DESCRIPTION OF THE GENES FOUND IN PHARBITIS NIL

by

YOSHITAKA IMAI

Since the genetic study of *Pharbitis Nil* was started some twenty years ago, a considerable number of genes have been brought to light by several investigators, especially during the last ten years. The present paper contains a list of the genes so far determined. Some genes, the determination of which is still uncertain, are omitted from this list and we hope to be able to give them in a future paper. The table includes 111 genes, the behaviour of which, with the exception of two (giant and Stellate), is described after my own observations. Only 15 of these genes are found to act as dominant to the normal or standard. The first letter of the name of the dominant genes is printed in capital type that of the recessives in small one. The Japanese morning glory is a plant from the Old World, and is now found under cultivation only. As a medical herb this plant has been known for some two thousand and two hundred years in China. It was over a thousand years ago that this plant was first introduced into Japan, where afterwards many garden varieties have been raised, especially during the last century and a quarter, when its intense cultivation was started for ornamental purposes. The plant seems to have grown before then in a semi-wild condition and appealed to the lovers of flowers. As is the case with all other ornamental plants, the fashion for the Japanese morning glory has changed, so that some old mutant characters have disappeared from the gardens. A description and illustration of the original morning glory is found in our classic literature, and we can get a general idea of the normal or standard type (Figs. 1, 7 and 40) of this plant. The leaf of the normal form is three-lobed (Fig. 16); the flower is single, funnel-shaped (Fig. 28), and has a dilute blue colour. A majority of the genes listed in the text made

their occurrence in old times. The registered genes are regarded as mutants, though this is uncertain in one or two cases.

The writer wishes to express his hearty thanks to Professor Dr. K. MIYAKE for his valuable suggestions, and to Professor B. MIYAZAWA, Mr. T. HAGIWARA and Mr. N. HACHIUMA for their kindness in supplying the seeds of some strains.

A LIST OF GENES

acuminate, ac. (ac L. G.[1]). Stalk broadened at the junction of the cotyledons. (Fig. 12). Lamina deep-lobed and sharp-pointed; lobes rolling backwards (Fig. 19); sometimes compound. Corolla funnel-shaped, with a narrow opening; margin turned outwards and sometimes split irregularly; flower-tube comparatively long (Fig. 32). Fertility low. Jap. name "Nanten" or nandina.

albescent, ab. Cotyledon with white or whitish smear. Stalk of cotyledon pale or white. Bud appearing between the first young leaves distinctly white. The first one or two leaves of the seedling whitish, but not permanently so; leaves of a grown-up plant apparently green or normal. Viability of seedling low. Fertility normal.

albino, al. Cotyledon immediately after germination almost pure white, with a little chlorophyll; turns pure white later on; seedling dies a few weeks after germination, without forming leaves. YASUI (1920) studied this character. In IMAI's culture (1927b), it appeared twice by mutation.

anchor, ar. Petiole broadened at the junction of the lamina, but not crooked. Jap. name "Ikari".

Blizzard-1, Bz1. Manifests a Blizzard character in co-operation with Blizzard-2. Deep-coloured stripes or areas occur on a light-coloured background, frequently whitish spots appear scattered sparsely over a deep-coloured background. Variegation varies considerably, resulting sometimes in extreme cases of a nearly self-coloured flower of a heavy or light tone.

Blizzard-2, Bz2. Complementary to Blizzard-1 in the production of a Blizzard character.

Blown-1, Bl. (v L. G.). Stalk broadened at the junction of the cotyledon (Fig. 14), and also of the base of the lamina of the leaf, making it crooked (Fig. 17). Jap. name "Rimpu".

Blown-2, B2. (p L. G.). Less conspicuous than Blown-1.

blown-3, b3. Still less conspicuous hardly noticeable in upper leaves.

brown, br. (v L. G.). Seed colour brown.

buff, bf. Seed colour lighter than brown.

bush, bu. Bush habit; a number of branches grow up together with

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1) "L. G." is an abbreviation of "linkage group".

main stem; only about 2 feet high. Fertility low. Appeared as a mutation in IMAI's culture (1927b); lost.

chocolate, ch. Seed colour darker than cocoa.

cocoa, ca. Seed colour a little darker than brown. Appeared as a mutation (IMAI in press, b).

contorted, cd. Rays of corolla containing chlorophyll, prevents the flower from complete opening, making it crooked and contorted; sometimes hard to open without aid. Jap. name "Nejiume".

contracted, ct. (ct L. G.). Cotyledon and leaf contracted and dark green; texture thick and brittle. Flower small (Fig. 3); seed also small. Sometimes mutable, reverting to normal. Jap. name "Uzu".

cordate, co. (co L. G.). Heart-shaped leaf (Fig. 20). Jap. name "Maruba".

couple, cu. (v L. G.). Two flower-buds grow in a leaf-axil (Fig. 41), one blooming several days later than the other.

cream, cr. (ct L. G.). Creamish flower with a few fine anthocyanin splashes. Hypocotyl green, sometimes speckled. Mutable, frequently reverting to normal.

creased, fec. (co L. G.). Recessive allelomorph to feathered. Cotyledon a little crumpled; leaf nearly flat or slightly crumpled. Flower feathered; apparently no altering of sexual organs. Fertility low. Jap. name "Ranjishi".

crêpe, cp. (co L. G.). Crêpe texture of leaf; cup flower varying in intention manifestation; hair on flower-bud. Jap. name "Chirimen".

crisscrossed, cs. Flower split down to the base of tube; narrow petals crossing one another at the neck of tube (Figs. 38 and 39). Sometimes imperfectly split, with whitish lines or grooves left on tube, at which parts tube split. Calyx somewhat broad; hair considerably bobbed. Jap. name "Ishidatami". Reappeared by mutation in IMAI's culture (1927b).

