Barley Genetics Newsletter 36:3-5 (2006)

Response of Induced Dwarf Mutants of Barley to Exogenous Application of Gibberellic Acid

Bandarupalli Ramesh∗ and Bateshwar Kumar
Department of Genetics & Plant Breeding (formerly Agricultural Botany),
Ch. Charan Singh University, Meerut - 250 004 (Uttar Pradesh), India.
∗e-mail: bandarupalli_ramesh@yahoo.com

Abstract

Response of five induced plant height mutants (dwarfs and semi-dwarfs) of barley to gibberellic acid (GA_3) treatment was studied. The gibberellic acid response index (GRI) was calculated and based on this value, the mutants have been categorized as sensitive (high or moderate) or insensitive. The GRI value was highest for dwarf mutant followed by early maturing mutant with the former being highly sensitive to GA_3 treatment while the latter was moderately sensitive. On the other hand, semi-dwarf and chlorina mutants and the control were insensitive to exogenous application of GA_3.

Key words: GA_3 treatment, reduced height mutants, barley, gibberellic acid response index (GRI).

Introduction

Gibberellins stimulate extensive growth in intact plants. These enable to overcome genetic dwarfness in some species if that dwarfness is because of a gene mutation, resulting into blocked gibberellin production. Lack of gibberellins causes shortening of internodes and reduces the height of the plant. Exogenous application of gibberellic acid (GA_3) fulfils its requirement and the plant achieves normal height. Gibberellins have little effect when they are applied to plants of normal height. The most outstanding effect of gibberellins on plants is the abnormal stem elongation. This is brought about primarily by increased cell elongation, and secondarily by accelerated cell division. Under its influence generally dwarf varieties have been changed in to tall varieties in some species. The small size of genetically dwarf plants is due to some natural growth inhibitors. The rapid elongation of the stem that follows the application of gibberellins is attributed to the neutralization of such inhibitors by gibberellin.

The development of semi-dwarf cultivars has occurred with little understanding as to the effects of the plant height genes on plant traits other than straw length. In wheat, traits pleiotropic to or closely associated with, *Rht1* and *Rht2* genes include gibberellic acid insensitivity, cell size and cell number, root weight, coleoptile length, leaf size, grain yield, yield components, biomass, harvest index, protein content, and disease reaction (Gale and Youssefian 1985). In any mutation breeding programme, reduced height mutants are one of the most frequently occurring class of mutations. However, there are not many studies dealing with the response of dwarf mutants to GA_3 treatments. Hence, the present report on the response of induced dwarf mutants of barley to exogenous application of gibberellic acid.

Materials and Methods

A laboratory experiment involving five induced dwarf mutants of barley along with parental control was conducted at the department of Agricultural Botany, Ch.

Charan Singh University, Meerut during 2002-03. The M_6 seeds of the five true breeding barley mutants viz. dwarf, semi-dwarf, early maturing, semi-dwarf with early maturity, and chlorina types (isolated from gamma irradiated populations of barley cultivar 'K 169') were used. Response of reduced height mutants to GA_3 was estimated following Yamada (1990). For the GA_3 response test, seeds were germinated in petri-dishes for 2 days at 20^0C, then transferred to seed trays containing a mixture of vermiculite, soil and sand in the ratio of 2:2:1 by volume. The seedlings were grown in trays in a growth chamber under controlled light and temperature conditions. After 5 days of growth at 20/15 ^{0}C (day/night) for 16/8 hours, the seedlings were supplied with 10 ppm GA_3 through irrigation water every other day. Seedling length and leaf sheath measurements were recorded on 20 days old seedlings.

Results and Discussion

The data recorded on seedling length and the length of first leaf sheath of 20 days old seedlings of both GA_3 treated and untreated mutants and control are presented in table 1. The gibberellic acid response index (GRI) was calculated and based on this value, the mutants have been categorized as sensitive (high or moderate) or insensitive. The GRI value was highest for dwarf mutant (141.81) followed by early maturing mutant (113.18). The dwarf mutant was highly sensitive to GA_3 treatment while the early maturing mutant was moderately sensitive. A moderate response was also recorded for the semi-dwarf mutant with early maturity while the other two mutants of the present study and the parental control were insensitive to GA_3 treatment (Table 1).

Table 1. Seedling and leaf sheath measurements (mean ± S E), GA_3 response index (GRI), and GA reaction in gibberellic acid treated seedlings of reduced height mutants in barley.

