Sugar Beet Production and Pest Management Practices in the Big Horn Basin of Wyoming

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ABSTRACT

A survey of the sugar beet producers in the Big Horn Basin, Wyoming, was conducted to evaluate their sugar beet production goals, use of IPM practices, perceived pest management and production problems, sources of sugar beet IPM and production information, and need for and worth of additional sugar beet IPM and production information. Goals of most producers included, in order of importance, producing maximum sugar per acre while keeping production costs as low as possible; producing maximum sugar per ton of sugar beets while keeping production costs as low as possible; taking care of their land; and preserving a family heritage, farming tradition or way of life. Greatest perceived pest or management problems were weeds and diseases although these perceptions were influenced by the county in which producers lived or company to which they contracted their sugar beets. The primary source of sugar beet information was the sugar company agriculturists. Some IPM and production practices, such as monitoring for insects, weeds, and diseases; use of resistant varieties; assessing nematode populations; use of early planting dates; crop rotation; and soil fertility testing are currently are being used. However, additional IPM and production practices, such as mapping the location of weeds and diseases, incorporating economic information when making pest management decisions, and closely monitoring soil moisture content for efficient irrigation scheduling could be used more frequently. Most producers indicated that they need more information on specific topics of IPM and sugar beet production. Educational programs and research projects, computer-driven information delivery systems, and decision support computer software are suggested as appropriate ways to aid producers

in making sugar beet IPM and production management decisions.

Additional Key Words: *Beta vulgaris*, IPM, disease, economics

Since its inception, much has been written about integrated pest management (IPM) (Glass 1975, Metcalf and Luckman 1975, Apple 1976, Newsom 1980, Douce et al. 1983, Adkisson 1986). Recently, the emphasis of IPM has been placed on defining and implementing a management system for pests (Glass 1975, Douce et al. 1983). In Wyoming, the focus of IPM has been placed on defining and working with a total farm management system within which pest management tactics and strategies are chosen and carried out according to the goals of the producer.

Although some information is available on sugar beet IPM in the Great Plains region (Yun and Sullivan 1980), we chose to examine more specifically the IPM practices currently used in the Big Horn Basin (primarily Washakie, Big Horn and Park counties).

The history of sugar beet production in the Big Horn Basin involves four sugar companies: Wyoming Sugar, Holly Sugar, Great Western Sugar and Western Sugar. Wyoming Sugar built a factory in Washakie County (Worland) in 1917. This factory was bought by Holly Sugar in 1928 and since has operated continuously under that management. The Great Western Sugar Company built a factory in northern Big Horn County (Lovell) in 1916. With the exception of 1943, this factory operated until 1983; it was idle in 1984, then resumed operation in 1985 under the ownership of Western Sugar Company.

Climatic and biotic conditions in the Big Horn Basin vary from the relatively warmer and arid Washakie County to the relatively cooler, higher elevation of Park County. Natural vegetation in Washakie and southern Big Horn County is dominated by a sagebrush ecosystem. Natural vegetation types of northern Big Horn and Park Counties, east of the Cedar-Heart Mountain areas, are grassland/sagebrush and grassland ecosystems, respectively. Elevations of the Big Horn Basin range from 3,814 feet above sea level in the north (Lovell) to 4,061 feet in the south (Worland) to 5,016 feet in the west (Cody).

Pest management in sugar beets is being practiced throughout the Great Plains region (Yun and Sullivan 1980). However, surveys have not been conducted to determine the prevalence of various strategies being used to manage both pest and common sugar beet production problems in the Big Horn Basin. In addition, growers' goals for producing sugar beets and their perception of major pest and sugar beet production problems must be identified prior to defining and implementing an integrated systems management approach to sugar beet production. The objec-

tives of our study were to determine producers' goals for sugar beet production, their perception of major sugar beet pest and production problems, and which pest management practices are currently being used. Towards these ends, a questionnaire was developed and sent to sugar beet growers in the Big Horn Basin. We planned to use the findings from the questionnaire to design a specific IPM program for this area.