crumpled-1, c1. (v L. G.). Lamina uneven or crumpled; diagnosis at times uncertain in later growth. Behaves as a dominant on delicate, creased, crêpe and deformed genotypes. Jap. name "Uchikomi".

crumpled-2, c2. (dl L. G.). Character similar to that of crumpled-1.

defective, dv. Seed very thin and rusty tan in colour; air-dried seed weighing about one half normal seed. Seedling with small and deformed cotyledons; less vigorous. Fertility a little low. Appeared by mutation under IMAI's observation (1927b).

deficient, df. Sometimes fine variegation on cotyledon, with irregular missing of parts. Same character on leaf. Flower sometimes split and deformed with whitish stripes (Fig. 2). Jap. name "Kake".

deformed, de. (y L. G.). Cotyledon with shallow lobing and long stalk (Fig. 13). Petiole long; lamina with thin mesophyll and sometimes deformed. Plant habit peculiar. Flower doubled, bearing hardly any sexual organs. Propagated through "parental stocks" heterozygous for deformed. Jap. name "Tenaga-botan".

delicate, dl. (dl L. G.). Leaf with sharp-pointed lobes and less protruded shoulder (Fig. 18); mesophyll thin. Cotyledon with narrow lobes (Fig. 15). Cotyledon and lamina a little crumpled. Flower split, rather narrow, five petals (Fig. 31). Fertility low. Sometimes mutable, reverting to normal. Jap. name "Sasa".

Dilute, D. (dp L. G.). Standard flower colour, RIDGWAY's "Bradley's Blue", diluted into "Amparo Blue".

dragonfly, dg. (dp L. G.). Lamina with elongated median lobes and one or two narrow side-lobes on both sides (Fig. 21). Flower somewhat large; rays of corolla rarely over five in number. Jap. name "Tombo-ba".

dragonfly-suppressed, dg-s. Modifier of dragonfly. Leaf normally three-lobed.

duplicated, dp. (dp L. G.). Flower doubled or proliferated, including flower-buds with sepals, and without sexual organs. Propagated by "parental stocks" heterozygous for duplicated. Jap. name "Botan". Reappeared by mutation in IMAI's culture; lost.

duskish, dk. (ct L. G.). Flower more dilute than dusky in colour, having a unique hue or RIDGWAY's "Vinaceous Purple".

dusky, dy. (y L. G.). Flower colour dull, or RIDGWAY's "Dark Hyssop Violet" intensified.

dwarf, dw. Hypocotyl short, with cotyledons of hard texture. Stem thick; about 2.5 feet high, with short internodes (Fig. 5). Star-shaped corolla with short peduncle. Jap. name "Kidachi".

dwarfy, da. Stem short; internodes short, with overlapping leaves; flower normal. Appeared by mutation (IMAI 1927b); lost.

Expanded, Ex. (ct L. G.). White margin extended broadly on corolla, leaving star-like coloured parts.

extended, e. (dp L. G.). Working on faint, results in full-coloured flower-tube.

faded, fd. (v L. G.). Flower faintly coloured. Hypocotyl green, except lower part which is faintly coloured by anthocyanin pigment. Faded flower with a coloured ring just inside white margin.

faint, ft. In a magenta flower resulting in faintly coloured tube. Bottom of tube rather faintly coloured.

fasciated-1, f1. (p L. G.). Fasciated stem caused by three recessive genes, fasciated-1, fasciated-2 and fasciated-3. Frequently fails to be fasciated, remaining as normal, due to fluctuating manifestation. Flower sometimes deformed. Fertility low.

fasciated-2, f2. (p L. G.). Works in co-operation with f1 and f3.

fasciated-3, f3. (v L. G.). One of three polymerous genes for fasciated character.

feathered, fe. (co L. G.). Cotyledon much crumpled or rolled. Corolla feathered, with supplementary petaloid pieces, sometimes split irregularly. Leaf rolled. Fertility generally low or perfectly sterile. Jap. name "Shishi".

flecked, fl. (ct L. G.). Green hypocotyl, sometimes speckled. Flower with fine anthocyanin stripes. Mutable, producing normal flowers.

folded, fol. Flower-bud not open, remaining folded all through its existence. Anthers do not shed pollen; sterile. Appeared by mutation (IMAI in press, b).

foliate, fo. (r L. G.). Modifier of terminal. Peduncle very elongated, bearing crowded roundish, small leaves; frequently with branchlets (Fig. 44). Flowers few.

giant, gi. Cotyledon and leaf stout and deep green. Flower large; fertility very low. Appeared by mutation under HAGIWARA's observation (1926); lost (personal information).

glabrous, g. Hairs very few; smooth to touch.

glabrous-suppressed, g-s. Modifier of glabrous, giving hairy foliage.

golden, gn. Vividly yellow; frequently green spots occurring on cotyledon; dies without unfolding leaves. Sometimes one or two leaves develop when green areas of cotyledons are large, but very hard to grow. Green spots or areas due to recurrent mutations. Appeared by mutation in HACHIUMA's garden.

half-white, hw. Lower half of flower-tube white.

intense, i. (ct L. G.). Intensifier of flower colour, giving RIDGWAY's "Dark Bluish Violet".

interaxil-green, ig. (ct L. G.). Green hypocotyl; green stem with

anthocyanin colour on the base of branches and peduncles.

ivory. Possibly allelomorphic to white-3. Seed ivory in colour. Stem green; flower white, with white tube.

light-1, lt1. (y L. G.). Colour of hypocotyl dilute; colour of flower also dilute.

light-2, lt2. Character similar to that of light-1, but not linked with dusky.

