Feasibility of Broccoli as a New Enterprise — A Systems Approach

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Abstract. An interdisciplinary systems approach was used to explore the potential of fall, fresh-market broccoli as a new enterprise for eastern Virginia. Thirty cultivars were evaluated in three plantings. Crop value was estimated at each harvest based on weekly market prices. The market window was open from mid-October until late November, with production of 160 cartons/ha, each at 11 kg. However, production of 120 cartons/ha narrowed the window to 2 weeks. Yield of some cultivars exceeded 160 cartons/ha in the first planting; yield of others was below the target production in the second planting. Low yield and low prices during most of the harvest period for the second planting suggests that the optimum harvest season ends in mid- to late November. Problems with poor plant establishment must be addressed before growers can fully capitalize on potential of broccoli as a new enterprise.

Vegetables are frequently considered a viable option for diversification by agricultural producers. The decision to evaluate a new horticultural enterprise requires the careful consideration of many factors. Grower interest is essential, as is grower willingness to address the specific needs of a new crop. Concurrent evaluations of trends in per capita consumption, potential demand for the commodity, condition of the market windows, seasonal patterns of production, and possible competition need to be completed (Bauer et al., 1987; Runyan et al., 1986; Sterrett et al., 1989). There are several additional concerns that also must be addressed. Vegetable production is labor intensive and often requires specialized equipment, skilled production management techniques, and unique postharvest handling to produce and maintain the quality product needed to be competitive in the marketplace (CAST, 1984; Klíne et al., 1986). The interdisciplinary approach includes the evaluation of the production feasibility and the economic and marketing potential to establish a realistic assessment of new enterprise combinations (Sterrett et al., 1989).

This study focuses on the production feasibility of fall broccoli as a new enterprise for eastern Virginia. In addition to growers’ interest, other factors that were involved in the selection of broccoli for evaluation as a new enterprise included an increase of 330% in per capita consumption of broccoli since 1975 (Harem, 1988), the possible extension of the existing harvest window in Virginia to expand existing marketing opportunities, the possibility that fall broccoli production would fit into the production schedules of currently grown vegetable commodities (potatoes, snap beans, etc.), the proximity of five major terminal markets within 250 km radius, and the development of a regional farmers market by the state of Virginia that will require a more diverse product mix. To estimate potential yields and product quality, as well as determine the potential harvest season, replicated yield trials with 13 cultivars were planted 10 Aug. (week 31), 19 Aug. (week 33), and 10 Sept. (week 36) 1987 on a Bojac sandy loam soil (coarse loamy, mixed thermic Typic Hapludult) at the Eastern Shore Agricultural Experiment Station, Painter, Va. Three-row plots were 7.6 m long, with 0.6 m between rows and 0.1 m between seeds within the row (26,700 seed/ha). Fertilizer (112N-49P-93K, kg/ha), B (1.1 kg/ha), and α,α,α−trifluoro-2,6-dinitro-N,N-dipropyl-p-toluol.
Table 1. Yield, plant population, marketable heads, head diameter, and head weight of broccoli planted 10 and 19 Aug. 1987.

