Genetic Mapping of a Dwarfing Gene Found in Solanum phureja Clone 1.22

Takafumi Kimura and Kazuyoshi Hosaka*

Experimental Farm, Kobe University, 1348 Uzurano, Kassai, Hyogo 675-2103, Japan.
*Corresponding author: Tel: 81-790-49-3121; Fax: 81-790-49-0343, E-mail: hosaka@kobe-u.ac.jp

ABSTRACT

Dwarf plants were obtained in an F2 population of a cross between Solanum chacoense (clone chc 525-3) and S. phureja (clone 1.22). Segregation analyses in F2 and backcross populations suggested that the dwarfism was controlled by a single recessive gene transmitted from S. phureja clone 1.22. The dwarf plants responded to treatment with gibberellic acid, which recovered normal growth. We named this gene 'ga2'. Linkage analysis of the gene ga2 with RFLP and RAPD markers indicated that the gene ga2 was located on the most or near distal end of chromosome 7.

RESUMEN

Del cruce entre Solanum chacoense (clon 525-3) y S. phureja (clon 1.22) en una población F2 se obtuvieron plantas enanas. Los análisis de segregación en F2 y las poblaciones en retrocruza sugirieron que el enanismo estuvo controlado por un solo gen recesivo transmitido del clon 1.22 de S. phureja. Las plantas enanas respondieron al tratamiento con giberellico, con lo cual recuperaron su crecimiento normal. A este gen lo hemos denominado "ga2". Los análisis de enlace del gen ga2 realizados con marcadores de RFLP y RAPD indicaron que el gen ga2 estaba localizado en la parte más extrema del cromosoma 7 o cerca de su extremo distal.

INTRODUCTION

Dwarfism has been successfully used in several cereal crops to shorten stem length and to confer lodging resistance. Many wild and cultivated potato species grow in low latitude regions in Andes (Hawkes 1990). These and their hybrid progeny with the common potato (Solanum tuberosum L. ssp. tuberosum, referred to those presently grown worldwide) tend to grow vigorously without initiating tuber formation due to long day-length in summer season in medium latitude regions. Dwarfism may contribute to some extent to improving vine shape of potato.

Dwarf plants in potato may be commonly appearing in practical breeding programs, but virtually all such plants are eliminated in a very early stage of selection. Hermsen et al. (1978) obtained extreme dwarf plants with single stems carrying many small, generally simple leaves on relatively long petioles, in a selfing population of a haploid clone of S. tuberosum ssp. tuberosum cv. Gineke. They assumed the dwarf trait to be controlled by a single recessive gene (Hermsen et al. 1978). In progeny of a cross between S. tuberosum ssp. andigena and ssp. tuberosum, Bamberg and Hanneman (1991) found dwarf plants having very short internodes, small and dark green leaves and a compact ball-shaped appearance which could be completely restored to normal appearance by exogenous GA3. By test crosses, a single recessive gene 'ga1' was proposed to explain this dwarfism (Bamberg and Hanneman 1991). The block of gibberellin biosynthesis between GA12 and GA53 in this dwarf plant has been found (van den Berg et al. 1995). Significant yield differences were also reported for tetraploid ga1 heterozygotes that show no obvious vine differences (Bamberg and Hanneman 1993). Dwarf plants having the same morphological characteristics with Bamberg and Hanneman's (1991) were reported in a haploid population of S. tuberosum ssp. tuberosum cv. Pito (Valkonen et al. 1999). They measured endogenous gibberellin and found very low amounts of all analyzed GAs in the dwarfs, indicating an early part of the gibberellin biosynthesis pathway is blocked. They gave a gene symbol 'pito' to a recessive dwarfing gene without a genetic analysis.

We obtained extreme dwarf plants in an F2 population of a cross between a wild diploid species, S. chacoense (clone chc...
Materials and Methods

*Solanum chacoense* clone chc 525-3 is a highly inbred line (S_7) obtained through continued selfings utilizing S locus inhibitor gene (Sli) (Hosaka and Hanneman 1998a). *Solanum phureja* clone 1.22 is known as a superior diploid pollinator from PI 225682 commonly used in haploid extraction in North America (Kotch and Peloquin 1987). One of F_1 hybrids between chc 525-3 and 1.22 (clone F_1-1) was selfed with the help of Sli gene, or backcrossed to both parents (2KH72 and 2KH73 families) (Figure 1). F_1-1 was crossed with a cultivated diploid clone 63H100-1 (94H89 family). A randomly chosen individual from 94H89 family was selfed (1H76 family). A dwarf plant 90H29-173 obtained by selfing F_1-1 was backcrossed to F_1-1 (2KH75 family).

Seeds were soaked in 2000 ppm GA_3 for 48 h and sown in cell pots individually. Young seedlings were transplanted to 4 inch clay pots 35 days after seed sowing. A further 35 days later, dwarf plants were distinguished. After determination of phenotypes, some dwarf plants of 2KH74 family were sprayed with 50 ppm GA_3 three times a week for 3 wk to test whether they recovered to normal growth or not.

Plants of 2KH74 family were used for mapping a dwarfing gene. DNA isolation and detection procedures for RAPD and RFLP markers have been described previously (Hosaka and Hanneman 1998b). RFLP probes prefixed with 'TG', 'CT' or 'CD' were single-copy tomato probes obtained from S. D. Tanksley, Cornell University, NY, USA. These have been localized on tomato or potato genetic maps (Tanksley et al. 1992). The probes prefixed with 'P' were single-copy DNA probes selected from a random genomic DNA library of *S. phureja* 1.22 (Hosaka and Spooner 1992), which have been localized on potato genome (Hosaka and Hanneman 1998b; Hosaka 1999). Linkage analysis was carried out by the program 'MAPMAKER' (Lander et al. 1987) with Kosambi mapping function.

Results and Discussion

Parental clones chc 525-3 and 1.22 had normal appearance. F_1 hybrids were also all normal. One of the F_1 hybrids, F_1-1, was selfed, and extreme dwarf plants were found in a ratio of 120 normal : 37 dwarf in the selfed progeny. Dwarf plants had very short internodes, small dark green leaves with edges of leaflet often curled to upside, and compact ball-shape appearance (Figure 2), which looked like the dwarfs of Bamberg and Hanneman (1991) and Valkonen et al. (1999). F_1-1 was backcrossed to chc 525-3 and to 1.22, and the latter yielded dwarf plants in a ratio of 199 normal : 63 dwarf (Table 1), indicating that the dwarfism was inherited from 1.22. These and other segregation ratios (Table 1) suggest that the dwarfism is controlled by a single recessive gene.

By spraying GA_3, complete recovering to normal growth was observed in many of the dwarfs. Some did not recover probably because very poor root system could not sustain rapid aboveground growth.

Morphological features, sensitiveness to exogenous gibberellin, and a single recessive genic action in the present dwarfs suggest a high similarity of the present dwarfing gene to previously reported *ga_1* or *pito*. Since allelism tests of these genes are not completed, we herein designate our gene to be 'ga_2'. The pos-