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Giant hills may be classified as semi-giant, giant, or super-giant depending on the degree of the variation. All are large, vigorous, profusely flowering plants with characteristically poor tuber shape, although some giant hills may have smooth tubers. Thirteen of the fifteen Russet Burbank giant hill selections grown in Corvallis, Oregon were inferior to normals in tuber shape.

Russet Burbank giant hills were characterized for seasonal changes in plant height, flowering, and tuberization. Giant hills tuberized later than normals. Giant hills produced more than twice as many flowers as normals, and continued flowering three times as long. Giant hills were taller than normals from midseason on. Based on growth and flowering characteristics, giant hills were detectable earlier in the season than has been generally acknowledged, generally by 63 days after planting.

To investigate the nature of giant hill, plants were regenerated from shoot tips, heat treated meristems, and tuber tissues of cortex, perimedullary, and pith regions of giant hill and normal Russet Burbank tubers in vitro. Regenerated plants were grown in the field and examined for growth characteristics. Results strengthen Howard's hypothesis that giant hill is a chimera arising in the L2 cell layer and later moving to the L3 layer by cell replacement. Further, the intensity of the variation seen in the field may be related to its presence in L2 cells only or both L2 and L3 cells.

GROSS CHARACTERISTICS OF RUSSET BURBANK GIANT HILL POTATOES AND PLANT TYPES REGENERATED FROM TISSUES AND ORGANS

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDIX TABLES

GROSS CHARACTERISTICS OF RUSSET BURBANK GIANT HILL POTATOES AND PLANT TYPES REGENERATED FROM TISSUES AND ORGANS

INTRODUCTION

In recent years a variation in the vegetative and reproductive expressions of the potato (Solanum tuberosum) has been occurring with increasing frequency in some Oregon potato fields. The variants, called giant hills, remain green and often continue flowering after normal plants have died. These studies were undertaken to characterize the variation in Oregon grown Russet Burbank potatoes and to gain a better understanding of its significance.

Giant hills, sometimes known as bolters, mannetjes or bull plants, are thought to arise from a mutation (6). They appear de novo in many potato varieties as large, erect, profusely flowering, late maturing plants with large misshapen tubers. Stanton (13) distinguished different degrees of the variation (semi-bolter, full bolter, and super bolter). Most American authors have not made such distinctions, but among fifteen Russet Burbank giant hill selections collected from around Oregon differences in the degree of the variation were obvious (Appendix Table 17).

Giant hill potatoes have generally been considered undesirable due to poor tuber shape (1, 2, 3, 5, 8, 11, 13, 14, 15), but one recent author (3) suggested that some giant hills may be superior to the parent cultivar. Giant hills may outyield normals if allowed to fully mature (1, 2, 4, 9, 10, 11, 12, 15), and various giant hills have shown resistance to early frosts (7, 8, 12, 15), early blight (8, 15), late blight (6, 11, 14), rhizoctonia (15), and verticillium

wilt (3, 15). Thirteen of fifteen Russet Burbank giant hill selections planted as tuber units in Corvallis in 1982 were inferior to normal controls in tuber shape, although some seemed quite promising during the selection process (Appendix Table 18).

LITERATURE CITED

1. Carson, G.P. and W.H. Howard. 1944. Inheritance of the "bolter" condition in the potato. Nature 154:829.
2. Dearborn, C.H. 1963. "Stitched end", "giant hill" and fasciated stem of potatoes in Alaska. Am. Potato J. 40:357-360.
3. Easton, G.D. and E.M. Nagel. 1981. Giant hill a problem or a possibility. Spudman. Feb. pp. 11-25.
4. Hawkes, J.G. 1947. The photoperiodic reaction of potato bolters. Empire J. Exptl.. Agric. 15:216-226.
5. Hill, Helen D. 1934. A comparative study of certain tissues of giant hill and healthy plants. Phytopathology 24:577-598.
6. Howard, H.W. 1970. Genetics of the Potato. Logos Press Limited, London. 126 pp.
7. Lauer, K.W. 1929. Seed potato certification in Pennsylvania. Penn. Dept. of Agric. Bull. 471. 15 pp.
8. Morris, H.E. and P.A. Young. 1930. Potato diseases in Monatana. Montana Agric. Exp. Sta. Bull. 227. 51 pp.
9. Mosley, A.R. and D. Hane. 1982. Research and extension progress report. Proceedings Oregon Potato Growers Annual Meeting and the Northwest Agricultural Show. pp. 103-115.
10. Mosley, A.R., D. Hane, and S. Kwiatkowski. 1983. Research and extension progress report. Oregon Potato Conference and Trade Show Proceedings. pp. 114-128.
11. Munro, J. 1981. Genetic abnormalities. pp. 7-8. In W.J. Hooker (ed.) Compendium of Potato Diseases. American Phytopathological Society. 125 pp.

12. Raeder, J.M. 1944. Diseases of potatoes in Idaho. Idaho Exp. Sta. Bull. 254. 39 pp.

13. Stanton. W.R. 1952. Bolting, a vegetative variation in the potato. Heredity 6:37-53.

14. Whitehead, T., T.P. McIntosh and W.M. Findlay. 1945. The Potato in Health and Disease. Oliver and Boyd, London. 400 pp.

15. Yarwood, C.E. 1946. Increased yield and disease resistance of giant hill potatoes. Am. Potato J. 23:352-369.

SEASONAL CHANGES IN PLANT HEIGHT, FLOWERING AND TUBERIZATION OF RUSSET BURBANK GIANT HILL POTATOES IN OREGON

Stephen Kwiatkowski and Alvin R. Mosley

ABSTRACT

Russet Burbank giant hills were characterized for seasonal changes in plant height, flowering, and tuberization. Giant hills tuberized later than normals. Maximum flowering of giant hills was more than twice that of normals, and flowering continued three times as long. Giant hills were taller than normals from midseason on. Giant hills were detectable earlier in the season than has been generally acknowledged.

Key words: Giant hill, Bolters, Late maturity, Solanum tuberosum.

