Response of 1-Dwarf, 2-Dwarf, and 3-Dwarf Strains of Milo to Repeated Foliar Applications of Gibberellic Acid1

J. E. Freeman and H. H. Hadley2

WITTWER and Bukovac (21) have listed a number of general effects which exogenous gibberellin has on growing plants. Hyperelongation of stems is the most characteristic response and has been observed in practically all species that have been studied. Some of the most dramatic differences in height following treatment with gibberellin have been with dwarf mutants. Brian and Hemming (3) reported that dwarf varieties of peas (Pisum sativum), broad bean (Vicia), and French bean (Phaseolus) responded more to gibberellin acid (GA3) than did tall varieties. They concluded that the cause of dwarfness was probably the same in all of these plants.

Phinney (12) recognized the genetic usefulness of such differential responses as a means of contributing to a better understanding of gene action. He reported four cases in corn (Zea mays) where the ability to respond to GA3 is controlled by single genes.

Allan et al. (1) concluded that the dwarf and semi-dwarf characteristics of wheat varieties which they studied are not due to a specific lack of GA3, or a material which can be replaced by GA3. They suggested, however, that the dwarfism could be due to the inability of these plants to utilize GA3 or related growth substances to any appreciable extent. Unlike peas, beans, or corn, tall wheat varieties responded even more than dwarf varieties.

Strains of tomatoes, homozygous for a dwarfing gene, were induced by gibberellin to grow to heights exceeding that of the untreated normal plants; however, significant growth responses were observed for both height groups (13). Gibberellic acid stimulated growth of dwarf alfalfa plants, but treated dwarf plants did not attain heights comparable with those of untreated normal plants (10).

Types of Sorghum vulgare are available which differ for known dwarfing genes that are inherited independently and are truly brachytic, in that they are characterized only by a shortening of internodes. The effects of these dwarfing loci appear to be accumulative, though not strictly additive in a statistical sense. Therefore, this species was selected as being potentially very useful for evaluating differential responses to GA3. Possible failure of strains differing genetically for height to respond similarly to GA3 could be interpreted as a function of specific loci to control the production or utilization of natural gibberellins or gibberellin-like compounds in the plant.

MATERIALS AND METHODS

Early White Milo SA1170, Dwarf White Milo SA2238, and White Sooner Milo DS2229 were used in this study. These 3 strains of milo have the same genotype (ma5, ma5, ma5, ma5) for maturity (15, 17) but differ in their genotype for height (14, 16). The four major genes which influence height have been designated as dw5, dw5, dw5, dw5. Early White Milo SA1170 is recessive at the dw5 locus only, Dwarf White Milo SA2238 is recessive at both the dw5 and dw5 loci, and White Sooner Milo DS2229 is recessive at the dw5, dw5 and dw5 loci. Accordingly, these strains are referred to as 1-dwarf, 2-dwarf, and 3-dwarf strains. Number of internodes is influenced by the maturity genes, and length of internodes is controlled by the four dwarfing genes. Both number and length of internodes are known to influence height.

Seed from each of the 3 types were included in a planting that was made on the Agronomy South Farm, Urbana, Ill., on May 30, 1961. The basic experimental design was a randomized complete block with three replications. Rate of application of GA3 constituted main plots and height genotype formed subplots. Each subplot consisted of a 10-foot row in which plants were spaced approximately 1 foot apart. Spray solutions containing 100 ppm and 200 ppm of GA3 as potassium gibberellate and a water control were applied bi-weekly. The first of 5 applications was made on June 16. The spray solutions were applied with a garden sprayer supplied with constant pressure through a regulator valve from a compressed air tank. A sufficient volume was applied to wet the leaf surface of the treated plants without runoff.

The distance from the ground to the tip of the longest leaf of each plant was recorded seven weeks after planting, and the distance from the ground to the collar of the flag leaf was measured at maturity. Since the genes for peduncle length and panicle length are independent of those controlling internode length, the most accurate measure of stem height would be the height to the uppermost or peduncle node (16). However, this measurement is difficult to make because the uppermost node frequently is enclosed within 3 or 4 leaf sheaths. The height to the collar of the flag leaf is easily measured and, according to Quinby and Kasper (16), is a reasonably accurate estimation of relative stem height. Other observations included number of tillers, number of days from planting to anthesis, yield of tillers, yield of main heads, number of leaves per plant, and protein content of grain as determined by the Kieldahl method.

Since some of the lower leaves ordinarily dry up and disintegrate before the plants are mature, the leaves were identified at early dates by punching holes in the fifth and tenth leaves with a paper punch.

RESULTS

Height—Seven weeks after planting, the height to the tip of the longest leaf of plants receiving repeated foliar applications of GA3 was greater than that of the controls (Table 1). However, the difference in height of plants receiving 100 ppm and that of plants receiving 200 ppm of GA3 was not significant. The 3 genotypes had already been retarded by both applications of GA3 (Table 1).

The distance from the ground to the tip of the longest leaf of each plant was recorded seven weeks after planting, and the distance from the ground to the collar of the flag leaf was measured at maturity. Since the genes for peduncle length and panicle length are independent of those controlling internode length, the most accurate measure of stem height would be the height to the uppermost or peduncle node (16). However, this measurement is difficult to make because the uppermost node frequently is enclosed within 3 or 4 leaf sheaths. The height to the collar of the flag leaf is easily measured and, according to Quinby and Kasper (16), is a reasonably accurate estimation of relative stem height. Other observations included number of tillers, number of days from planting to anthesis, yield of tillers, yield of main heads, number of leaves per plant, and protein content of grain as determined by the Kieldahl method.

Since some of the lower leaves ordinarily dry up and disintegrate before the plants are mature, the leaves were identified at early dates by punching holes in the fifth and tenth leaves with a paper punch.

Number of leaves—Plants which were sprayed with GA3 produced an average of about 2½ fewer leaves than control plants which were sprayed with water; but the number which developed on plants treated with 200 ppm of GA3 was not different. Plants of the 1-dwarf strain had an average of approximately 1 more leaf than plants of either the 2-dwarf or 3-dwarf types (Table 1).

Days to anthesis—Applications of either GA3 solution hastened the onset of anthesis by approximately 2 days, and flowering started later in the 1-dwarf strain than in either of the other 2 strains (Table 1).

Number of tillers—Control plants produced nearly twice as many tillers as did plants receiving gibberellic acid treatments (Table 1). The number of tillers produced by plants sprayed with 100 ppm of GA3 was not statistically different from the number produced by plants sprayed with