Lined, Ln. Irregular stripes on dilute background of corolla; variegation varies considerably.

magenta, mg. (ac L. G.). Flower colour purplish red or RIDGWAY's "Rood's Violet" intensified. Colour of hypocotyl dark red instead of dark purplish red. Hair white instead of brownish.

maple, m. Lobes of cotyledon arranged in parallel (Fig. 8); veins. Leaf lobed deeply like that of maple tree; normal maple five-lobed (Fig. 22). Flower split regularly (Fig. 29). Pistil sometimes deformed; fertility low. Jap. name "Tatsuta".

Margined-1, Mr1. (ct L. G.). In co-operation with Margined-2 manifests white margin on corolla. Jap. name "Fukurin".

Margined-2, Mr2. (ac L. G.). Complementary to Margined-1 for the manifestation of a Margined character.

Margined-fluctuated, Mr-f. (sp L. G.). Modifier of Margined. Fluctuating the manifestation of white margin.

Margined-reduced, Mr-r. (ct L. G.). Modifier of Margined. White margin reduced.

margined-slight, mr-rs. Allelomorphic to Margined-reduced. (ct L. G.). Producing very small amount of white margin on corolla.

Margined-suppressed, Mr-s. Modifier of Margined. Inhibiting completely the manifestation of white margin, results in normal, self-coloured flower.

miniature, mi. Cotyledon very small. Leaf very small; flower also very small and split. Flowers in small clusters. Sterile. Jap. name "Tsubame" or swallow. Reappeared by mutation under IMAI's observation (1927b); lost.

palmate, pl. (co L. G.). Leaf five-lobed. Flower funnel-shaped.

pear, p. (p L. G.). Oblong leaf without side-lobes (Fig. 25); sometimes side-lobes develop. Cotyledon with Blown-like character in a very slight degree. Flower somewhat small. Jap. name "Kujaku".

petaloid, pt. Stamen petaloid; much variation occurs. Pistil always fertile.

pigmy, pg. Hypocotyl very short. Cotyledon thick, crumpled and deep green, with very short stalk. Between cotyledons a few thick and crumpled leaves with very short petioles appear. Seedling does not grow after this stage. Appeared by mutation under my observation (IMAI in press, b).

pine, pi. Cotyledon very small. Leaf filiform. Flower split very narrow. Highly mutable, reverting to normal. Reappeared by mutation (IMAI 1927b). Jap. name "Matsu-ba".

polymorphic, py. Cotyledon with retracted, roundish lobes (Fig. 10), sometimes split or compound. Leaf split irregularly, with sharp-pointed lobes (Fig. 23); sometimes not split. Corolla creased, with super-numerous rays (Fig. 33); often irregularly split. Fertility low. Jap. name "Rangiku".

precocious, pc. (co L. G.). Early blooming; flower-buds appear on lower nodes of stem.

Projected, Pj. Leaf with small projections on its margin.

projected-enhanced, pj-e. Modifier of Projected. Leaf with large projections.

purple, pr. Flower colour in RIDGWAY's "Cotigna Purple" in intense variation.

Rayed, Ry. (ct L. G.). Flower with coloured rays, colour fading off in regions between rays. Reappeared by mutation (IMAI in press, a).

retracted, r. (r L. G.). Cotyledon with roundish lobes (Fig. 11). Leaf with retracted lobes; especially median lobe much shortened (Fig. 26). Corolla large, frequently with over five rays (Fig. 30). Sometimes numerous sepals and bracts. Fertility low. Jap. name "Suhama".

reversed, cpr. (co L. G.). Recessive allelomorph of crêpe. Flower reversed to cup. Leaf not crêpe.

rootletless, rl. Cotyledon with generally shallow lobing. Rootless in early seedling stage; later thick and crooked rootlets appear. Hair remarkably short. Appeared by mutation (IMAI in press, b).

semi-contracted, sc. (co L. G.). Cotyledon and leaf somewhat thick and brittle. All organs somewhat contracted.

septalobate. Modifier of maple, resulting in seven-lobed leaf.

shrubby, sh. (ct L. G.). Seedling somewhat small. Lobes of leaf sharp-pointed, with hard texture. Branches occur on the lower part of main stem. Occurred by mutation (IMAI in press, b).

side-reduced, sr. Side-lobes of leaf retracted and roundish (Fig. 24). Jap. name "Hana-ba".

smeary, fds. Dominant allelomorph of faded. (v L. G.). Flower colour dilute or RIDGWAY's "Light Violet-Blue" intensified. Margined dirty flower with a heavily coloured ring on region adjoining white margin.

speckled, sp. (sp L. G.). Hypocotyl and stem speckled. Fine spots distributed over corolla; speckling varies considerably in its qualitative and quantitative expressions.

speckled-reduced, sp-r. (y L. G.). Modifier of speckled. Green hypocotyl. Nearly green stem, with very dilute anthocyanin colour on the base of branches and peduncles. Flower with or without a few fine anthocyanin spots on otherwise yellowish or white background.

spheloid, sph. Seed small, roundish and brownish.

star, cts. Recessive allelomorph to contracted. (ct L. G.). Character similar to contracted, except flower which star-shaped (Fig. 4). Jap. name "Uzu-kikyo".

