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The Influence of Irrigation and Row Spacing on the Quality of Processed Snap Beans[1]

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***Abstract*. Irrigation method and row spacing had a significant influence on the quality of fresh, canned, and frozen snap beans (*Phaseolus vulgaris* L.). Sprinkle irrigated fresh and canned snap beans contained more ascorbic acid than rill irrigated snap beans. Rill irrigated snap beans had more intense color, lower shear values, less turbid brine, and less drained weight loss. Canned snap beans grown in narrow rows had less drained weight loss than snap beans from wide rows. Frozen snap beans from narrow rows had more drip loss, less moisture, increased soluble solids, and increased ascorbic acid content than those from wide rows. Under the conditions of this study, rill irrigated snap beans and snap beans grown in narrow rows did have quality advantages over sprinkle irrigated snap beans and snap beans grown in wide rows.**

During recent years snap bean production has undergone many changes. Cultural practices have changed from small areas, dependent on seasonal conditions, to large areas where seasonal conditions are controlled to some degree with irrigation. To increase yields, changes in cultural practices have included increased plant populations. These increased plant populations have been obtained by more plants/row, and closer spacing of rows. What quality changes, in snap beans, can be expected from these changes in cultural practices?

Studies have shown (4, 7, 11, 12, 16, 17) that weather conditions and water stress have marked effects on pod yield, percent seed, sieve size distribution, color, firmness, and sloughing. Row spacing (12) affected yield and color; snap beans grown in narrow rows (22.9 cm) had less color intensity and uniformity resulting in reduced sensory quality.

Processed snap bean quality has been the subject of many studies (2, 3, 5, 7, 9, 10, 14, 15, 16, 17), particularly the influence of blanching conditions on quality. Low temperature blanching of snap beans (82.2°C or less) resulted in excess vitamin losses (16), as a result of enhanced enzyme activity, and was not recommended unless necessary to avoid other quality losses. As blanching temperature increased, sloughing increased, and firmness decreased. When snap beans were blanched at temperatures less than 82.2°, increased blanching time led to less sloughing (6).

Above 82.2° increased blanch time led to greater sloughing (8, 10, 15). One study (17) indicated that a short-time high temperature (90.6° to 93.3°) blanch resulted in less loss in color for frozen snap beans. Longer blanch times resulted in less color and a softer product. Pectic substances were found to be responsible for firmness in processed snap beans (6, 10, 14) and were influenced by blanching conditions. Blanching conditions also influence water retention (8) by plant material, which may have a relationship with drained weight and turbidity of the brine. Sloughing was influenced by transit from processor to consumer (3).

This study was conducted to determine what influence irrigation, row spacing, blanching temperature, and blanching time have on the quality of processed snap beans.

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Materials and Methods

'Blue Mountain' snap bean was planted in 1978 and 1979, 3 reps/year, in mid-May and harvested in late July. Plant populations were constant (430,456 plants/ha) in 56-cm rows 21 seeds/m, and in 28-cm rows 15 seeds/m of row. The first irrigation was 3 weeks after planting. Subsequent irrigations were scheduled to replace the amount of water used since the previous irrigation, on a 60% available soil moisture basis. This varied from 2.5 to 6.3 cm of water every 4 to 7 days depending on soil water-holding capacity, weather, and stage of crop development. Standard fertilization and herbicide application practices for snap bean production were followed.

Snap beans, by sieve size, were blanched at 76.7° or 87.8°C for 2 or 4 min, and cooled with water. All sieve size 6 snap beans were used for French style beans. A weighed amount of snap beans from each replication, sieve size, cultural and blanching treatment, were placed into 303 × 406 cans with a 60 grain NaCl tablet, covered with 200 ml of 76.6° water, sealed, and processed at 115.5° for 21 min. Snap beans (454 g) from each replication, sieve size, row spacing, and blanching treatment were placed in 2 mil polyethylene bags and frozen at −23.3°. No snap beans were frozen from the irrigation treatments due to limited sample size. The canned product was held at ambient temperature and the frozen product at −23.3° for 90 days before analysis. Prior to analysis the canned snap beans were placed on a Gyrotory Shaker with the speed control set at 2, for 16 hr to simulate transportation to consumer markets (3).