MATERIALS AND METHODS

The questionnaire consisted of 14 questions concerning biographical data (4 questions), goals of sugar beet production (1 question), perceived pest management and sugar beet production problems (2 questions), current IPM practices and strategies being used (3 questions), worth of and need for additional IPM information (1 question) and sources of sugar beet IPM and production information (3 questions). County in which the respondent lived was added as a fifth variable to the biographical data group. Two inquiries concerning growers' interest in learning more about the IPM program and interest in conducting cooperative research with the University of Wyoming also were made. A copy of the questionnaire is available from the senior author upon request.

Questionnaires were distributed to all sugar beet producers in the Big Horn Basin: 90 producers from Washakie, 48 from Big Horn and 91 from Park Counties. The questionnaire and cover letter were sent via United States Postal Service first class mail. If a response was not received within 14 days, a reminder letter was sent. If a response was not received within 14 days of the reminder letter, a second questionnaire and cover letter were sent. A postage-paid, pre-addressed envelope was enclosed with each mailing to facilitate questionnaire return.

Degree of dependency between the biographical variables was tested by constructing a two-way contingency table between each biographical variable and the other biographical variables. Degree of dependency (similarity) between biographical variables was then determined by the chi-square statistic, which tested the null hypothesis of independence (Feinberg 1980).

Statistical analysis of questionnaire responses was performed by first constructing a two-way contingency table between each of the five biographical variables and each of the remaining questions. Next, the hypothesis that responses from questions concerning producer's goals, perceived pest and sugar beet production problems, current IPM practices and strategies, worth of and need for additional IPM information and sources of sugar beet IPM and production information were independent or unaffected by the biographical variables was tested by a two-dimensional chi-square test (Feinberg 1980). Data were reported separately for each level of each biographical variable when the latter influenced the frequency of responses. Questionnaire results were transformed to and reported in percents.

Tests for the possibility of two biographical variables simultaneously influencing responses to some questions were conducted by first constructing three-dimensional tables, taking logarithms of the row, column and depth totals, summing the appropriate logarithm-transformed row, column and depth totals and subtracting 2(log(**N**)) from that sum (where **N** is the total number of responses) (Feinberg 1980). Antilogs were then taken of these transformed values to estimate each cell's response. Expected cell responses were initially calculated according to one of two models: **complete independence,** where neither biographical variable simultaneously influenced the response to the question and were independent of one another (all one factor model), and **conditional independence**, where both biographical variables simultaneously influenced the response to a question **and** were highly dependent on one another (all two-factor model). These are log-linear models (Feinberg 1980). Degree of fit for the estimated cell responses of each model was evaluated by the maximum likelihood test statistic which was computed and compared to the tabulated chi-square value at the 0.05 type I error rate with the appropriate degrees of freedom (Feinberg 1980). If the all one-factor model fit the observed frequency of responses, then the biographical variables did not simultaneously influence growers' response to that particular question. If the all one-factor model did not fit the observed frequency of responses but the all two-factor model did, then various sub-models of the all two-factor model were established and tested for fit to the observed responses via the backward stepwise procedures of Feinberg (1980). The goal of testing these sub-models for fit to the observed responses was to determine which of the following situations explained the extent of multiple biographical influence on the response: 1) one or the other biographical variable completely explained the biographical influence on the question of interest, 2) both biographical variables simultaneously influenced the response to the question but were independent of each other, 3) one or the other biographical variable influenced the response to the question while accounting for a high degree of dependence between them, or 4) both biographical variables influenced the response to the question while accounting for a high degree of dependence between them. Statistical calculations were conducted with the Loglinear option of STATISTIX (Nimis and Heisey 1985).