Stellate, Sl. Modifier of Margined, working on homozygous Margined flower. White margin extended broadly, leaving a coloured part of = star-shape on corolla. Studied by HAGIWARA (1922).

striated, sa. Dilute flower colour brushed by very fine stripes; colour somewhat faded off to margin of corolla; sometimes with clear fine stripes.

striped, st. (dp L. G.). Stripes occur irregularly on dilute background of corolla.

stunted, sd. Growth slow and stunted. Stem stout; frequently nodes crowded. Leaf crumpled (Fig. 6). Flower irregularly split, with short peduncle; calyx and bracts large (Fig. 35). Fertility very low. Appeared by mutation under IMAI's observation (1927b).

terminal, t. Peduncle with a few axillary flower-buds, bearing small leaves without side-lobes; terminal flower with no bracts; axillary flowers with two or three small bracteal leaves on their stalks; sometimes axillary peduncles bear subaxillary flowers (Fig. 43). Terminal flower blooms first. Sported under observation (IMAI 1927b). Almost similar character (Fig. 42) studied by HAGIWARA (1928).

tinged, tg. Flower colour diluted considerably.

trilobate. Modifier of maple, reducing the number of lobes into three.

tube-white, tw. (ct L. G.). Flower-tube white.

variegated, v. (v L. G.). White or whitish variegation on leaf. Stem with whitish stripes. Cotyledon frequently variegated. Seed brownish, with black stripe on the back.

variegated-reduced, v-r. Leaf finely variegated with very dilute green colour. Variegation somewhat netlike.

velvet, vt. Long hair on seed-coat.

virescent, vi. Cotyledon and leaf pale green. Viability low; growth slow. Leaf and flower small, due to malnutrition. Mutated under IMAI's observation.

white-1, w1. (sp L. G.). White flower with coloured stem. Flower-tube always white.

white-2a, w2a. (dp L. G.). White flower with green stem. The dominant allelomorph works complementary with W1, W2b and W3 in the production of coloured flower.

white-2b, w2b. White flower with green stem.

white-3, w3. White flower with green stem; flower-tube always white. Seed white.

willow, mw. Recessive allelomorph to maple. Cotyledon with narrow lobes (Fig. 9); veins clear. Leaf narrow like that of willow tree (Fig. 27). Flower split into narrow petals (Fig. 34); sometimes crooked. Usually sterile, but anther frequently contains good pollen. Mutable, altering to maple.

wrinkled, wr. Corolla wrinkled, somewhat star-shaped (Figs. 36 and 37). Fertility low. Mutable, reverting to normal. Jap. name "Chijimi-zaki". Reappeared by mutation in IMAI's culture (1927b).

yellow, y. (y L. G.). Foliage yellowish green.

yellow-inconstant, yi. Dominant allelomorph to yellow. (y L. G.). Fine green spots occur on yellow leaf; green spots sometimes large, or giving green or chimerical branches, due to vegetative mutation. Mutable, reverting to normal. Jap. name "Matsushima". MIYAZAWA (1929) obtained a similar form by mutation; frequency of mutability higher than yellow-inconstant studied by IMAI (1927a, 1930).

yellowy, ye. Cotyledon yellowish green, very frequently with green patches. Young leaf yellowish green and finely mottled with green spots; later, green mottling extends over leaf — so far that demar-

cation with normal green leaf is difficult. Frequently green spots or areas occur on leaf, and sometimes green or chimerical branches appear, due to recurrent mutations. Originally sported under IMAI's observation.

REFERENCES

HAGIWARA, T. 1922. Genetic studies of corolla-design in the morning glory. Bot. Magazine, Tokyo 36 : 205—225. (In Japanese).

— 1926. Genetic studies of leaf-character in morning glories. V. Bot. Magazine, Tokyo 40 : 226—235. (In Japanese).

— 1928. Genetic studies of leaf-characters in morning glories. VII. Bot. Magazine, Tokyo 42 : 85—95. (In Japanese).

IMAI, Y. 1927a. A genetic study of green-variegated yellow leaves in the Japanese morning glory. Journ. Genetics 17: 329—348.

— 1927b. The vegetative and seminal variations observed in the Japanese morning glory, with special reference to its evolution under cultivation. Journ. Coll. Agri., Imp. Univ. Tokyo 9 : 223—274.

— 1929. The segregation of albescent seedlings and the mutation to defective seeds in a pedigree of the Japanese morning glory. Amer. Naturalist 63 : 151—159.

— 1930. Studies on yellow-inconstant, a mutating character of *Pharbitis Nil*. Journ. Genetics 22 : 191—200.

In press, a. The property of the genes affecting the flower colour in *Pharbitis Nil*. Journ. Genetics.

In press, b. New mutant characters of the Japanese morning glory. Journ. Heredity.

MIYAZAWA, B. 1929. On the inheritance of the "Matsushima"-variegation in the Japanese *Convolvulus*. Jap. Journ. Genetics 4 : 167—184. (In Japanese).

YASUI, K. 1920. Genetical studies in Japanese morning glory. I. Bot. Magazine, Tokyo 34 : 141—145. (In Japanese).

PLATE I

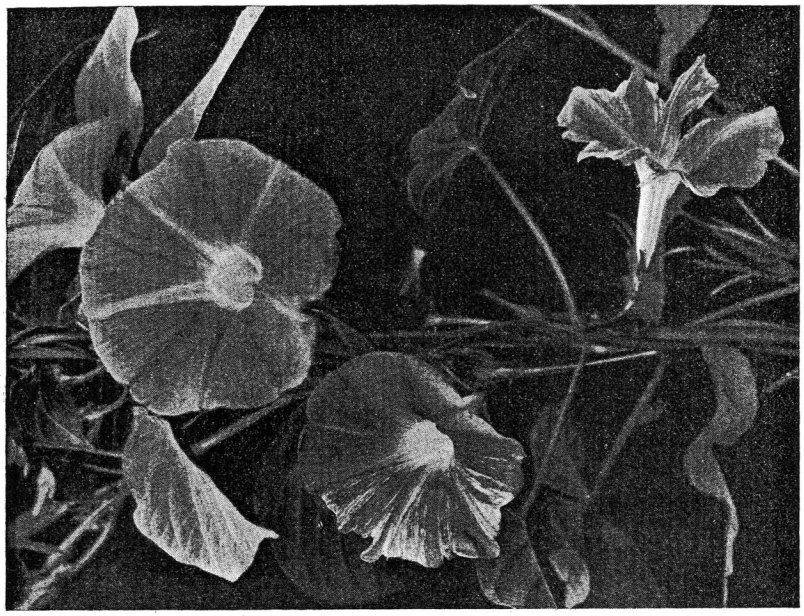


Fig. 2. Deficient.