Drained weight, drip loss, and ascorbic acid were determined by AOAC methods (1). The 2,6-dichloroindophenol visual titration procedure was used to determine ascorbic acid content. Color was determined with an Agtron, model 300, reflectance spectrophotometer. Turbidity of the brine was determined with a Hach Ratio Turbidimeter and reported in Nephelometric Turbidity Units (NTU). Shear values were obtained with a Food Technology Corp., model TP-1 Texturepress equipped with a multiple blade CS-2 cell, a TG 4 texture gauge, and reported in newtons. Sloughing, carpel separation, and pod breakdown were determined by following USDA standards (13). The analysis of variance for the canned product used irrigation methods (two levels) as the main plot, row spacing (two levels), blanching temperature (two levels), and blanching time (two levels) as the subplots. The analysis of variance for the frozen product was similar to the canned product except irrigation methods were removed and row spacing was used as the main plot.

Results and Discussion

Fresh. Analysis of the fresh snap beans prior to processing, depending on sieve size, indicated that sprinkle irrigated snap beans contained 20 to 25% more ascorbic acid than rill irrigated snap beans. Snap beans grown in narrow rows (27.9 cm apart) contained 20% more ascorbic acid than snap beans grown in wide rows (55.9 cm). Snap beans grown with rill irrigation had a more pronounced green color than sprinkle irrigated snap beans. Small-sieved snap beans (1–4) produced on plants from narrow rows had a less desirable green color than snap beans grown on plants from wide rows. Large-sieved (5 and 6) snap beans from wide rows had a more desirable intense color than those from narrow rows.

Canned. The drained weight of canned snap beans was significantly influenced by irrigation treatment and row spacing (Table 1). Sprinkle irrigated snap beans lost more in drained weight than rill irrigated snap beans, regardless of sieve size, but the loss in drained weights gradually decreased as sieve size increased (7.1% to 4.2%). Snap beans grown in wide rows lost more drained weight than snap beans grown in narrow rows, regardless of sieve size, and again loss in drained weights gradually decreased as sieve size increased (7.7% to 2.7%). The drained weight of French style snap beans was not influenced by irrigation treatment or row spacing. Neither blanching temperature nor time had any influence on the drained weights of canned snap beans.

Irrigation treatment significantly influenced the turbidity of the brine from the canned snap beans. The brine of sprinkle irrigated snap beans was more turbid (6.9 to 23.3%) than the brine from rill irrigated snap beans, regardless of sieve size, but this difference in turbidity was much greater (23.2%) for sieve size 5 snap beans than for the other sieve sizes. The turbidity of the brine of French style snap beans was not influenced by irrigation method. Row spacing had a significant influence on the brine turbidity of sieve

Table 1. Quality factors for canned snap beans as influenced by irrigation, row spacing, blanch temp, and blanch time (1979 and 1980).

	Drained wt loss (%)		Turbidity (NTU)		Shear values (newtons)		Ascorbic acid (mg/100 g)		Agtron green color	
	Sieve size		Sieve size		Sieve size		Sieve size		Sieve size	
Treatment	1–5[z]	FS[y]	1–5	FS	1–5	FS	1–5	FS	1–5	FS
Irrigation										
Rill	17.4*[x]	24.9[NS]	49.5*	29.9[NS]	45.2*	45.9[NS]	15.6*	14.5*	22.4*	30.5[NS]
Sprinkle	18.4	25.6	58.5	27.7	49.5	46.1	19.7	16.5	27.1	30.8
Row spacing (cm)										
27.9	17.4*	24.8[NS]	50.7*	30.4[NS]	47.5[NS]	45.5[NS]	17.6[NS]	15.8[NS]	24.3[NS]	29.9[NS]
55.9	18.4	25.7	57.2	27.3	47.5	45.8	17.7	15.2	25.1	31.5
Blanch temp (°C)										
76.7	18.2[NS]	25.2[NS]	48.6*	31.1*	58.7*	54.7*	17.6[NS]	15.5[NS]	24.6[NS]	30.8[NS]
87.8	17.6	25.3	59.3	26.5	36.2	37.4	17.7	15.5	24.9	30.6
Blanch time (min)										
2	17.5[NS]	25.3[NS]	54.1[NS]	30.0[NS]	48.9*	47.2*	17.7[NS]	15.6[NS]	24.8[NS]	30.4[NS]
4	17.5	25.2	53.8	27.6	45.9	44.9	17.6	15.4	24.7	31.0

[z]Values displayed represent the mean for sieve size 1 through 5.
[y](FS) French Style (sieve size 6)
[x] Treatment significantly different by analysis of variance, 5% level (*).

size 1–5 snap beans, but not French style. The brine from sieve sizes 1–5 snap beans grown in narrow rows was more turbid than the brine from snap beans grown in wide rows.