INTRODUCTION

This study was undertaken to quantify seasonal differences in flowering, plant height, and tuberization of Russet Burbank normal and giant hill potatoes. Giant hill potatoes are tall plants which produce rough tubers and flower profusely when compared to normals, but differences in height and in the amount and duration of flowering depend somewhat on the variety. Latitude also affects the giant hill expression through regulation of daylength (1). Giant hill is thought to be a permanent condition in affected seed stock.

Giant hills must be rogued from potato seed crops in order to retain uniform tuber quality, and detection is somewhat difficult. Increased height and flowering are the two most obvious morphological characteristics of giant hills and are often used for detection. Studies which seasonally quantify differences in height and flowering should be useful in developing an improved system for roguing giant hills. Hill (2) and Stanton (3) indicated that giant hills tuberize later than normals. If giant hills tuberize later than normals, then cultural practices such as early harvest might reduce the incidence of giant hill tubers.

MATERIALS AND METHODS

Suspected giant hill and normal Russet Burbank seed lots were collected from grower fields in 1981. These were then field planted in 1982 and characterized for giant hill expression. Seed pieces were planted on May 13 in four pairs of adjacent plots with 33 plants per plot, for determining height and flowering differences. A similar planting containing eight pairs of plots was used for tuber counts and weights. Plots were single 7.6 m (25 ft) rows spaced 86.4 cm (35 inches) apart, with seed pieces 22.9 cm (9 inches) apart in the rows.

Plant heights were measured, inflorescences and tubers per plant were counted and weights of tubers per plant determined at twelve consecutive weekly intervals beginning at the onset of flowering (49 days from planting). Heights were determined for ten plants per plot at each measurement; measurements were taken at 61 cm intervals in the rows by measuring from the soil level to the tallest shoot tip. Plant heights were therefore not always synonimous with shoot lengths. Inflorescences per plot were counted at each date. Three hills were dug from each member of four pairs of plots at each sampling date, and tubers were counted and weighed. Data were analyzed with a t-test for paired samples.

RESULTS AND DISCUSSION

Plant Height

When normals were at maximum seasonal height (at 63 days from planting), giant hills averaged 10 cm taller (Table 1.1). By 77 days from planting when normals were declining in height due to canopy lodging, giant hills were at their tallest averaging 30 centimeters taller than normals. Thereafter giant hills declined in height but slower than normals. By the end of the season (126 days from planting) normals were rapidly senescing and averaged only 10 cm tall while giant hills were relatively green and upright averaging 51 cm. Thus, giant hills were visually taller than normal plants at approximately 63 days from planting, and this distinction increased throughout the season.

Flowering

Normals attained maximimum flowering of 2.9 inflorescences per plant at approximately 56 days from planting, while giant hills flowered most profusely, averaging 4.1 inflorescences, at 70 days from planting when normals had declined to only 0.5 (Table 1.2). Giant hills flowered significantly more profusely than normals between 63 and 105 days from planting. Giant hills retained flowers for about nine weeks compared to three for normals. Thus, giant hills became distinctive, profusely flowering plants at 70 days from planting and this profuse bloom continued for 35 days during which normal plants had few or no flowers.

Tuberization

At 49 and 56 days from planting, giant hills produced fewer tubers than normals, but thereafter more (Table 1.3). At 49 days from planting, giant hills averaged only one gram of tuber per plant compared to 32 for normals. Giant hills yielded less than normals from 49 to 84 days from planting but usually more thereafter (Table 1.4). Giant hills, then, began tuberization later than normals but may surpass normals in number and weight of tubers by the end of a long growing season.

SUMMARY AND CONCLUSIONS

1. Giant hills can be detected earlier in the season than has been generally acknowledged. In Corvallis it was possible to identify giant hills by mid July (63 days from planting) based on growth and flowering. Giant hills and normals began blooming at approximately the same time and in comparable amounts, but two weeks after the onset of full bloom giant hills had twice as many inflorescences as normals and one week later giant hills averaged more than four inflorescences per plant while normals averaged less than one; this situation existed throughout August. Increased flowering, then, is a major criterion for detecting giant hill at mid season. This must, however, be coupled with increased plant height and obvious plant vigor. Diseases or other conditions which reduce flowering might preclude detection.

2. Rogueing of giant hills from seed crops would be most effective toward the end of the growing season when normal plants are senescing. However, this study has shown that giant hills could be rogued at mid season. More research is needed to determine if early rogueing is effective.

3. In Corvallis giant hills began tuberization between one and two weeks later than normals.

Table 1.1. Seasonal changes in shoot height (cm) of giant hill and normal Russet Burbank potato plants in Oregon.

	Days from planting											
Strain	49	56	63	70	77	84	91	98	105	112	119	126
Giant Hill	53	66	89	81	91	89	89	81	79	69	56	51
Normal	51	63	79	69	61	58	64	51	46	41	18	10
LSD, 0.05	2	2	2	NS	2	5	5	8	5	8	8	8

Table 1.2. Seasonal changes in flowering of giant hill and normal Russet Burbank plants in Oregon. Inflorescences/plant.[1]

	Days from planting											
Strain	49	56	63	70	77	84	91	98	105	112	119	126
Giant Hill	1.8	3.4	4.0	4.1	3.1	2.8	3.9	3.4	1.8	0.4	0.7	0.0
Normal	2.1	2.9	1.7	0.5	0.1	0.6	0.4	0.4	0.3	0.1	0.1	0.3
LSD, 0.05	0.3	NS	0.6	0.9	0.2	0.5	0.6	1.1	1.1	NS	0.5	NS

[1]Inflorescences were cymose, usually with five or more individual flowers.

Table 1.3. Tuberization of giant hill and normal Russet Burbank potato plants in Oregon. Tubers per plant.

Strain	Days from planting											
	49	56	63	70	77	84	91	98	105	112	119	126
Giant Hill	1	4	16	17	17	12	15	13	15	11	13	10
Normal	4	13	10	9	12	12	7	9	8	9	9	6
LSD, 0.05	3	NS	NS	8	1	NS	NS	NS	5	NS	3	NS

Table 1.4. Tuberization of giant hill and normal Russet Burbank potato plants in Oregon. Grams of tubers per plant.

