HortScience 20(1): 131–132. 1985.

Yield and Harvest Efficiency of Savoy Type Spinach

F.J. Dainello[1], R.K. Jones[2], and R.R. Heineman[3]
Texas A&M University Agricultural Research and Extension Center, Uvalde, TX 78801

Additional index words. bolting, stem elongation, seed stalks, *Spinacea oleracea*

Abstract. **Selected gibberellin A_3 (GA_3) rates and application dates on yield and harvest efficiency of the savoy spinach (*Spinacea oleracea*) cultivar 'Iron Duke' were evaluated. The most favorable yield response was achieved under fall conditions with 15–20 g GA_3/ha applied 7–14 days prior to the anticipated harvest date. When cool temperatures (5° to 12°C) prevailed during the treatment and posttreatment periods, increased GA_3 rates and prolonged response times were necessary. Gibberellin A_3 did not induce bolting when applied as early as 1 Nov. but applications later than 15 Feb. enhanced the rate of seed stalk development.**

Texas produces about 35% to 40% of the total annual United States spinach acreage. The savoy type grown for the fresh market dominates the industry. Historically, fresh market spinach has been hand harvested. Shrinking labor supply and rising costs are major concerns of fresh market spinach producers. Consequently, a need exists to develop cultural practices which enable mechancial harvest of fresh market spinach.

Gibberellin A_3 (GA_3) induces upright growth habit in many plants (1, 2, 5, 7, 8). Gonzales et al. (2) demonstrated that GA_3 could be used to increase spinach yield. The objective of this study was to develop use patterns for GA_3 to aid mechanical harvest of savoy type fresh market spinach.

In Expt. 1, the influence of 0, 5, and 20 g GA_3/ha (10% liquid formulation, Abbott Laboratories, Chicago, Ill.) at 3-, 7-, and 14-days application to harvest intervals (AHI) were evaluated for improving machine harvest efficiency of full savoy spinach in the fall of 1981. Treatments were evaluated using a randomized block design having 4 replicates. Each treatment combination consisted of single bed plot (0.96 m × 1.53 m) with double plant rows. The savoy variety, 'Iron Duke', was planted on 12 Oct. The GA_3 treatments were initiated when the plant foliage began to touch within and between the double rows. A surfactant (78% alkylphenyl hydrox-polyoxyethylene + polarized resins and fatty acids, Helena Chemicals, Lubbock, Texas) solution at the rate of 1 ml/liter was included in all sprays. Sprays for the 14-, 7- and 3-day AHI were applied on 7, 15, and 18, Dec. respectively. A hand-held Ultra Low Volume battery powered applicator calibrated to deliver 51.4 liters/ha was used to apply the GA_3. Plots were cut mechanically, using a tractor mounted sickle bar set 6.4 cm above the bed surface, on 21, 22, 23 Dec., respectively for the 3-, 7-, and 14-day AHI treatments. The severed leaves then were hand-gathered and weighed. The remaining plant stubble was hand-cut at the bed surface, and weighed.

The treatment variables were evaluated under late season conditions in Expt. 2, using a split-plot design having 4 replicates. The AHI treatments were established as the main plot factor and the GA_3 rates, as the subplot factor. Each subplot consisted of a single bed (0.96 m × 3.05 m) with double plant rows. The test plots were planted on 12 Dec. 1981, and the 14-, 7-, and 3-day AHI treatments were applied on 4, 11, 15 Mar., respectively. All plots were harvested on 18 Mar.

The treatment combination selected for investigation on Expt. 3 consisted of 4-, 8-, and 12-days AHI and 0, 10, 15, and 20 g GA_3/ha rates. In this experiment, the GA_3 rates were used as the main-plots and the AHI's as the subplots. All other experimental conditions were similar to those of Expt. 2. The plots were established 21 Oct., and the GA_3 treatments were applied 9 Dec. subplot harvest (AHI treatments occurred on 13, 17, and 21) Dec. Fifteen random leaves per treatment per replicate were harvested, and total leaf length, petiole length, leaf weight, petiole weight, and leaf disk weight were determined. Leaf disk weight was obtained from disks cut with a No. 5 cork borer at the basal portion of each leaf next to the midrib.