RESULTS AND DISCUSSION

Of 229 questionnaires mailed, 138 (60.3%) were returned by the growers. Of that number, 11 were excluded because those individuals had moved (5 individuals), were no longer farming (4 individuals), or were deceased (2 individuals). Of the usable questionnaires, 24 were returned from Big Horn, 61 from Park and 42 from Washakie Counties. The proportion of questionnaires returned was equivalent among counties (chi-square =

2.34, $P = 0.31$, df=2)

Biographical Influence on the Biographical Variables

Prior to testing for biographical influence on grower response to the questions, the biographical variables were tested for influence on themselves. Each biographical variable was influenced by one or more of the other biographical variables (Table 1). Examination of each instance in which biographical variables influenced other biographical variables indicated that most growers from Park County contracted their sugar beets to Western Sugar company, Big Horn County growers contracted their sugar beets to Western Sugar or to both companies, and the Washakie County growers contracted their sugar beets to Holly Sugar. In addition, number of sugar beet acres produced by the respondents depended on their age, with the younger growers producing small sugar beet acreages (Fig. 1). Acres of sugar beets grown also depended on the company to which sugar beets were contracted, with Western Sugar growers producing all of the smallest acreages and Holly Sugar growers producing the majority (75.1%) of the largest acreages (Fig. 2). Age of respondents also was related to the number of years farmed, with the older respondents having farmed more years than the younger.

Table 1. Chi-square statistics and degrees of freedom associated with biographical variables (county, company, years farmed, age, and acres of sugar beets grown) as influenced by other biographical variables.

	Biographical Variable				
Biographical Variable	**County**	**Company**	**Years Farmed**	**Age**	**1988 Acres of Beets Grown**
County	–				
Company	150.11^{a}_{4}	–			
Years farmed			–		
Age			120.85_{4}	–	
1988 acres of beets grown	37.75_{8}	35.80_{8}		51.23_{20}	

[a]Chi-square statistics are presented only where the null hypothesis of independence was rejected at the 0.05 type I error level. Subscripted number is the degrees of freedom.

Biographical Influence on the Remaining Questions

Significant biographical influence on grower response to the remaining questions occurred in 14 instances (Table 2). Twelve of these had at least two biographical variables that affected grower responses, and one had five. By far the most frequent biographical variables affecting grower response were the county in which respondents lived (COUNTY) and the company to which they contracted their sugar beets (COMPANY). Because

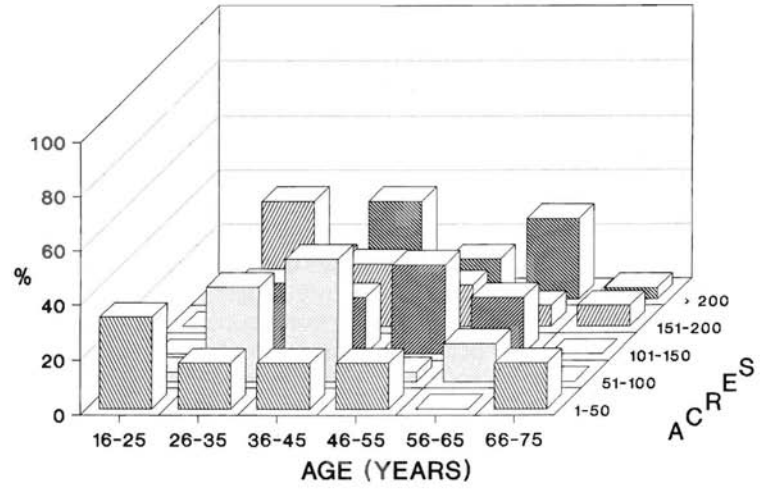

Figure 1. Percent of growers, by age class, and their 1988 sugar beet acreage.