Strain	Days from planting											
	49	56	63	70	77	84	91	98	105	112	119	126
Giant Hill	1	13	142	292	496	455	675	774	795	983	1077	973
Normal	32	150	245	285	576	700	554	732	753	1063	884	825
LSD, 0.05	1	72	NS	NS	NS	NS	NS	NS	NS	NS	160	NS

LITERATURE CITED

1. Hawkes, J.G. 1947. The photoperiodic reaction of potato bolters. Empire J. Explt. Agric. 15:216-226.
2. Hill, Helen D. 1934. A comparative study of certain tissues of giant hill and healthy plants. Phytopathology 24:577-598.
3. Stanton, W.R. 1952. Bolting, a vegetative variation in the potato. Heredity 6:37-53.

PLANT TYPES REGENERATED FROM TISSUES AND ORGANS OF RUSSET BURBANK GIANT HILL POTATOES IN OREGON

Stephen Kwiatkowski and Alvin R. Mosley

ABSTRACT

Plants were regenerated from shoot tips, heat treated meristems, and tissues of the cortex and perimedullary and pith regions of tubers of giant hill and normal Russet Burbank potatoes in vitro. Regenerated plants were grown in the field and evaluated for giant hill characteristics. Results are consistent with the hypothesis that giant hill is a chimera occurring in the L2 cell layer and later moving to the L3 layer by cell replacement. Further, the intensity of the variation seen in the field may depend on whether only L2 cells are involved or both L2 and L3 cells are involved.

Key words: Bolters, Tissue culture, Chimera, Variant potatoes, Mutation, Solanum tuberosum.

INTRODUCTION AND LITERATURE REVIEW

Giant hill has been characterized and its occurrence documented in Oregon (12). Giant hills appear as large plants which bloom profusely, mature late, and generally produce large, rough-shaped tubers. This study was undertaken to elucidate the chimeral status of giant hill.

Causes of giant hill were studied as early as the 1920s (3, 5, 14). Early reports associated the disorder with a virus (1, 3, 5). By the 1940s and 1950s the virus hypothesis was being severely challenged. Grafting experiments (17, 18) showed that giant hill was not transmitted to the normal partner and that the scion determined the giant hill behavior (17). In 1944 Carson and Howard (2) found that the giant hill conditions could be inherited even when both parents were normal. Work by Stanton (17) indicated that the variety was more influential than the condition of the parents in determining the number of progeny showing the variation. Carson and Howard (2) counted and compared chromosomes of giant hills and normals but could discern no differences. They noted that maturity, flowering and stolon development in the potato are strongly influenced by day length and suggested that giant hill was caused by a mutation in an unstable gene or genes controlling photoperiodic response. In 1947 J.G. Hawkes (6, 7) showed that the characteristics of giant hills and normals were similar under short days (8 hours) but not under long days (British summer). Hawkes envisioned giant hill as a mutation to an ancestral characteristic (short day

plant) found in the potatoes of the South American Andes. More work is needed on photoperiod effects on giant hill expressions.

If giant hill is caused by a somatic mutation it could be a chimera. Howard (8) cites evidence suggesting that a periclinal chimera is involved. A periclinal chimera is a mutation involving a cell layer of the shoot growing point (4, 8). The three outer layers of the potato shoot meristem (L1, L2, L3) generally remain distinct (4) (Figure 1). Each layer has its own initials, and the cells divide in a manner that retains the identity of each layer, but L3 may sometimes be replaced by cells from L2 during axillary meristem formation (4, 8). The cells of L1 form the epidermis only (4, 8). L2 cells form the outer cortex and possibly some inner tissues, and L3 cells form perimedullary and pith tissues (4, 8). Thus, growing plants from these tissues could show differences in the makeup of the merismatic layers.

Recently methods have been described for regenerating plants from potato tissues and organs in vitro (9, 10, 11, 13, 15, 16). This study used these methods to provide additional information on the chimeral status of giant hill.

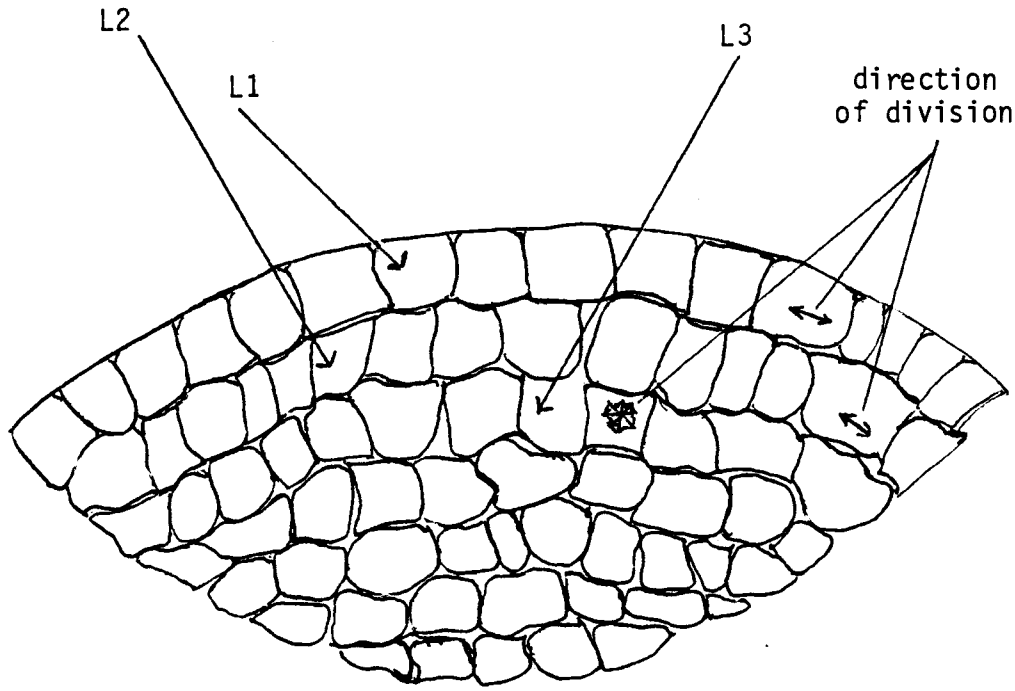

Figure 1. Longitudinal section of potato, Solanum tuberosum, shoot meristem.[1/]

[1/]Cells of L1 and L2 undergo anticlinical divisions only while the cells of L3 divide in various planes. Thus, the integrity of these three cell layers is maintained in the meristem (after Esau).