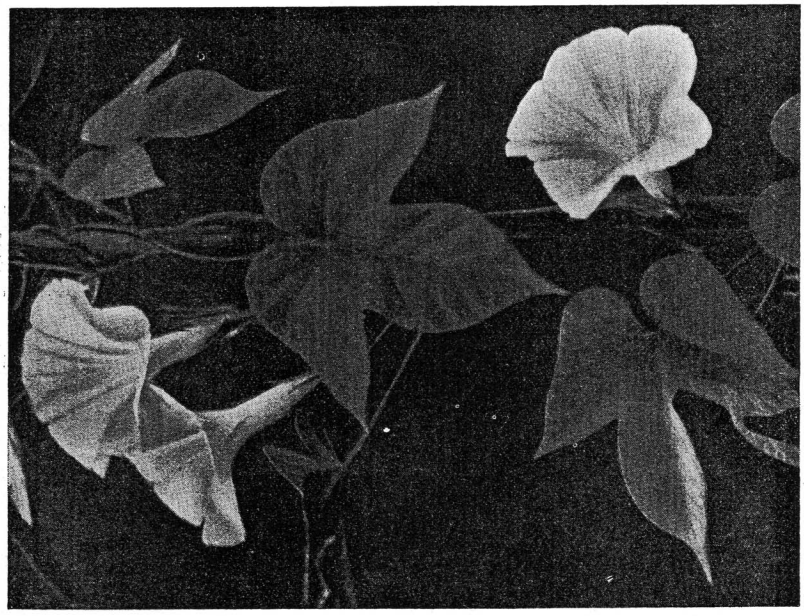


Fig. 1. Normal.

PLATE II

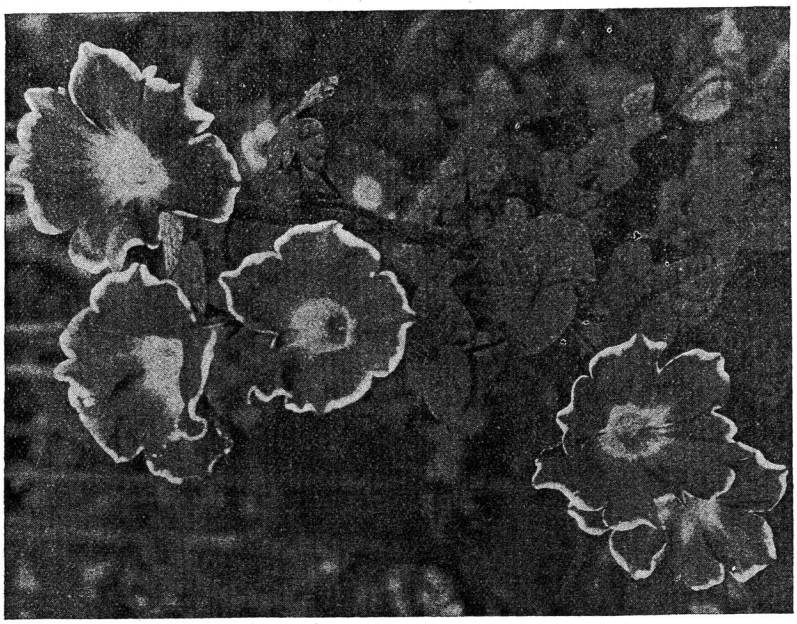


Fig. 4. Star (retracted).

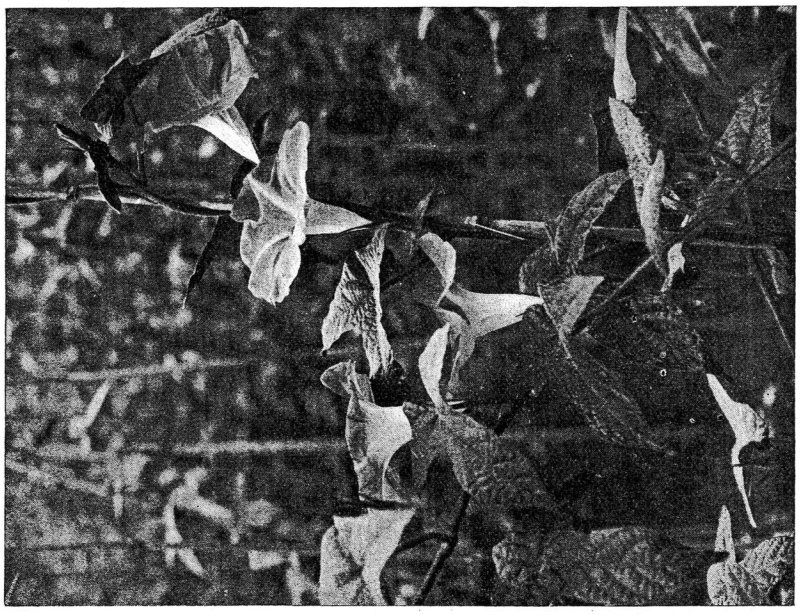


Fig. 3. Contracted.

