GIANT HILL-- FRIEND OR FOE OF THE POTATO INDUSTRY [1/]

by
Gene D. Easton and Michael E. Nagle [2/]

SUMMARY

Giant hill, a genetic mutation, is becoming an important problem in commercial and foundation seed lots of Russet Burbank. It is usually a large, single-stemmed plant that continues growing until frost and usually produces knobby, spindle-shaped tubers that are undesirable. However, we have selected a few giant hill plants of moderate size which have multistems and smoother tubers. These selections are resistant to Verticillium wilt and produce high yields. We propose testing giant hill selections made by interested seed growers for them to choose superior clones of Russet Burbank that are resistant to Verticillium wilt and produce good yields of high quality tubers.

INTRODUCTION

In 1924 according to Helen Hill (16) "giant hill" was first reported as a plant abnormality described several years previously by Dr. E. L. Dixon of Pennsylvania State College. Giant hill has been described as an abnormal plant with some or all of the following characteristics: large plant canopies developing from a single or at most two stems (18), large stems 3/4 to 1 inch or more in diameter with large cracks in epidermis (16), larger than normal numbers of leaves (25), but leaves smaller and thinner than normal (16), profuse flowering, (2,17), with several to all tubers per hill knobby, pointed, or spindle shaped and occasionally with "stitched", fasciated or dimpled areas at bud end of tubers (3,6), eyes of tubers of greater than normal depth (37), and buds of tubers having a longer than normal period of dormancy (37).

Giant hill has also been called "bolters" (2,4,14,15,21,24,25,30,33), "males" (8), "bull plants" and "wild types". It was first speculated that giant hill was caused by a virus (5, 6,11,12,16,19,22,28, 29) like the spindle tuber virus (12), now known to be a viroid (7), because of the club-shaped or spindle-shaped tubers produced. Later giant hill was found not graft transmissible (33) and was caused by a genetic mutation or alteration (1,2,4,14,15,21,23, 36) and did not include cytoplasmic inheritance (33). Occasionally, crosses between giant hill and normal plants yield giant hill progeny (4). Different giant hill strains or clones have been reported (38). Giant hill plants are thought to be long day mutants responding to photoperiodism (2,14,15,21,30,33). They grow normal under short day but develop exaggerated growth characteristics under long days (14). This supports the theory that giant hill is caused by a mutation of an unstable gene controlling response to day length and is a reversion to the short-day potato types found in the South American Andes (15).

Generally, giant hill plants produce more tubers and greater weight per hill, but the tubers are of poorer quality (9,18,21,24,37). Giant hill plants usually take longer to mature (2,24). The specific gravity of giant hill tubers increased with length of season and surpassed a normal cultivar of Russet Burbank (37). Giant hill plants have been reported resistant to several potato diseases, including Verticillium wilt (2,17,21,37).

1/ This investigation was made possible by grants supplied by the Washington State Potato Commission. Scientific paper No. 5827. Project 4709. Agriculture Research Center, Washington State University, Pullman, 99164.

2/ Plant Pathologist and Agricultural Research Technologist III, Department of Plant Pathology, Irrigated Agriculture Research and Extension Center, Prosser, Wa. 99350.

According to Yarwood (37) tubers of giant hill have been selected to increase yields of a potato cultivar and selecting within cultivars as a means of increasing yield is not new. As early as 1917, Gilbert suggested that growers should go through their commercial fields and stake plants which show unusual vigor and desirable habit. However, growers with this in mind have usually selected giant hill and discarded them later because of low grade and undesirable tuber shape.

In the past, only an occasional giant hill plant has occurred in Washington fields. Starting about 1975, many fields of Russet Burbank have begun showing 1 to 5% hills with giant hill by late September. Giant hill readings of the Washington Voluntary Foundation Seed Lot Trials show that 3 out of 77 lots or 3.8% and 24 out of 54 lots or 44.4% had giant hill plants in 1979 and 1980, respectively (34, 35). One foundation seed lot had 9% giant hill in 1980. Giant hill was present in some lots of seed from the state certification programs of Idaho, Montana, Oregon, and Washington and Alberta, Canada.

During the summer of 1980 investigations were begun to determine the importance of giant hill to our industry. This report includes preliminary observations, impressions and determinations to alert both commercial and certified seed potato growers about the giant hill problem.

PROCEDURE

In September, 1980, upon invitation from a state seed improvement association, several foundation seed lot fields were observed for giant hill. Giant hill counts were made in two commercial fields that had been planted with foundation seed known to have giant hill. From these fields on September 30, we hand dug 10 hills of typical giant hill mostly single stemmed, 10 hills with modified symptoms of giant hill mostly multistemmed, and 10 hills of normally dead plants. The tubers were placed in paper bags, weighed and stored at 40°F for planting in 1981 trials.