MATERIALS AND METHODS

In April of 1982 terminal shoot tips one to two mm long were taken from two semi-giant hill, two giant hill and two normal Russet Burbank plants growing in the greenhouse. Shoot tips were placed in aseptic culture on Murashige and Skoog salts and vitamins (16). These shoot tips produced plants which were maintained in vitro by subculturing nodal cuttings every six to eight weeks until the spring of 1983 when ten of each were hardened off in the greenhouse for three weeks and then planted in the field on 36 x 36 inch centers.

Rooted shoot cuttings of one semi-giant hill and one normal Russet Burbank potato were subjected to virus freeing techniques of heat treatment and axial meristem culture as described by Mellor and Stace-Smith (15). Regenerated plants were then tested for potato viruses A, M, S, X, Y, and leafroll using enzyme linked immunosorbant assay (ELISA). The plants contained Potato Virus S. Additional cuttings from the same mother plants and one additional Russet Burbank giant hill subjected to similar treatment were free of viruses. These five virus tested plants were multiplied in vitro and ten of each were planted in the field in May of 1983 along with shoot tip cultured plants previously described.

Beginning in February of 1982 attempts were made to regenerate plants from tuber discs of giant hill and normal Russet Burbank potatoes. Tubers were rinsed in commercial laundry bleach (5% sodium hypochlorite) and the skins were removed. Cylinders of tissue 4 mm in diameter were excised with a cork borer. The borer

was inserted transversely through the tuber at the widest point, approximately midway between the apex and stem ends (Figure 2). Cylinders were sliced into nine discs consisting mainly of cortex, perimedullary, or pith tissue.

Early attempts at plant regeneration using tubers which had been stored for five months and techniques described by Jarret et al. (10, 11) were mostly unsuccessful. In August of 1982, discs as previously described were excised from young tubers (approximately 5 cm in diameter) of semi-giant hill, super-giant hill and normal Russet Burbank potatoes and cultured according to Jarret et al. (9). This later method resulted in plants being regenerated from thirty-four of forty-five tuber discs comprising tissues of cortex, perimedullary, and pith of super-giant hill and normal potatoes and cortex and perimedullary of a semi-giant hill. These plants were multiplied in vitro, hardened in the greenhouse, and planted in the field in replicated plots in May 1983 along with and in the same manner as other tissue cultured plants previously described.

Plants were measured for height and number of inflorescences and rated for vigor in mid season (late July) and late season (late August). Plants were observed for abnormalities such as deformed leaves, total absence of flowering, or variations in tuber skin type. Plants were classified as normal, semi-giant hill, giant hill, or super-giant hill based on plant height and inflorescences per plant at both sampling dates and visual confirmation of plant type in early and late September (12).

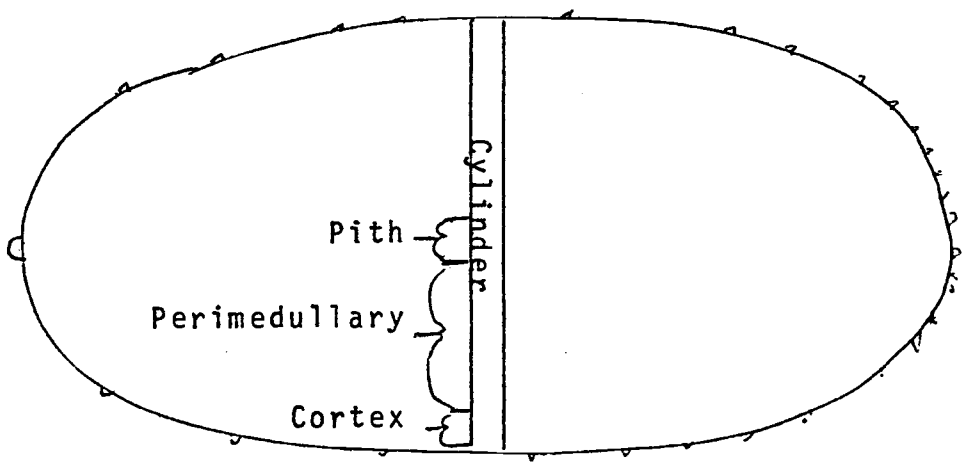

Figure 2. Tuber tissues and cylinder

RESULTS AND DISCUSSION

Shoot tip cultured plants retained their original characteristics of normal, semi-giant hill and giant hill, but the meristem cultured plants did not. Meristems from normal plants produced normals, and the giant hill meristem produced a giant hill, but meristems of the semi-giant hill produced one giant hill and one super-giant hill (Table 2.1).

Tuber tissues of the super-giant hill produced all super-giant hills and tuber tissues of normals produced all normals except for one with deformed leaves and one with smooth-skinned tubers. As with meristem culture, the semi-giant hill was again the anomaly. Cortical tissues of the semi-giant hill produced two super-giant hills while perimedullary tissues produced two normals and one semi-giant hill (Table 2.2). Cortical tissues of the semi-giant hill produced super-giant hills because the cortex is derived from the L2 cell layer of the shoot meristem, which in the semi-giant hill is apparently mutated, while the L3 layer initial cells remain true to type. Plants regenerated from the mutated cortical tissue would contain the mutation in all cells and tissues thus becoming giant hills or super-giant hills. Giant hills regenerated from the mutated tissue must contain the mutation in L1 while the giant hill occurring during normal vegetative propagation would not likely contain the mutation in L1. Since, however, these plants are similar in form, L1 (which forms the single cell layer of the epidermis) apparently does not determine the giant hill phenotype. These results indicate that the semi-giant hill is a chimera with

the variation contained in L2 of the shoot meristem but not in L3. The super-giant hill apparently contained the variation in both L2 and L3, and the normal did not contain the variation in L2 or L3.