In Expt. 1, 20 g GA_3 was the most effective rate in enhancing the efficiency of foliage removal by mechanical harvest (Table 1). Of the treatment combinations, only 20 g + 14 days AHI was found to be significantly better than the other GA_3 rate-AHI combinations in increasing yield ($P \leq 0.05$). Yield increases were detected, however, with all other treatment combinations except 5 g + 3 AHI. Earliest evidence of a GA_3-induced hyponastic plant response occurred 3 days after the 20 g application. A similar response occurred with 5 g GA_3 after 8 days. Upright growth was observed in all GA_3 treatments 14 days after application. Data for percentage of plant removed at harvest shows that GA_3 did improve machine harvest efficiency. The percentage of plant removed with the 20 g treatment combinations ranged from 36% (20 g + 7 day AHI) to 41% (5 g + 7 or 14 day AHI). In contrast, only 29% of the plant was removed in the untreated plots.

The dramatic plant response to GA_3 found in Exp. 1 did not occur under the late season conditions of Expt. 2. No significant interactions between AHI and GA_3 rates were detected ($P<0.05$). Only a slight increase in yield was induced by the GA_3 as an average of all AHI's. The nonsignificant differences in plant response under late season conditions can be attributed to the initiation of

Table 1. Influence of gibberellin A_3 (GA_3) rates and application to harvest intervals on savoy type spinach planted 12 Oct. 1981.

Treatments	MT/ha: Marketable yield (foliage removed at harvest)	MT/ha: Residue remaining in field[z]	Plant removed at harvest (%)
20 g/ha + 14 days (AHI)[y]	22.8	26.7	46
20 g/ha + 7 days (AHI)	18.8	33.6	36
20 g/ha + 3 days (AHI)	15.7	26.2	37
5 g/ha + 14 days (AHI)	14.6	21.1	41
5 g/ha + 7 days (AHI)	13.9	20.4	41
5 g/ha + 3 days (AHI)	11.2	23.1	33
Control - no treatment	12.1	30.2	26
LSD at 5%	1.7	3.8	9

[z]Represents plant stubble remaining in the field after once-over harvest. Simulated mechanical cutting 6.4 cm above bed surface.
[y]Application to harvest interval.

Received for publication 30 Dec. 1983. The authors gratefully acknowledge the grant support provided by Abbott Laboratories which enabled this research. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

[1]Associate Professor.
[2]Vegetable Crops technician.
[3]Extension Plant Pathologist. Present Address: Dept. of Plant Pathology, Texas A&M Univ., College Station, Texas.

Table 2. Influence of gibberellin A_3 (GA_3) rates as an average of all application to harvest intervals on yield and quality of savoy type spinach planted 21 Oct. 1982.

Treatments	Yield MT/ha	Length whole leaf cm/leaf[z]	Length petiole cm/petiole	Wt whole leaf g/leaf	Wt petiole mg/petiole
0 g/ha	3.0	11.2	1.2	4.3	160
10 g/ha	3.0	11.9	1.6	4.6	210
15 g/ha	3.5	12.1	1.8	4.6	240
20 g/ha	4.1	12.6	2.1	5.0	310
LSD at 5%	0.7	0.6	0.4	0.6	NS

[z]Based on a 15 leaf sample/treatment/rep.

seed stalk development (bolting) prior to treatment application. Bolting in spinach is normally accompanied by an uplifting of foliage due to increased concentration of endogenous gibberellins produced under long days (4). Because bolting is a function of day length and temperature (6), these stimuli requirements for the variety 'Iron Duke' were satisfied prior to GA_3 application. As a result, leaf uplifting also occurred in the unsprayed plots.