Stems from plants with modified symptoms of giant hill and stems from dead plants were collected, air dried at 72 F for 3 months, ground in a Wiley Mill No. 3, Arthur H. Thomas Co., Philadelphia, Pa. with no sieving, diluted 1:100 (.5 g stem tissue to 49.5 ml water) and spread on modified Streptomycin-alcohol agar (10). Nine plate replications from each stem collection were stored in the dark at 72 F and read for presence of V. albo-atrum microsclerotia propagules two weeks later. Tubers from about 40 hills with typical giant hill Russet Burbank plants were hand dug from the 1980 Washington Voluntary Othello Seed Lot Trials near Othello, Wa. These tubers are also being stored at 40°F for planting in 1981 disease and yield trials.

OBSERVATIONS AND DETERMINATIONS

In one foundation seed field with a noticeable giant hill problem all plants in some tuber unit plantings had giant hill. This giant hill, however, was generally atypical. Plants from those hills were usually multistemmed and tubers showed few abnormalitites other than small swellings of eyes on the bud ends from a few tubers. In a commercial 125-acre center pivot irrigation circle of potatoes planted with the same source of seed, 4.5% of the plants showed giant hill symptoms. Most giant hill plants had large single stems (over 1 inch in diameter) and a large 10 to 12 ft. diameter plant canopy. However, we were surprised to find that the tubers from these plants were not misshapened, spindle-shaped, or bottle-necked but were relatively smooth. A few tubers again had slight swelling of eyes at the bud ends. A few of the giant hill plants had a moderately large 5- to 6-ft plant canopy supported by multiple stems (3 or more) and all the tubers were smooth. Both of these giant hill types were healthy, green, and appeared resistant to early dying. Yields of giant hill plants were 2 to 3 times greater than the normal, dead susceptible plants (Table 1). The yield of the multiple-stemmed, smooth-tubered giant hill type was even greater than the single-stemmed type and its vines had about 1/2 the Verticillium propagules of the normal dead plants.

Several tubers harvested from each giant hill plant in the Washington Voluntary Othello Seed Lot Trials were either bottle-necked, spindle-shaped or severely misshapened. Occasionally, all tubers were normal under a giant hill plant.

DISCUSSION

Recently the occurrence of giant hill has increased in Russet Burbank potatoes grown in Washington, possibly through emphasis on selection of vigorous plants in stem cutting programs for control of black leg (13). Mutations to giant hill may have occurred naturally or been induced by the heat treatment and meristem culturing used recently to rid Russet Burbank and other cultivars of latent mosaic viruses (20, 26, 27, 32). It may be possible to improve Russet Burbank by utilization of giant hill.

We agree with Shepard (31) that it might be simpler to selectively enhance a popular variety than to create a new one. We propose that individual seed growers and seed improvement associations with heat treatment and stem cutting programs select and increase clones of vigorous, multistemmed, smooth-tubered giant hill plants. These clones could be tested for yield, quality and disease resistance in long season production areas. Such a program if proven effective could provide foundation seed of a superior high yielding, disease-resistant Russet Burbank type within 5 years.

We are planning to develop such a program. Any interested grower should contact us for details.

LITERATURE CITED

1. Asseyva, T. 1927. Bud mutations in the potato and their chimerical nature. J. Genetics 19:1-26.

2. Azariah, M. D. 1961. Bolters in potatoes. Indian Potato J. 3:38-41.

3. Blodgett, E. C. and A. E. Rich. 1949. Potato tuber diseases, defects and insect injuries in the Pacific Northwest. State College Washington Popular Bull. 195. 116 pp.

4. Carlson, G. P. and W. H. Howard. 1944. Inheritance of the "bolter" condition of Potato. Nature 154:829.

5. Dana, B. F. 1926. Mosaic and related diseases of the potato and other crops. Wash. Agr. Exp. Sta. Bull. 208. pp. 33-34.

6. Dearborn, C. H. 1963. "Stitched end", "Giant Hill" and fasciated stem of potatoes in Alaska. Am. Potato J. 40:357-360.

7. Diener, T. O. and R. D. Smith. 1971. Potato spindle tuber viroid. Virology 46:498-499.

8. Dorst, J. C. 1924. Knopmutatie bij den aardappel. Genetics 6:1-123.

9. Folsom, D., E. S. Schultz, and R. Bonde. 1926. Potato degeneration diseases; natural spread and effect on yield. Maine Agr. Exp. Sta. Bull. 331. pp. 57-112.

10. Easton, G. D., M. E. Nagle, and D. L. Bailey. 1969. A method of estimating Verticillium albo-atrum propagules in field soil and irrigation waste water. Phytopathology 59:1171-1172.

11. Folsom, D. 1927. Virus diseases of the potato. 17th Ann. Rept. Quebec Soc. Prot. Plants 1925-26. pp. 14-29.

12. 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.