A high blanch temperature (87.8°C) resulted in a cloudy, more turbid brine than a lower blanching temperature, or an increase of 15.0 to 49.7%, depending on sieve size. The reverse was true for French style snap beans, where a low blanching temperature resulted in a more turbid brine. Turbidity was not influenced by blanching time.

Sprinkle irrigated canned snap beans were firmer (had higher shear values) than rill irrigated snap beans, regardless of sieve size. This firmness difference between irrigation treatments gradually decreased as sieve size increased from 1 to 5 (10.8 to 5.2%). The firmness of French style snap beans was not affected by irrigation treatment. The firmness of snap beans was not influenced by row spacing. The firmness of snap beans was significantly influenced by blanching temperature and time. As blanching temperature or time was increased, firmness decreased in all sieve sizes including French style snap beans. Increased temperature had a much greater influence on decreasing shear values than increased time of blanch.

There was a significant interaction between irrigation treatment and blanching temperature on firmness. Snap beans blanched with a high temperature (87.8°C) had similar values (36.3 as compared to 33.4) regardless of irrigation treatment. But when snap beans were blanched with a low temperature (76.7°) sprinkle irrigated snap beans displayed much higher firmness values (51.6) than rill irrigated snap beans (36.6). This difference, in firmness values, was true for all sieve sizes, but was not present in French style snap beans.

Sprinkle irrigated canned snap beans contained significantly more ascorbic acid than rill irrigated snap beans, regardless of sieve size, and including French style snap beans. Lower ascorbic acid, due to rill irrigation treatment, was greater (20.8%) for sieve size 1–5 snap beans than French style (12.1%). Row spacing, blanching temperature, or time had no significant influence on the ascorbic acid content of canned snap beans.

Irrigation treatment had a significant influence on the green color of canned snap beans, particularly in the smaller sieve sizes. The green color of sieve sizes 1–5, grown under rill irrigation, was much darker than for the same sieve sizes grown under sprinkler irrigation. The color of French style snap beans was not affected by irrigation treatment. Row spacing, blanch temperature, and blanching time did not affect the green color of canned snap beans.

Frozen. Drip losses and moisture content of frozen snap beans were significantly influenced by row spacing and blanching temperature (Table 2). Snap beans grown in narrow rows had a significantly greater drip loss during thawing than snap beans grown in wide rows. As sieve size increased, drip loss differences due to row spacing increased from 15.8 to 33.1%. Drip losses in French style snap beans were not influenced by row spacing. The data for snap beans moisture content agreed very closely with drip losses. Snap beans grown in narrow rows contained significantly less moisture than snap beans grown in wide rows. This difference in moisture, due to row spacing, was present regardless of sieve size and included French style snap beans.

High blanch temperature resulted in significantly less drip loss for French style snap beans. This drip loss due to blanching temperature was most probably due to loss of water during the blanch. These data agreed with the values determined for snap bean moisture content where French style snap beans blanched with a high temperature (87.8°C) had a higher moisture content than comparable snap beans blanched at a lower temperature.

Row spacing had a significant influence on the soluble solids content of snap beans. The soluble solids of snap beans grown in narrow rows were higher than the soluble solids for snap beans grown in wide rows. This difference in soluble solids was present regardless of sieve size and included French style snap beans. This also agreed with moisture values, as influenced by row spacing, where low moisture values concentrate or increase soluble solids content. The soluble solids of snap beans blanched at a low temperature were higher than the soluble solids for snap beans blanched at a higher temperature. This difference in soluble solids combined with drip loss, due to increased blanching temperature, strongly suggested that moisture was lost during a blanch at a high temperature.

Snap beans grown in narrow rows had significantly higher ascorbic acid than snap beans grown in wide rows. This increase in ascorbic acid due to row spacing ranged from 8.3% for sieve size 1–5 to as much as 17.0% for French style snap beans. Blanching temperature had a significant effect on ascorbic acid content of frozen snap beans. Only the ascorbic acid content of sieve size 1–5 snap beans was influenced by blanching temperature and increased blanch temperature increased ascorbic acid content, which agreed with previously reported research (16).

Frozen, large-sieved size snap beans from narrow rows were a darker green, more uniform colored product than snap beans from wide rows. Increased blanch temperature produced a darker green, more uniformly colored frozen product, particularly in French style snap beans. Blanch time had no influence on the quality of frozen snap beans in this study.