The yield response to GA_3 in Expt. 3 were similar to the response noted in Expt. 1. Increased yield occurred with increasing GA_3 rates. Only the 20 g rate was found to be significantly better than the untreated check. No significant yield differences were detected between the 15 and 20 g rates (Table 2). Leaf measurements indicated a significant portion of the yield increase induced by GA_3 was due to increased harvest of petiole tissue. This was not expected to be a limiting factor, because petiole removal can be reduced by adjusting the cutting blade height during harvest. Nonsignificant differences in leaf disk weights were obtained. As expected, yield obtained among AHIs, as an average of all GA_3 rates, increased significantly with increasing AHI (Table 3).

Gibberellin A_3 has been shown to induce flowering under certain conditions (8). In this study, GA_3 seemed to exert a greater influence on the rate of seed stem development than on the initiation of bolting. No bolting was evident when GA_3 applications were made under early to mid season conditions (November-January), whereas all plots, including the unsprayed checks, bolted in the late season (after 15 Feb.) when the day length/temperature requirements for bolting were satisfied. Similar results regarding stem development of overwintered spinach were reported by Gonzales and Marx (3). Reduced rates and shorter AHI were required for the GA_3 induced hyponastic plant response when warm temperatures (13° to 20°C) prevailed at and during the posttreatment.

Table 3. Influence of application to harvest intervals as an average of all gibberellin A_3 (GA_3) rates on yield and quality of savoy type spinach planted 21 Oct. 1982.

Treatments	Yield MT/ha	Length whole leaf cm/leaf[z]	Length petiole cm/petiole	Wt whole leaf g/leaf	Wt petiole mg/petiole
4 days after application	1.9	10.7	1.2	3.8	130
8 days after application	3.2	12.4	2.0	4.6	270
12 days after application	5.0	12.7	1.9	5.5	290
LSD 5%	0.4	0.5	0.1	0.3	60

[z]Based on a 15 leaf sample/treatment/rep.

The findings of this study suggest that 15 and 20 GA_3 g/ha applied 7–14 days prior to anticipated harvest can be used to increase mechanical harvest efficiency and yield of savoy spinach by rendering more leaf tissue available for cutting. These results agree with Gonzales and Marx (3), who reported that a single application of 20 pm GA_3 2 weeks prior to harvest increased plant height and yield of spinach. Therefore, GA_3 merits consideration as a harvest aid for savoy type fresh market spinach.

Literature Cited

1. Bryan, P.W. 1959. Effects of gibberellins on plant growth and development. Biol. Rev. 34:37–84.
2. Gonzales, A.R., M.R. Lanier, and K.M. Edwards. 1979. Effect of gibberellic acid on yield and quality components of spinach. Ark. Farm Res. 23:15.
3. Gonzales, A.R. and D.B. Marx. 1983. Effect of gibberellic acid on yield and quality of fall-harvested and overwintered spinach. J. Amer. Soc. Hort. Sci. 108(4):647–651.
4. Metzger, J.D. and J.A.D. Zeevaart. 1980. Effect of photoperiod on the levels of endogenous gibberellins in spinach as measured by combined gas chromatography-selected ion current monitoring. Plant Physiol. 66:844–846.
5. Marth, P.C., W.V. Audia, and J.W. Mitchell. 1956. Effects of gibberellic acid on growth and development of plants of various genera and species. Bot. Gaz. 118:106–111.
6. Ryder, E.J. 1979. Spinach, p. 195–227. Leafy salad vegetables. AVI Pub., Westport, Conn.
7. Stuart, N.W. and H.M. Cathey. 1961. Applied aspects of gibberellins. Ann. Rev. Plant Physiol. 12:369–394.
8. Wittwer, S.H. and M.J. Bukovac. 1957. The effects of gibberellin on economic crops. Econ. Bot. 12:213–255.