PLATE III

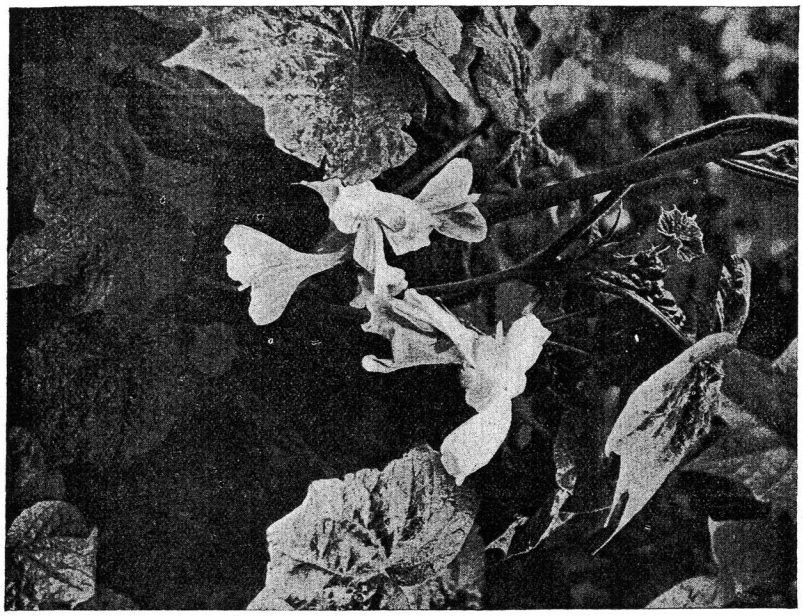
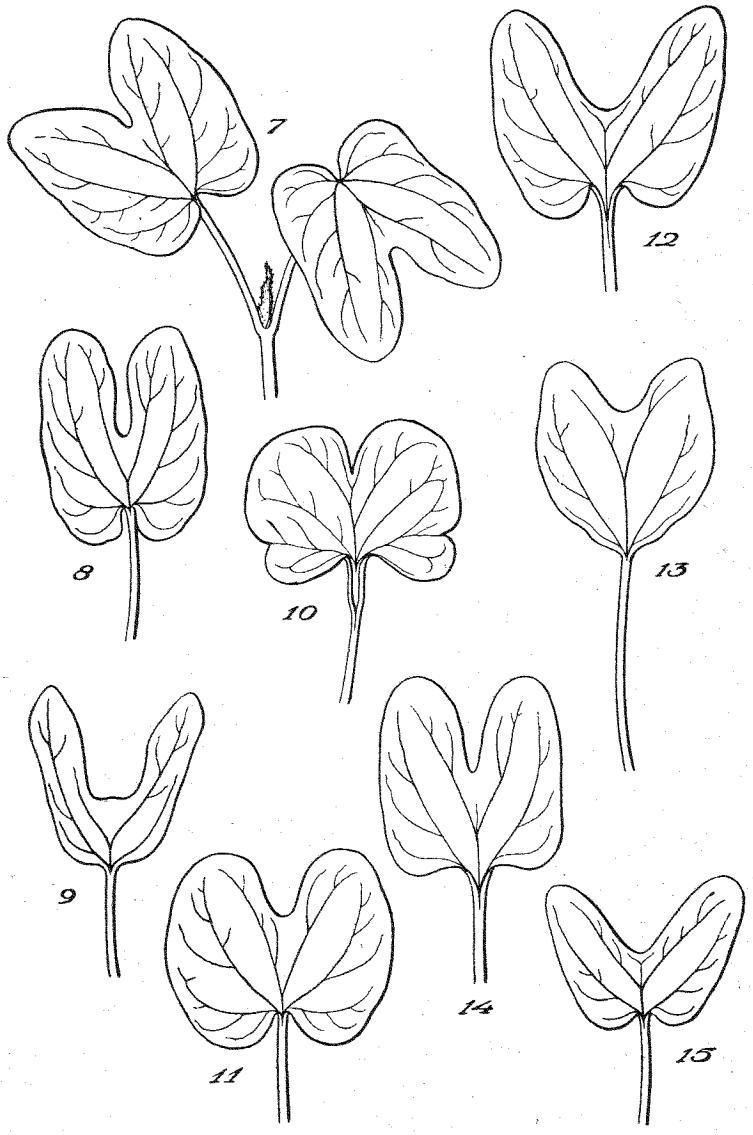


Fig. 6. Stunted.

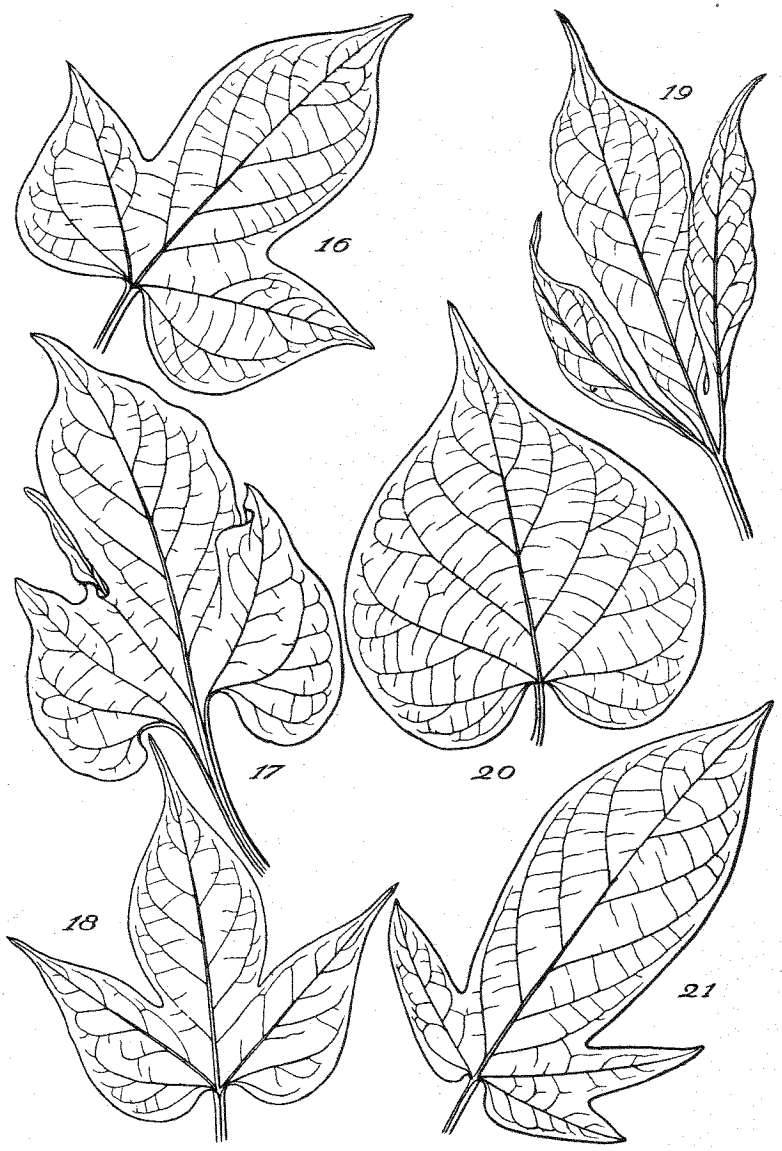
Fig. 5. Dwarf (left) and normal (right).