These findings strengthen Howard's hypothesis (8) that giant hill originates as a chimera occurring in L2 and is later transferred to L3 by cell replacement. Additionally, it is indicated that the intensity of the giant hill variation seen in the field is related to its presence in L2 and/or L3. Plants with the variation in L2 and L3 would be giant hills and super-giant hills. Further, it appears that meristem culture may transform the milder forms of giant hill to the more severe form indicating that replacement of L3 cells by cells of L2 may occur frequently during meristem culture.

SUMMARY AND CONCLUSIONS

1. These studies are consistent with Howard''s hypothesis that giant hill is perpetrated by a chimera occurring in the L2 layer of the shoot meristem, and the condition is later transferred to the L3 layer, possibly during axillary meristem formation.
2. Since the semi-giant hill in this and another study (8) was chimerical with variants in L2 but not in L3 while giant hills contained the variation in both L2 and L3, the degree of phenotypic expression is apparently related to the number of initial cells which are variant.
3. Since meristems of the semi-giant hill produced giant hills, replacement of L3 cells by cells of L2 may occur frequently during meristem culture. Since shoot-tip-cultured semi-giant hill plants retained their previous character, it appears that the size of the apex cultured plays a role in the frequency of L3 cell layer replacement by cells from L2. It may be that when small meristems are excised, damage occurs to the cells of L3 or L2, thereby facilitating the cells of L2 to divide periclinically.

Table 2.1. Plant types regenerated from shoot tips and meristems of Russet Burbank giant hills.[1]

		Plant regenerated[2]	
		No.	Type
Normal	shoot tip	2	normal
	meristem	2	normal
Semi-giant	shoot tip	2	semi-giant
	meristem	1,1	giant, super-giant
Giant	shoot tip	2	giant
	meristem	1	giant

1/ Shoot tips consisted of meristems and associated tissues 1-2 mm long taken from terminal shoots of greenhouse grown plants. Meristems consisted of meristems about 0.5 mm long with one or no primordial leaves and taken from lateral buds of plants grown in a heat chamber at 30°C for 6 weeks.

2/ Numbers refer to the number of shoot tips or meristems which regenerated plants.

Table 2.2. Plant types regenerated from tissues of Russet Burbank giant hills.

Strain	Tissue[1]	Plant regenerated	
		No.[2]	Type
Normal	cortex	4	normal
	perimedullary 1	3	normal
	perimedullary 2	2,2	normal, off type[3]
	perimedullary 3	3	normal
	pith	4	normal
Semi-giant	cortex	2	super-giant
	perimedullary 1	1	normal
	perimedullary 2	1,1	normal, semi-giant
Super-giant	cortex	1	super-giant
	perimedullary 1	2	super-giant
	perimedullary 2	3	super-giant
	perimedullary 3	4	super-giant
	pith	1	super-giant

[1/] 1 = outer, 3 = inner perimedullary tissue.

[2/] Number of discs regenerating plants.

[3/] Two off-type plants were regenerated from this normal tuber. One had deformed leaves; the other had smooth white skin on the tuber.

LITERATURE CITED

1. Blodget, E.C. and A.E. Rich. 1949. Potato tuber diseases, defects, and insect injuries in the Pacific Northwest. Idaho Agric. Exp. Sta. Bull. 274. 116 pp.
2. Carson, G.P and W.H. Howard. 1944. Inheritance of the 'bolter' condition in the potato. Nature 154:829.
3. Dana, B.F. 1926. Mosaic and related diseases ofthe potato and other crops. Wash. Agric. Exp. Sta. Bull. 208. pp. 33-34.
4. Esau, Katherine. 1977. Anatomy of Seed Plants. 2nd Ed. John Wiley and Sons. 550 pp.
5. Gilbert, A.H. 1925. Giant hill potatoes, a dangerous source of seed. A new phase of spindle tuber. Vermont Agr. Exp. Sta. Bull. 245. 16 pp.
6. Hawkes, J.G. 1947. The photoperiodic reaction of potato bolters. Empire J. Exptl. Agric. 15:216-226.
7. Hawkes, J.G. 1946. Potato "bolters". An explanation based on photoperiodism. Nature 157:375-376.
8. Howard, H.W. 1970. Genetics of the Potato. Logos Press Limited, London. 126 pp.
9. Jarret, R.L., P.M. Hasegawa and R.A. Bressan. 1981. Gibberellic acid regulation of adventitious shoot formation from tuber discs of potato. In Vitro 17:825-829.
10. Jarret, R.L., P.M. Hasegawa and H.T. Erickson. 1980. Factors affecting shoot initiation from tuber discs of potato (Solanum tuberosum). Physiol. Plant. 49:177-184.

11. Jarret, R.L., P.M. Hasegawa and H.T. Erickson. 1980. Effects of medium components on shoot formation from cultured tuber discs of potato. J. Amer. Soc. Hort. Sci. 105:238-242.

12. Kwiatkowski, S. and A.R. Mosley. 1983. Seasonal changes in flowering, plant height and tuberization of Russet Burbank giant hill potatoes in Oregon. Am. Potato J. In press.

13. Lam, S.L. 1977. Plantlet formation from potato tuber discs in vitro. Amer. Pot. J. 54:465-486.

14. Lauer, K.W. 1929. Seed potato certification in Pennsylvania. Penn. Dept. of Agric. Bull. 471. 15 pp.

15. Mellor, F.C. and R. Stace-Smith. 1977. Virus free potatoes by tissue culture. In J. Reinert and Y.P.S. Bajaj (eds.) Applied and Fundamental Aspects of Plant Cell, Tissue and Organ Culture. Springer-Verlag, Berlin. pp. 616-637.

16. Murashige, T. and F. Skoog. 1962. A revised medium for rapid growth and bio assays with tobacco tissue cultures. Physiol. Plant. 15:473-497.

17. Stanton, W.R. 1952. Bolting, a vegetative variation in the potato. Heredity 6:37-53.

18. Whitehead, T., T.P. McIntosh and W.M. Findlay. 1945. The Potato in Health and Disease. Oliver and Boyd. London. 400 pp.