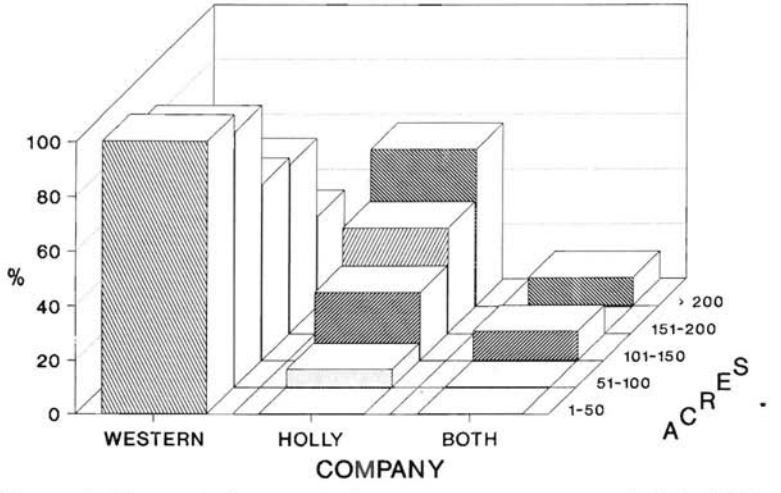

Figure 2. Percent of growers, by sugar company, and their 1988 sugar beet acreage.

these two variables constituted the large majority of multiple biographical influences on questionnaire responses, they were the sole object of log-linear analyses.

Log-linear analyses of the 12 instances in which both COUNTY and COMPANY influenced the grower response indicated that, in every case, either COUNTY or COMPANY influenced the response when accounting for a high degree of dependence between them. This result indicates that COUNTY and COMPANY are highly dependent on one another and that their influence on grower response to various questions was essen-

Table 2. Chi-square statistics and degrees of freedom (subscripts) associated with questionnaire responses that were significantly ($P<0.05$) influenced by the biographical variables (county, company, years farmed, age, and acres of sugar beets grown).

Question	County	Company	Years Farming	Age	1988 Acres of Beets Grown
Goals for producing sugar beets:					
primary goal				48.94_{25}	
secondary goal	18.33_{10}	20.99_{10}			
Current IPM practices used:					
Regular scouting for diseases insects and weeds	6.00_2	7.44_2			
Nematode population assessment	37.50_2	35.12_2	10.28_3	14.67_5	21.42_4
Use of resistant varieties	14.18_2	12.45_2			
Use of crop rotation	6.97_2	7.08_2			
Perceived greatest management and pest problems:					
Greatest problem	46.03_{14}	43.00_{14}			
Primary disease problem	34.00_6	19.31_6			
Secondary disease problem	35.39_{10}	34.20_{10}			
Effectiveness of Beet Leafhopper Monitoring Program	21.04_4	27.30_4			
Needs for and worth of additional IPM information:					
Nematode management	10.64_4	10.51_4			
Insect management			13.86_6		
Crop rotation	12.72_4	10.43_4			
Use of a computer in farming	7.34_2	7.54_2			

tially equivalent.

While influence of COUNTY or COMPANY on grower's responses was quite strong, highly dependent on one another and explained identical variances in the model, they do not infer cause and effect; hence, their influences are inseparable.

Goals of Beet Producers

The majority of respondents indicated that their primary goal for producing sugar beets was maximum sugar production per acre while keeping production costs as low as possible (range: 61.5 - 80.0%). Age group, however, had a significant influence on the response to this question. This was caused by a relatively high response (11.8%) from producers in the 56-65 age group who indicated that their primary goal was maximum sugar pro-

duction per acre while disregarding production costs. This response was much higher than those from the other age groups (range: 0.0-2.8%).

Responses concerning the second most important goal indicated that Park County/Western Sugar growers both wanted to produce maximum sugar per ton of sugar beets while keeping production costs as low as possible (37.0 and 39.7%, respectively), and to take care of their land (33.3% for each). Although responses for counties and companies are reported separately, the effects of COUNTY and COMPANY are statistically inseparable; these are joined by a slash (/) to indicate this fact. Big Horn County producers wanted to obtain maximum sugar yield per ton of sugar beets while minimizing production costs (50%). The majority of Washakie County/Holly Sugar producers (44.0% for both), however, indicated that taking care of their land was their second most important goal. Respondents' choice for their third most important goal indicated that they have a great deal of concern for taking care of their land (47%), and for maintaining the farming tradition, a family heritage or way of life (33%).