PLATE IV



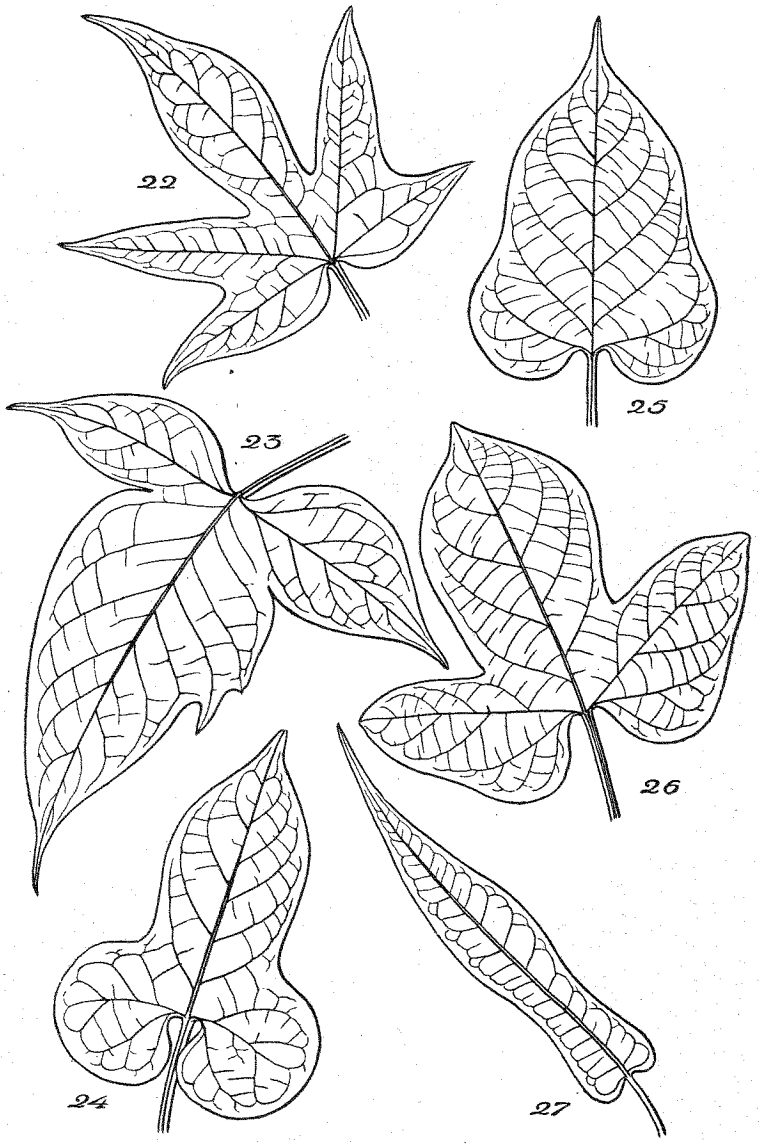
Figs. 7—15. A collection of different cotyledons: 7, normal; 8, maple; 9, willow; 10, polymorphic; 11, retracted; 12, acuminate; 13, deformed; 14, Blown-1; 15, delicate.

PLATE V



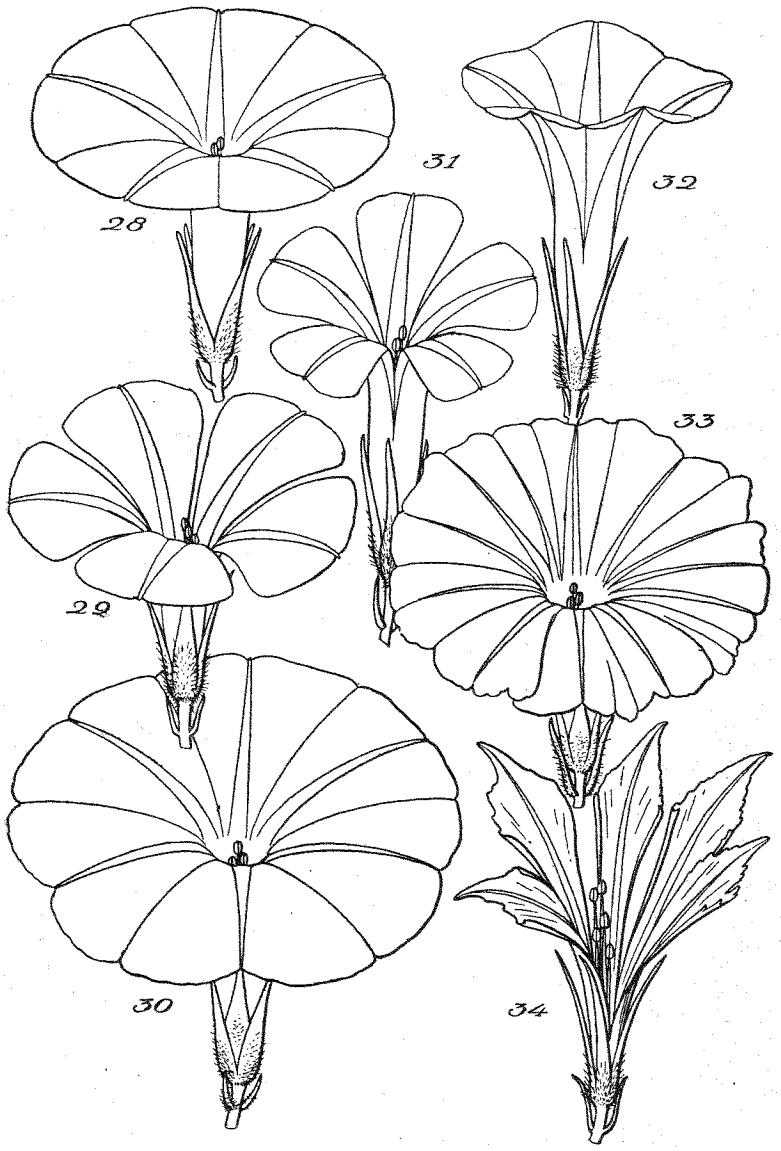
Figs. 16—21. Various leaves-I: 16, normal; 17, Blown-1; 18, delicate; 19, acuminate; 20, cordate; 21, dragonfly.