AN APPROACH TO ROGUEING RUSSET BURBANK GIANT HILLS AND SOME SUGGESTIONS FOR FURTHER INVESTIGATION

Rogueing of Russet Burbank giant hills from seed potato fields could begin by mid-season, two weeks after most plants have started flowering. But rogueing four weeks after flowering starts would be more efficient since most normals would have ceased flowering by this time, making giant hills and super-giant hills more apparent. Super-giant hills are large plants which at times show twenty to forty inflorescences on a single plant. They are often extremely erect with thick main stems and may produce fruit. Giant hill characteristics are similar to those of super giants, but the effect is less extreme. Semi-giant hills, unfortunately, are much more difficult to detect. They occur as plants slightly more vigorous than normals with slightly more flowers. Normal virus free plants in a virus infected planting will generally be slightly more vigorous than average with slightly more flowers and could easily be mistaken for semi-giant hills. Rhizoctonia and similar disorders which increase plant size and flowering might also be mistaken for semi-giant hills. Failure to detect and remove semi-giant hills could become a great problem since semi-giant hills may produce giant hills in the following or a later year.

Rogueing semi-giant hills may result in an inferior crop due to less vigorous and more diseased plants, but failure to rogue semi-giant hills may eventually result in a crop of giant hills and super-giant hills. It appears that seed stocks should be

essentially free of viruses and other diseases in order to effectively rogue semi-giant hills.

It appears from unrecorded observations that semi-giant hills tuberize slightly later than normals while giant hills and super-giant hills tuberize slightly later than semi-giant hills. If semi-giant hills tuberize later than normals, early kill down of vines could decrease the yield of semi-giant hill tubers by stopping tuberization at a point when normals have a greater bulk of tubers. More investigation aimed at detecting or reducing semi-giant hills in potato seed fields is needed. The effects of time of vine kill on the occurrance and propagation of the three giant hill types should especially be investigated.

In vitro propagation and rapid multiplicatin present special problems in giant hill detection. Experience has shown that it has not been possible to reliably detect giant hills in the greenhouse, and no differences can be seen between normals and giant hills in vitro. Thus, in vitro or greenhouse propagation could increase giant hill types since a shift toward giant hill would not be detectable without growing the plants in the field.

Control of tuberization might provide a method for detecting giant hill in rapid-increase programs. Normals and giant hills tuberize differently under field conditions and so might be induced to tuberize differently under in vitro or greenhouse conditions. The regulation of environmental factors, especially photoperiod, light intensity, light quality, temperature, and media constitution,

might allow tuberization of normals while giant hill types fail to tuberize. Work is needed in this area.

The induction of flowering in small potato plants in the greenhouse and in vitro might also provide a method of giant hill detection. While the tuberization of small potato plants in the greenhouse and in vitro occurs under a variety of conditions, flowering does not normally occur. The use of flowering as a giant hill indicator under these conditions depends on developing a method to induce flowering in these small plants. Flowering is an important characteristic of giant hills, and at least some plant species can be induced to flower in vitro.

Another method of detection in the greenhouse and in vitro might rely on tuber shape and size. In the field giant hills produce longer, larger tubers than normals, and this may be related to environmental factors such as photoperiod. The use of sugar in the culture media should be investigated since it may interfere with the response to other factors, especially photoperiod, light intensity, and light quality.

Finally, it would be desirable to have more than one method of detecting giant hill, thereby increasing the reliability of the conclusion. Much work is needed. With the current increased use of in vitro propagation it seems likely that research aimed at detecting giant hill types is needed more now than ever before.

BIBLIOGRAPHY

1. Blodget, E.C. and A.E. Rich. 1949. Potato tuber diseases, defects, and insect injuries in the Pacific Northwest. Idaho Agric. Exp. Sta. Bull. 274. 116 pp.
2. Carson, G.P and W.H. Howard. 1944. Inheritance of the 'bolter' condition in the potato. Nature 154:829.
3. Dana, B.F. 1926. Mosaic and related diseases of the potato and other crops. Wash. Agric. Exp. Sta. Bull. 208. pp. 33-34.
4. Dearborn, C.H. 1963. "Stitched end", "giant hill" and fasciated stem of potatoes in Alaska. Am. Potato J. 40:357-360.
5. Easton, G.D. and E.M. Nagel. 1981. Giant hill a problem or a possibility. Spudman. Feb. pp. 11-25.
6. Esau, Katherine. 1977. Anatomy of Seed Plants. 2nd Ed. John Wiley and Sons. 550 pp.
7. Gilbert, A.H. 1925. Giant hill potatoes, a dangerous source of seed. A new phase of spindle tuber. Vermont Agr. Exp. Sta. Bull. 245. 16 pp.
8. Hawkes, J.G. 1947. The photoperiodic reaction of potato bolters. Empire J. Exptl. Agric. 15:216-226.
9. Hawkes, J.G. 1946. Potato "bolters". An explanation based on photoperiodism. Nature 157:375-376.
10. Hill, Helen D. 1934. A comparative study of certain tissues of giant hill and healthy plants. Phytopathology 24:577-598.
11. Howard, H.W. 1970. Genetics of the Potato. Logos Press Limited, London. 126 pp.

12. Jarret, R.L., P.M. Hasegawa and R.A. Bressan. 1981. Gibberellic acid regulation of adventitious shoot formation from tuber discs of potato. In Vitro 17:825-829.

13. Jarret, R.L., P.M. Hasegawa and H.T. Erickson. 1980. Factors affecting shoot initiation from tuber discs of potato (Solanum tuberosum). Physiol. Plant. 49:177-184.

14. Jarret, R.L., P.M. Hasegawa and H.T. Erickson. 1980. Effects of medium components on shoot formation from cultured tuber discs of potato. J. Amer. Soc. Hort. Sci. 105:238-242.

15. Kwiatkowski, S. and A.R. Mosley. 1983. Seasonal changes in plant height, flowering, and tuberization of Russet Burbank giant hill potatoes in Oregon. Am. Potato J. In press.