Control/Mutant	Length of first leaf sheath in		GRI (%)	Reaction to GA_3	Seedling length in		GRI (%)
	GA_3 treated	Un-treated			GA_3 treated	Un-treated	
'K 169' control	18.25 ± 0.34*	17.85 ± 0.21	102.34	Insensitive	23.16 ± 0.32	22.45 ± 0.34	103.16
Dwarf	11.70 ± 0.66	8.25 ± 0.21	141.81 **	Highly sensitive	13.66 ± 0.16	10.32 ± 0.74	132.36**
Semi-dwarf	13.33 ± 0.67	13.10 ± 0.48	101.75	Insensitive	18.20 ± 0.46	17.84 ± 0.58	102.01
Semi-dwarf w/ early maturity	13.05 ± 0.48	12.37 ± 0.50	105.49	Mildly sensitive	17.42 ± 0.36	16.32 ± 0.51	106.74
Early maturing	15.28 ± 0.48	13.50 ± 0.45	113.18	Sensitive	20.50 ± 0.77	18.65 ± 0.46	109.91
Chlorina	12.00 ± 0.28	11.65 ± 0.29	103.00	Insensitive	16.12 ± 0.36	16.12 ± 0.32	105.91

In wheat, out of 133 Norin varieties tested by Yamada (1991), 103 were GA-insensitive and 30 GA-responsive with all the 6 breeding lines being GA-insensitive. On the other hand, out of the 16 landraces tested, 10 were GA-insensitive and 6 GA-responsive. One of the possible mechanisms of GA_3 action appears to be the promotion of changes in RNA synthesis during cell elongation. Apparently, GA_3 action in all target tissues may be via its effect on the transcriptional process. GA_3 may be enhancing the rate of synthesis of all classes of RNA, or it may be inducing some of the specific enzymes as in cereal aleurone.

The many effects of gibberellins suggest that they have more than one important primary site of action. Thus far, research with hormone receptors neither verifies nor denies that idea. Even a single effect such as enhanced stem elongation on whole plants results from at least three contributing events – (i) cell division is stimulated in the shoot apex, (ii) gibberellins sometime promote cell growth because they increase hydrolysis of starch, fructans, and sucrose into glucose and fructose molecules, and (iii) gibberellins sometime increase wall plasticity (Salisbury and Ross 2001).

The positive association between GA-insensitivity and height reduction has been shown in wheat for both Gai_1 with Rht_1 and Gai_2 with Rht_2 in crosses involving Norin 10 derivative semi-dwarfs (Gale and Marshall 1973, Hu 1974) and for Gai_3 with Rht_3 in 'Tom Thumb' type dwarf (Gale et al. 1975, Fick and Qualset 1975). Whether the nature of this association is pleiotropic, i.e. the *Gai* and *Rht* genes are, in fact, the same, or due to linked loci, as suggested by Konzak et al. (1973), it is clear that the chromosomal location of Gai_1, Gai_2, and Gai_3 are the same as those of Rht_1, Rht_2 and Rht_3. The exact nature of the relationship between gibberellin insensitivity and height reduction is of practical importance to wheat and barley breeders who are using different sources of dwarfism.

References

Fick, G.N. and C.O. Qualset, 1975: Genetic control of endosperm amylase activity and gibberellic acid responses in standard height and short strawed wheats. Proc. National Acad. Sci. U S A 72, 892-895.

Gale, M.D. and G. A. Marshall, 1973: Dwarf wheats and gibberellins. Pages 513-519 in Proc. 4th Wheat Genetics Symp.

Gale, M.D., C.N. Law, G.A. Marshall and A.J. Worland, 1975: The genetic control of gibberellic acid insensitivity and coleoptile length in a dwarf wheat. Heredity 34, 393-399.

Hu, M.I., 1974: Genetic analysis of semi-dwarfing and insensitivity to gibberellin GA_3, in hexaploid wheat. Ph D thesis, Washington State University, USA.

Konzak, C.F., Sadam Mir and E. Donaldson, 1973: Inheritance and linkage in durum wheats of semi-dwarfing genes with low response to gibberellin GA_3. Pages 29-40 in Proc. Symp. 'Genetics and Breeding of Durum Wheats' (Bari, 1973)

Morris, R., J.W. Schmidt and V.A. Johnson, 1972: Chromosomal location of a dwarfing gene in Tom Thumb wheat derivative by monosomic analysis. Crop Sci. 12, 247-249.

Salisbury, F.B. and C.W. Ross, 2001: Plant Physiology. CBS Publishers & Distributors, New Delhi (India).

Yamada, T., 1990: Classification of GA response, *Rht* genes and culm length in Japanese varieties and land races of wheat. Euphytica 50, 221-239.