PLATE VI



Figs. 22—27. Various leaves-II: 22, maple; 23, polymorphic; 24, sidereduced; 25, pear; 26, retracted; 27, willow.

PLATE VII



Figs. 28—34. Different flower types: 28, normal; 29, maple; 30, retracted; 31, delicate; 32, acuminate; 33, polymorphic; 34, willow.

PLATE VIII

Figs. 35—39. Peculiar flowers: 35, stunted; 36 and 37, wrinkled; 38 and 39, crisscrossed.

PLATE IX

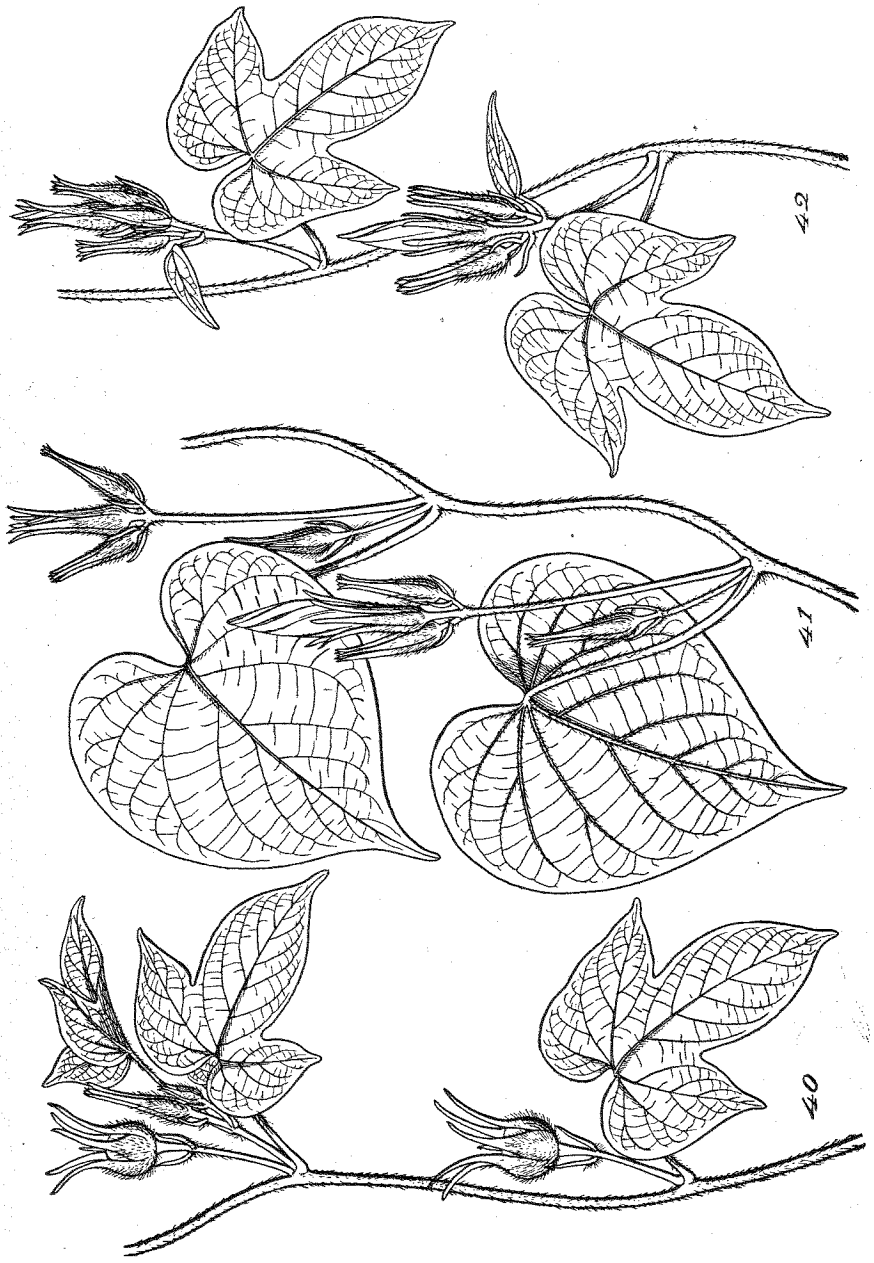


Fig. 42. HAGIWARA's terminal.

Fig. 41. Couple.

Fig. 40. Normal.

PLATE X

Fig. 43. Terminal.

Fig. 44. Foliate.