16. Lam, S.L. 1977. Plantlet formation from potato tuber discs in vitro. Am. Potato J. 54:465-486.

17. Lauer, K.W. 1929. Seed potato certification in Pennsylvania. Penn. Dept. of Agric. Bull. 471. 15 pp.

18. Mellor, F.C. and R. Stace-Smith. 1977. Virus free potatoes by tissue culture. In J. Reinert and Y.P.S. Bajaj (eds.) Applied and Fundamental Aspects of Plant Cell, Tissue and Organ Culture. Springer-Verlag, Berlin. pp. 616-637.

19. Morris, H.E. and P.A. Young. 1930. Potato diseases in Montana. Montana Agric. Exp. Sta. Bull. 227. 51 pp.

20. Mosley, A.R. and D. Hane. 1982. Research and extension progress report. Proceedings Oregon Potato Growers Annual Meeting and the Northwest Agricultural Show. pp. 103-115.

21. Mosley, A.R., D. Hane, and S. Kwiatkowski. 1983. Research and extension progress report. Oregon Potato Conference and Trade Show Proceedings. pp. 114-128.

22. Munro, J. 1981. Genetic abnormalities. pp. 7-8. In W.J. Hooker (ed.) Compendium of Potato Diseases. American Phytopathological Society. 125 pp.

23. Murashige, T. and F. Skoog. 1962. A revised medium for rapid growth and bio assays with tobacco tissue cultures. Physiol. Plant. 15:473-497.

24. Raeder, J.M. 1944. Diseases of potatoes in Idaho. Idaho Exp. Sta. Bull. 254. 39 pp.

25. Stanton, W.R. 1952. Bolting, a vegetative variation in the potato. Heredity 6:37-53.

26. Whitehead, T., T.P. McIntosh and W.M. Findlay. 1945. The Potato in Health and Disease. Oliver and Boyd. London. 400 pp.

27. Yarwood, C.E. 1946. Increased yield and disease resistance of giant hill potatoes. American Potato J. 23:352-369.

APPENDICES

Appendix Table 1. Seasonal changes in height (centimeters) of giant hill and normal plants. 1981.

	Location and days from planting										
	Corvallis			Hermiston		Merrill			Powell Butte		
Strain	63	73	104	93	117	47	81	105	48	78	103
Giant hill	79	91	83	85	57	39	85	66	22	68	58
Normal	70	72	42	69	38	45	63	31	25	57	37
LSD, 0.05	2	3	7	4	4	3	3	4	3	6	3

Appendix Table 2. Shoot height (centimeters) of greenhouse grown giant hill and normal plants thirty-five days from planting. 1981.

Strain	n[1/]	$\bar{x}$	s
Giant Hill	79	54	8
Normal	95	53	9

[1/] n, number of samples; $\bar{x}$ = mean; s = standard deviation.

Appendix Table 3. Seasonal changes in flowering of normal and giant hill Russet Burbank plants. Inflorescences/plant. 1981.

	Location and days from planting										
	Corvallis			Hermiston		Merrill			Powell Butte		
Strain	63	73	104	93	117	47	81	105	48	78	103
Giant hill	4.7	5.5	0.0	4.4	1.5	0.6	4.5	4.2	0.1	3.7	4.3
Normal	1.7	0.8	0.0	1.8	0.0	0.9	0.3	0.1	0.2	0.5	0.4
LSD, 0.05	0.3	1.6	0.0	0.8	0.6	NS	0.8	0.5	0.1	2.1	0.9

Appendix Table 4. Tuberization of giant hill and normal plants. Number of tubers/plant. 1981.

	Days from planting		
Strain	74	98	117
Giant Hill	9.9	9.9	11.9
Normal	11.1	9.6	10.8
LSD, 0.05	NS	NS	NS

Appendix Table 5. Tuberization of giant hill and normal plants. Weight of tubers (grams/plant). 1981.

	Days from planting		
Strain	74	98	117
Giant Hill	522	1148	1160
Normal	617	1089	1170
LSD, 0.05	NS	NS	NS

Appendix Table 6. Vine length (centimeters) of stretched vines of giant hill and normal plants at ninety-one days from planting. 1981.

Strain	Vine length
Giant hill	128
Normal	109
LSD, 0.05	10

Appendix Table 7. Fresh weight of vines of giant hill and normal plants. Grams/plant. 1981.

Strain	Days from planting	
	74	98
Giant hill	862	726
Normal	862	590
LSD, 0.05	NS	41

Appendix Table 8. Dry weight of vines of giant hill and normal plants. Grams/plant at seventy-four days from planting. 1981.

Strain	Weight
Giant hill	104
Normal	100
LSD, 0.05	NS

Appendix Table 9. Fresh weight of roots of giant hill and normal plants. Grams/plant at seventy-four days from planting. 1981.

Strain	Weight
Giant hill	38
Normal	34
LSD, 0.05	NS

Appendix Table 10. Stems/plant of giant hill and normal plants at 117 days from planting. 1981.

Strain	Stems/plant
Giant hill	3.7
Normal	5.2
LSD, 0.05	0.1

Appendix Table 11. Shoot height (centimeters) of giant hill and normal plants produced from seed pieces with eyes excised at planting. 1981.

	Days from planting	
Strain	103	117
Giant hill	74	63
Normal	55	48
LSD, 0.05	9	11

Appendix Table 12. Flowering of giant hill and normal plants produced from seed pieces with eyes excised at planting. Inflorescences/plant. 1981.

	Days from planting	
Strain	103	117
Giant hill	2.2	1.3
Normal	0.2	0.2
LSD, 0.05	1.8	NS

Appendix Table 13. Shoot height (centimeters) of giant hill and normal shoot tip cultured plants transplanted to the field. 1982.

	Days from planting									
Strain	51	58	65	72	79	86	93	100	107	114
Giant hill	43	53	74	74	69	69	61	64	56	48
Normal	41	48	56	56	51	48	43	36	20	10
LSD, 0.05	1	2	1	2	2	6	5	6	8	4

Appendix Table 14. Flowering of giant hill and normal shoot tip cultured plants transplanted to the field. Inflorescences/plant. 1982.