Irrigation treatment and row spacing did not influence sloughing, carpel separation, or pod breakdown in canned or frozen snap

Table 2. Quality factors for frozen snap beans as influenced by row spacing and blanch temp (1979 and 1980).

	Drip loss (%)		Moisture		Soluble solids		Ascorbic acid (mg/100 g)		Agtron green color	
	Sieve size		Sieve size		Sieve size		Sieve size		Sieve size	
Treatment	1–5[z]	FS[y]	1–5	FS	1–5	FS	1–5	FS	1–5	FS
Row spacing (cm)										
27.9	13.4*[x]	29.6[NS]	90.9*	90.3*	5.4*	3.8*	14.0*	13.5*	25.9[NS]	39.6*
55.9	9.7	29.8	91.6	91.0	4.9	4.8	12.7	11.2	26.5	41.1
Blanch temp (°C)										
76.7	11.7[NS]	32.6*	91.1[NS]	90.1*	5.2*	3.8*	12.7*	12.2[NS]	26.7*	41.4*
87.8	11.4	26.8	91.4	91.2	5.0	3.4	14.1	12.5	25.7	39.4

[z]Values displayed represent the mean for sieve size 1 through 5.
[y](FS) French Style (sieve size 6)
[x] Treatment significantly different by analysis of variance, 5% level (*).

beans. The longer blanching periods (4 min) increased sloughing, carpel separation, sloughing, and pod breakdown regardless of blanching temperature, for canned snap beans only. In canned snap beans there was very little subjective carpel separation, sloughing, or pod breakdown in snap beans blanched at 76.7°C for 2 or 4 min, or snap beans blanched at 87.8° for 2 min. There was major carpel separation, sloughing, and pod breakdown for snap beans blanched at 87.8° for 4 min. This effect of blanching was not evident for frozen snap beans regardless of blanching temperature or time.

Discussion

Most of the studies concerning the influence of water stress on snap bean quality have originated in production areas where irrigation is used as a supplement and not in dry production areas where irrigation is essential. Method of irrigation is seldom mentioned and few studies are available concerning the influence of irrigation method on snap bean quality. In this study it was found that method of irrigation had a strong influence on snap bean color, ascorbic acid content, relative firmness, turbidity, and drained weight. Sprinkle irrigated fresh and canned snap beans contained more ascorbic acid than rill irrigated snap beans. Rill irrigated snap beans had a more intense darker color, lower shear values, a less turbid brine, and less drained weight loss than sprinkle irrigated snap beans.

Increased drained weight losses agree with increased turbidity and would indicate that sprinkle irrigated snap beans contain more moisture than rill irrigated snap beans. This is contrary to higher shear values and increased ascorbic acid determined for sprinkle irrigated snap beans.

Snap beans grown in narrow rows have been found to be lighter in objective color, and have little or no effect on subjective quality (12). In this study we found that the smaller sieve size 1–5 snap beans have a less desirable light color and the larger sieve size 6 snap beans (French style) had a darker color, but in fresh snap beans only. Row spacing did not affect the color, abscorbic acid content, shear values, or brine turbidity of canned snap beans. Row spacing did effect the drained weights of canned snap beans. Snap beans grown in narrow rows lost less when drained weights were considered.

Row spacing had a major influence on all of the quality attributes of frozen snap beans. Frozen snap beans from narrow rows have more drip loss, less moisture and increased soluble solids. Increased drip loss would lead to less moisture and a concentration of soluble solids. Row spacing has more influence on the quality of frozen snap beans than canned snap beans and is probably due to the heat processing required for canned snap beans.

In this study we found that blanching temperature and time have a direct influence on snap bean quality, and our findings agree with what has been reported previously in most instances. In this study blanching temperature had no influence on drained weight, ascorbic acid, or color of canned 'Blue Mountain' snap beans. The influence of blanching temperature on frozen snap beans varied greatly between sieve sizes and no definite pattern was established, except that high blanching temperature did result in a darker colored product. High blanching temperature also increased turbidity and lowered firmness values. There is a relationship between blanching temperature and irrigation method, and if low shear values are needed rill irrigated snap beans could be chosen.

High quality snap beans can be produced regardless of irrigation method or density of planting. There are definite quality differences due to these cultural practices. Under the conditions of this study, rill irrigated snap beans and snap beans in narrow rows did have quality advantages over spinkle irrigated snap beans grown in wide rows.

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