13. Graham, D. C. and J. L. Hardie. 1971. Prospects for the control of potato blackleg disease by the use of stem cuttings. *Proc. 16th Br. Insectic. Fungic. Conf.* 1:219-224.

14. Hawkes, J. G. 1946. Potato "bolters". An explanation based on photoperiodism. Nature 157:375-376.

15. Hawkes, J. G. 1947. The photoperiodic reaction to bolters. Empire J. Exptl. Agric. 15:216-226.

16. Hill, Helen D. 1934. A comparative study of certain tissues of giant hill and healthy plants. Phytopathology 24:577-598.

17. Howard, H. W. 1970. Genetics of the potato. Logos Press Limited, London, 126 pp.

18. Krause, J. E. 1943. Variation in Russet potatoes. In summary of progress of potato research. Aberdeen Exp. Sta. 2 pp. Archives Plant Sci. Dept. Univ. Idaho.

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

20. Macdonald, D. M. 1973. Heat treatment and meristem culture as a means of freeing potato varieties from viruses X and S. Potato Research 16:263-269.

21. Manickavasgam, P. and K. Radhakrishna Alwa. 1960. Preliminary note on the economic importance of potato bolters. Madras Agric. J. 47:445-446.

22. Martin, W. H. 1927. Report of seed certification committee. 1926. Proc. 13th Ann. Meeting Potato Assoc. Am., Dec. 28-29. pp. 141-154.

23. McIntosh, T. P. 1927. The importance of the variety in potato production. Garden Chron. 107:116-117.

24. McIntosh, T. P. 1932. Potato notes. Garden Chron. 91:66-67.

25. Meinl, G. and Karl-Heinrich Moller. 1967. Uber die Spaltoffnugsverhnisse von Schosser Standen einiger Kartoffeizuchtstamme. Flora Abt. B. Morphol. Geopot. 15:297-300.

26. Mellor, Frances C. and R. Stace-Smith. 1970. Virus strain differences in erradication of potato viruses X and S. Phytopathology 60:1587-1590.

27. Mellor, Frances C. and R. Stace-Smith. 1967. Erradication of Potato X by thermotherapy. Phytopathology 57:674-678.

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

29. Raeder, J. M. 1944. Diseases of potato in Idaho. Idaho Exp. Sta. Bull. 245. 39 pp.

30. Raghow, R. S., A. N. Purohit and M. D. Upadhya. 1971. Morphophysiological behavior of potato bolters. Potato Research 14:292-296.

31. Shepard, J. F. 1980. Potato protoplasts in crop improvement. Science 208:17-24.

32. Stace-Smith, R. and F. C. Mellor. 1968. Erradication of potato viruses X and S by thermotherapy and auxillary bud culture. Phytopathology 58:199-203.

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

34. Washington State Potato Commission. 1980. Final reading of 1980 Washington Voluntary Foundation Seed Lot Trials. Moses Lake, Wa. 5 pp.

35. Washington State Potato Commission. 1979. Final reading of 1979 Washington Voluntary Foundation Seed Lot Trials. Moses Lake, Wa. 7 pp.

36. Weiss, F. 1945. Virus, virus diseases, similar maladies of potatoes, Solanum tuberosum L. Plant Dis. Reptr. Supp. 155:82-140.

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

38. Young, P. A. and H. E. Morris. 1930. Researches on potato-virus diseases in Montana. Montana Exp. Sta. Bull. 231. 51 pp.

Table 1. Yields and Verticillium propagules of giant hill and normal Russet Burbank single hill selections from the same seed source when planted in commercial fields near Quincy, Wa.

Yields 9/30 [1]	Giant hill plants [2] Single stemmed [5]	Multiple stemmed [6]	Normal plants [3]	Verticillium propagules/g (10^3) [4] Giant hill Multiple stemmed [6]	Normal plants [3]
		Third year cropping to potatoes			
lb/hill	5.9	7.1	2.2	36.6	66.3
cwt/a	1090.4	1312.2	412.3		
ton/a	54.5	65.6	20.6		
		First cropping to potatoes			
lb/hill	--- [7]	8.7	4.5	18.7	49.6
cwt/a	---	1607.8	824.8		
ton/a	---	80.4	41.2		

1/ Average yields from single hill selections of plants spaced 10 inches apart in 34-inch wide rows.
2/ Resistant to Verticillium wilt caused by Verticillium albo-atrum (Microsclerotial type).
3/ All plants dead by September 30 due to Verticillium wilt.
4/ Verticillium propaguls per g stems collected on September 30.
5/ Plants mostly single stemmed; stems one inch or more in diameter. A few tubers per hill had small swellings in eyes on bud end of tubers.
6/ Plants multiple stemmed (3 or more) with smooth tubers.
7/ Data not collected.