	Days from planting									
Strain	51	58	65	72	79	86	93	100	107	114
Giant hill	0.4	2.1	6.4	6.9	8.0	7.6	4.5	1.6	1.0	0.3
Normal	0.2	1.2	1.8	1.4	0.8	0.8	0.3	0.0	0.0	0.0
LSD, 0.05	NS	0.3	0.6	0.7	1.9	1.3	0.5	0.4	0.5	0.2

Appendix Table 15. Yield of giant hill and normal plants. 1982.

	Cwt/acre			
Strain	Marketable	Cull	Undersize	Total
Giant hill	276	81	89	446
Normal	179	52	85	316
LSD, 0.05	48	NS	NS	63

Appendix Table 16. Plant height (cm), inflorescences/plant and vigor averages[1] for tuber disc, meristem and shoot tip regenerates of Russet Burbank giant hill and normal plants. 1983.

Explant[2]	Plant height		Inflorescences/plant		Vigor[1]	
	Days from planting					
	64	98	64	98	64	98
Su(1)	67	70	21.6	23.8	5.0	5.2
Su(2)	68	75	25.5	25.4	5.1	5.0
Su(2)	67	72	23.5	17.4	5.1	4.4
Su(2)	68	78	23.3	24.8	5.2	5.0
Su(3)	66	66	23.0	23.6	5.1	5.0
Su(3)	69	76	23.3	24.0	5.2	5.2
Su(4)	69	86	22.8	24.4	5.2	5.4
Su(4)	70	67	25.6	17.4	4.9	4.8
Su(4)	65	77	23.9	25.0	5.2	5.4
Su(4)	63	69	21.6	12.4	5.2	4.6
Su(5)	66	77	21.0	24.4	5.3	5.0
Se(1)	65	76	23.4	17.0	4.8	5.0
Se(1)	65	65	22.0	14.8	5.3	4.8
Se(2)	36	29	1.0	0.0	2.8	3.2
Se(3)	36	25	1.5	0.0	3.0	3.0
Se(3)	56	53	12.5	4.0	4.2	4.4
N(1)	44	28	1.0	0.0	3.8	2.6
N(1)	45	34	1.4	0.0	3.5	2.8
N(1)	42	23	1.9	0.0	3.5	2.6
N(1)	46	38	2.4	0.0	3.6	3.0
N(2)	46	35	1.3	0.0	3.8	3.8
N(2)	49	39	2.3	0.8	3.7	3.4
N(2)	49	41	5.2	2.0	4.0	3.6

[1]Vigor was rated on a scale of 1-6, six being the most vigorous.

[2]Su = super-giant, G = giant, Se = semi-giant, N = normal. Numbers in parentheses indicate tuber tissue type: (1) = cortex, (2) = outer perimedullary, (3) = middle perimedullary, (4) = inner perimedullary, (5) = pith; M = meristem, St = shoot tip.

Appendix Table 16. Continued

Explant	Plant height		Inflorescences/plant		Vigor	
	Days from planting					
	64	98	64	98	64	98
N(3)	17	2	0.0	0.0	1.1	1.0
N(3)	46	27	3.1	0.0	3.6	2.6
N(3)	47	39	1.6	1.0	4.1	2.8
N(3)	41	31	0.6	0.0	3.5	2.6
N(4)	47	24	1.9	0.0	3.8	2.6
N(4)	43	24	3.1	0.0	3.3	2.4
N(4)	51	28	1.5	0.0	3.5	2.8
N(5)	44	36	3.2	0.0	3.7	3.2
N(5)	43	25	3.7	0.2	3.7	2.8
N(5)	44	33	1.5	0.0	3.3	3.2
N(5)	46	33	1.1	0.0	3.6	3.0
NM	45	23	4.8	0.2	3.9	2.6
NM	49	35	4.3	1.0	3.7	2.8
SeM	69	73	17.7	18.2	4.7	4.6
SeM	62	69	26.8	14.4	5.1	4.8
GM	62	71	17.2	17.0	4.9	5.0
SeSt	58	76	13.2	7.8	4.5	4.4
SeSt	68	67	14.3	7.2	5.1	4.2
GSt	64	62	18.0	16.2	4.7	4.2
GSt	64	71	17.5	10.6	5.1	4.4
NSt	45	43	2.3	0.2	3.6	2.8
NSt	48	30	3.6	0.0	3.8	3.2
LSD, 0.05	8	14	4.8	5.9	0.6	0.8

Appendix Table 17. Giant hill expression based on plant height, flowering and vigor at 66 (x), 116 (y) and 122 (z) days from planting. 1982.

Strain[1/]	Normal	Semi Giant	Giant	Super Giant
1C	xyz			
2C	xyz			
3		yz	x	
4		yz	x	
5			xyz	
6	x	yz		
7	y	z	x	
8	yz		x	
9	xyz			
10		yz	x	
11			xyz	
12		z	xy	
13	xy	z		
14C	yz	x		
15		xz	y	
16			z	xy
17	yz	x		
18C	xyz			
19				xyz

[1/] C denotes normal Russet Burbank control for associated group. All others were suspected giant hills when selected.

Appendix Table 18. Yield and grade-out of fifteen Russet Burbank giant hill strains at Corvallis, Oregon. 1982.

Strain [1/]	Yield, % of control [2/, 3/]				Quality ratio
	mkt	cull		total	wt.mkt/wt.cull
1C	100	100	100	100	10.0
2					19.0
3					7.4
4					0.9
5	42	1800	41	177	0.2
6					2.6
7	268	866	235	356	3.1
8	260	1133	107	310	2.3
9	212	233	170	243	9.7
10	182	1167	140	308	1.1
11					1.4
12					0.9
13					3.8
14C	100	100	100	100	1.2
15	84	100	47	80	1.0
16	117	100	65	98	1.4
17	130	73	75	97	2.1
18C					3.3
19					0.3

1/ C denotes controls for associated group.

2/ mkt = smoothly shaped, sound tubers weighing over 4 ounces (113 grams). Culls = poorly shaped or skin blemished tubers over 4 ounces.

3/ Missing data indicate that less than 20 seed pieces were planted for that strain.