. This might lend again toward the uninvolved of background percentage, and too that *the indeterminance happens above the ear in literally indeterminate maize (exactly as indeterminate Lfy1 field plants in the tropics)*. Now it is further unattributable to allelic version, as this is ostensibly the third version (*Singleton, Shaver, Neuffer*), and none of the three express it indoors (consider MNL 38:23).

Thus, there are **two indeterminacies** in *id1*: **literal**, and **figurative**. Literal comes from *id1* outdoors, and figurative comes from the same mutation, but indoors. With the strong Neuffer allele, figurative is a contribution of 9 internodes without certain background, and 30 with certain background. Figurative can likewise be at least nominally increased (3 internodes from non-dwarf Neuffer allele in temperate background) by a proven synergy with night length.

Internodes of mutants are all less than 6 inches (same millipede appearance as Chiapas 234 outdoors), even after the elongation caused by the shift of light wavelength (heat increase, stress minimization) in the greenhouse. Alas, *id1*'s specter of **dwarfing** is, seeing the short-night growth of Huehuetenango, *the requirement of the literal indeterminacy*, perchance ameliorated by GA. As a comparison, a *Lfy1*, *dlf1*, and wild type plant readily attain the same height with half fewer internodes, even with *Lfy1* shortening itself (*id1* 55 internodes, *Lfy1* 32, *dlf1* 28, wild type 24).

LFY1 INDETERMINACY

Indeterminate *Lfy1* mutants happen outdoors under long night. Conversely (though axiomatic), they do not happen under the more-expected, opposite conditions (tassels found in all 40 ft plants in spite of the 80-98 internodes). Recently, at least **two of dozens** of *Lfy1* mutants were 3-4 meters plant height in marginal, outdoor, long-night (spring planting, 10° N latitude) conditions, yet with undifferentiated apical meristems, obviously vegetative in a height tier foreign to their co-segregants. One had an ear at 7.5 ft, *node 23*, with 6 ft of plant above, topped with a regularly vegetative whorl with an indeterminate meristem. The second plant issued roots at 5.5 ft, *node 21*. A third (equal) plant was noted in 2012.

UNIVERSAL INDETERMINACY

Literal indeterminance from *id1* and *Lfy1* appear the same phenomenon. An interesting discrepancy is the difference in highest rooting-earing between indeterminate *id1* and *Lfy1* plants with equable background. If background is indeed unresponsive, the below-ear difference may reflect an appreciably (13 internodes) greater addition by *id1* below the ear, a difference between the figurative part of *id1* and *Lfy1*.

Interesting furthermore are the phenomena of **reverse-silking** (lowest to highest ear) in the 68% *id1* material, and earing that **skips** multiple nodes in the *Lfy1* material (in other words a real version of the clumsy attempt to attach ears to 27 ft maize in Iowa, in 1942), not to mention the unusual quasi-*id1* events in the 68% material (Table 1, 2).

OUTDOORS AND SUNLIGHT INTENSITY

Thus, there are **3 conduits** to indeterminacy in maize: *id1*, *Lfy1*, and *sensitive teosinte* (e.g. Huehuetenango and Parviglumis).

id1 and *Lfy1* impart literal indeterminance as one component of a **binary** phenomenon in which the second component is some agent in outdoor growth. **UV** is used to turn-on genes in biotechnology, and maybe it has happened here naturally, all along. It is long known in natural gene activation.

However, the second component may only function with activation by a third component (making a trinary phenomenon), possibly high-**intensity** (particularly tropical) **sunlight**. It does not seem to instead be a late, indirectly night-length reactive **background**, only because Shaver's was ostensibly Gaspe (again, if Shaver's was literal indeterminance).

Though *id1* and *Lfy1* must be cultivated outdoors to see *literal indeterminacy*, it is not required for Huehuetenango, which instead requires short night length. Furthermore, *id1* and teosinte must be homozygous, *id1* for both its figurative and literal forms. **Multinary** mechanism, or stepwise recipe, is thus not just to literal indeterminacy in *id1* and *Lfy1* but obligacy in teosinte, and even high expression in figurative indeterminacy and *Lfy1* (background and short night synergy).

Thus, neither *id1* nor *Lfy1* would contribute literal indeterminacy in a **tall greenhouse**, unless something happens through an open top. Only teosinte will do it, possibly. In a tall greenhouse, *id1* will only contribute the 9-30 leaves of its figurative indeterminacy and *Lfy1* its ostensibly background-independent dose of 20 (plus their short night synergies).

Citations

Ftt: May 5, 2014 - <http://web.archive.org/web/20140505165252/http://www.gdcb.iastate.edu/faculty-and-research/faculty/michael-muszynski/>

APPENDIX

Table 1. *id1* F2 68%^a GH^b

# ^c	Blw Abv Tot ^d	Plln ^e
1	15520	2m2w
2	15520	2m2w
3	17522	2m2w
4	17522	2m2w
5	21829	3m2w
6	23629 ^{+f}	4m0w
7	-- 55 ^g	8m3w ^h

Parent 18725 selfed; planting Dec 6; ^atropical background; ^bgreenhouse; ^cplant; ^dinternodes below ear, above, total; ^epollen (months, weeks); ^fleaves without

internodes (above ear) excluded; ^adata missing; ^btassel eruption

Table 2. *id1* F2 68% FLD^a

#	Blw Abv Tot	Slk ^b
1	-- 21	-
2	-- 23	-
3	-- 23	-
4	-- 24	-
5	-- 25	-
6	19625	2m3w
7	20626	-
8	20626	-
9	24630	3m3w
10	prob <i>id</i> ^c	-

Parent 18725 selfed; planting Jan 4; ^afield; ^bsilk; ^cprobable *id1* mutant
(cull of dwarf-like plant with apparent indeterminate internode quantity)

Table 3. *id1* F2 75%

#	Parent					
	16521-gp1	15823-gp2	(<i>id1</i> +) 151025-gp3	18826-gp3	(<i>id1</i> +/ <i>Lfy1</i> +) 141024-gp7	151126-gp7
1	-- 17	-- 18	-- 21	-- 21	19625	-- 18
2	-- 17	-- 18	-- 21	-- 21	19625	-- 21
3	-- 18	-- 19	-- 23	-- 21	17926	-- 24
4	-- 18	16420	-- 24	-- 22	19 - <i>Lfy</i>	-- 24
5	-- 18	16420	17825	-- 22	19 - <i>Lfy</i>	17825
6	-- 19	15621	17825	-- 23	[- - 40]	-- 26
7	-- 20	14822	17926	-- 23	-	171027
8	-	16925	[- - 40]	171027	-	-
9						
10						

Planted Jan 7; *gp* - grand parent; *Lfy* - internode qty below ear known, but culled before *Lfy1* expression quantified above; [-] - preliminary data entry, later-analyzed literal *id1* mutant