<table>
<thead>
<tr>
<th>Main effect</th>
<th>Yield (cartons/ha)*</th>
<th>Established plants (%)</th>
<th>Marketable heads (%)</th>
<th>Head diam (cm)</th>
<th>Head wt (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southern Comet</td>
<td>185</td>
<td>83</td>
<td>28</td>
<td>79</td>
<td>8.1</td>
</tr>
<tr>
<td>Green Top</td>
<td>180</td>
<td>53</td>
<td>25</td>
<td>92</td>
<td>9.7</td>
</tr>
<tr>
<td>Galaxy</td>
<td>156</td>
<td>94</td>
<td>33</td>
<td>78</td>
<td>8.7</td>
</tr>
<tr>
<td>Symphony</td>
<td>147</td>
<td>48</td>
<td>30</td>
<td>59</td>
<td>7.5</td>
</tr>
<tr>
<td>Green Comet</td>
<td>142</td>
<td>33</td>
<td>34</td>
<td>55</td>
<td>5.5</td>
</tr>
<tr>
<td>Brigadier</td>
<td>102</td>
<td>12</td>
<td>26</td>
<td>41</td>
<td>3.7</td>
</tr>
<tr>
<td>Premium Crop</td>
<td>89</td>
<td>111</td>
<td>28</td>
<td>73</td>
<td>9.2</td>
</tr>
<tr>
<td>Green Belt</td>
<td>50</td>
<td>38</td>
<td>6.7</td>
<td>27.7</td>
<td>1.8</td>
</tr>
<tr>
<td>Wailer-Duncan (P = 0.05)**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 Aug.</td>
<td>137</td>
<td>28</td>
<td>93</td>
<td>7.2</td>
<td>227</td>
</tr>
<tr>
<td>19 Aug.</td>
<td>64</td>
<td>25</td>
<td>49</td>
<td>7.4</td>
<td>214</td>
</tr>
<tr>
<td>Significance</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>Interaction (C × P)</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

*11-kg cartons.

†Percent of plants established from 26,700 seeds sown/ha.

*Mean of four observations.

**Mean of 52 observations.

Turn over production costs may vary with planting date (Chung, 1985). In this study, stand establishment of the heat-tolerant 'Em- bassy' accounted for only 34% of the sown seed (Table 1). Plant stand establishment for high-yielding 'Galaxy' and 'Southern Comet' was between 2.5% and 31%, while the stand of low-yielding 'Green Duke' and 'Futura' was between 15% and 20%. Plant establishment must be improved if broccoli, particularly direct-seeded broccoli, is to be grown commercially in eastern Virginia. Plant establishment was significantly correlated with both yield ($r = 0.50$) and number of marketable heads/ha ($r = 0.62$). The low plant populations may be attributed, in part, to heat stress during and immediately after germination. Daily maximum air temperatures at Painter, Vs., frequently exceeded 32°C during the fall broccoli planting season (19 days in July and 16 days in August). Elson and Morse (1989) have shown that germination of broccoli seed was inhibited with constant soil temperatures exceeding 36°C. Plant establishment problems and subsequent low yields have also plagued the research plots and commercial plantings in southern Virginia (O'Dell et al., 1989).

In addition to marketable yield, quality is important in establishing and maintaining marketing opportunities (O'Dell et al., 1989; Runyan et al., 1989; Sterrett et al., 1989). The loose, more open-head type of 'Southern Comet', 'Green Comet', and 'Galaxy' detracted from the visual quality of these cultivars. While both 'Green Belt' and 'Green Valiant' produced high-quality, tight, uniform heads with fine beading, yields for the first harvest were 102 and 144 cartons/ha, respectively. The quality standards used in this trial are those adapted for broccoli in Virginia, as based on the USDA grade "fancy" for broccoli (USDA, 1943).
For cultivars with an average head diameter < 90 mm, up to four heads can be included per bunch without exceeding the maximum bunch diameter of 210 mm (8.5 inches). To meet the above criterion with four heads per bunch, the minimum average head weight is 195 g (14-count carton). Of the cultivars tested, only 'Futura' failed to meet the minimum head weight (Table 1). All other cultivars met both the bunch weight and bunch diameter criteria, based on average head weight and diameter. However, thick stems and short internodes noted for several cultivars detracted from the overall appearance.

Temperature influence on product quality and the potential length of the harvest period must also be considered. Average day-night temperatures exceeding 24°C have been associated with loose bud structure, uneven bud development, and premature flowering (O’Dell et al., 1989). Based on the 30-year average for Painter, Va., the average day-night temperature during August and early September could exceed 24°C (National Oceanic and Atmospheric Administration, 1987), thereby restricting the potential harvest period of high-quality broccoli. Quality can also be adversely affected by exposure to freezing temperatures late in the harvest season. The risk of freeze damage in late plantings can be minimized by harvesting before the date associated with 50% probability of first occurrence of temperatures below −4.4°C (O’Dell et al., 1989). The date of 50% freeze probability for Painter, Va., occurs on 4 Dec. (week 49) (Tinga and Bailey, 1967). The target production period for this growing area appears to be about mid-October to late November. High temperature constraints at planting may limit the possibility of production before week 42, while increased risk of frost during week 49 would curtail production in December.

A market window analysis was completed using selling prices from Atlanta, Baltimore, Boston, New York, and Philadelphia terminal markets. For each market, the selling prices were discounted 20% to adjust for wholesale commission and terminal market charges. Average maximum, minimum, and median prices for 14-count cartons of broccoli were calculated using quotes for 1983 through 1987 (Federal-State Market News Service, 1987). Since similar trends were noted for the five markets, the combined data are shown in Fig. 1. The market window was considered “open” when the average minimum adjusted price exceeded the cost of production (Runyan et al., 1986).

Estimates of grower costs are based on either 122 or 162 cartons/ha (300 or 400 cartons/acre). While the average yield in southern Virginia was 120 cartons/ha in 1987 (P., Ramsey, personal communication), yields >162 cartons/ha should be feasible with appropriate management practices (O’Dell et al., 1989). Estimates include production, shipping-point marketing, transportation costs, and the costs associated with packing and icing, assuming slurry ice facilities are available. Marketable yield and economic costs for harvesting, packing, and transportation will vary with specific situations.

As shown in Fig. 1, the market window for fall broccoli should be open until week 48, provided the average yield equals or exceeds 162 cartons/ha. However, with an average yield of 122 cartons/ha, the market window narrows to about weeks 46 and 47. The market window could also be expanded by the identification of specific marketing niches in marketing channels other than terminal markets (Green and Schuck, 1988; Runyan et al., 1986). A more-detailed analysis of potential marketing and economic factors would be needed to ensure successful implementation of broccoli as a new enterprise for eastern Virginia.

The economic analysis included crop value and grower cost, based on cultivar yield. The crop value was calculated using 80% of the average price quoted from the three closest terminal markets—New York, Philadelphia, and Baltimore. Grower cost included $478/ha production costs and $2.83/carton harvest, icing, and shipping-point marketing costs (P. Ramsey, personal communication). Estimated net return varied greatly with cultivar and planting date (Fig. 2). The negative returns from the second planting reflect the significantly lower plant population, the lower yield, fewer marketable heads (Table 1), and the notably lower market value during most of the harvest period (weeks 47-49, Fig. 1).

Since crop value is a function of market price and yield, those cultivars that yield during periods of greater demand (higher prices) produce the greatest return. While the yield of ‘Galaxy’ and ‘Green Top’ was similar, the lower price for the first harvest resulted in a lower estimated net return for the early maturing ‘Galaxy’ than for ‘Green Top’, which matured 1 week later (Table 2). The late maturity of ‘Green Valiant’ (weeks 47 and 48) resulted in an estimated net return of 68% of that of ‘Green Top’, even though the yield of ‘Green Valiant’ was 80% of that of ‘Green Top’. For both plantings in this study, lower yield and declining prices resulted in lower net return for the late-maturing cultivars. Additional studies are needed to refine cultivar selection and planting schedules to meet market demands and maximize net return.

Economic feasibility of direct-seeded fall broccoli on the Eastern Shore depends on cultivar selection and cultural practices that ensure adequate plant populations, acceptable product quality, and improved marketable yield. The problem of low plant populations from direct seeding must be addressed before the potential of broccoli as a new enterprise in eastern Virginia can be fully assessed. Perkins-VEazie and Cantliffe (1989) reported improved germination of cabbage with seed covers.
of peat-vermiculite or calcined clay when soil temperatures exceeded 30°C. Additional cultural and economic evaluations are needed to assess the feasibility of using transplants as an alternative production method. Based on the available marketing, production, and economic information, fall broccoli has potential as a new enterprise for Virginia, provided the average yield exceeds 160 cartons/ha and the harvest season ends before the first week in December (week 48).

Literature Cited