Perceived Pest Management and Production Problems

Both COUNTY and COMPANY had a significant influence on growers' perception of the most serious pest management and production problems. Nearly half of the growers in Park and Big Horn Counties felt that weeds were the most serious pest problem whereas 10% or fewer felt that diseases were their most pressing concern (Table 3). In contrast, a majority of sugar beet growers in Washakie county regarded diseases as the most important problem; 20% felt that weeds were the most important problem. Responses on queries to the second and third most serious management problems indicated that weeds (26%), insects (23%) and diseases (17%) were of second most concern while insects (18.6%) and diseases (17.6%) were of third most concern.

Table 3. Percentage response of growers, by county and sugar company, on their most serious pest management or sugar beet production problem.

Response	Park County	Western Sugar	Big Horn County	Both Companies	Washakie County	Holly Sugar
Weeds	47.2	47.0	45.0	42.9	20.0	20.0
Diseases	7.5	7.6	10.0	14.3	56.8	56.7
Variety Selection	3.8	3.0	0.0	0.0	3.3	3.3
Soil fertility	18.9	16.7	5.0	0.0	3.3	3.3
Insects	1.9	3.0	10.0	14.3	6.7	6.8
Economics of pest management decisions	15.1	15.2	10.0	0.0	3.3	3.3
Crop rotation	3.8	3.0	0.0	0.0	3.3	3.3
Availability of arable land	0.0	0.0	0.0	0.0	0.0	0.0
Irrigation management	1.9	4.5	20.0	28.5	3.3	3.3

The disparity over the perceived importance of sugar beet diseases between counties in the Big Horn Basin probably reflects the recent history of these counties with respect to disease outbreaks. An epidemic of sugar beet curly top occurred in the Big Horn Basin in 1986, although the disease reportedly was not uniformly present throughout the area. The epidemic was most severe in areas of Washakie and southern Big Horn Counties (D. Roth and R. Tharp, pers. comm.). In contrast, relatively few outbreaks of curly top were observed in central and northern Big Horn and Park Counties in 1986 (D. Roth and D. Lindshield, pers. comm.). Growers' concerns over specific diseases reflect this history: a majority of growers in Big Horn and Washakie counties ranked curly top as their most important disease problem, whereas growers in Park County generally were more concerned about Rhizoctonia root rot (Table 4). Several factors (Bennett 1971) are thought to have been involved in the 1986 curly top epidemic in the Big Horn Basin, including replanting of much acreage resulting in highly susceptible seedlings during leafhopper migration; reduced stands resulting in less shade, an environment more favorable for the leafhopper vector, *Circulifer tenellus* (Baker); and possibly prevalence of alternate hosts and overwintering sites of the curly top virus and vector.

Table 4. Percent grower perception, by county and sugar company, of their first and second most serious sugar beet disease problems.

Disease	Park County	Western Sugar	Big Horn County	Both Companies	Washakie County	Holly Sugar
			First Most Serious Problem			
Rhizoctonia root rot	71.2	57.7	11.1	50.0	15.6	15.6
Cyst nematode	3.4	7.0	16.7	0.0	21.9	21.8
Curly top	25.4	35.2	72.2	50.0	59.4	59.4
Fusarium yellows	0.0	0.0	0.0	0.0	3.1	3.1
Powdery mildew	0.0	0.0	0.0	0.0	0.0	0.0
Cercospora leaf spot	0.0	0.0	0.0	0.0	0.0	0.0
Rhizomania	0.0	0.0	0.0	0.0	0.0	0.0
			Second Most Serious Problem			
Rhizoctonia root rot	15.4	23.4	42.1	14.3	34.4	34.4
Cyst nematode	25.0	21.8	21.0	42.9	37.5	37.5
Curly top	44.2	39.1	21.0	28.6	6.3	6.2
Fusarium yellows	0.0	1.6	5.3	0.0	18.8	18.8
Powdery mildew	15.4	14.1	5.3	0.0	0.0	0.0
Cercospora leaf spot	0.0	0.0	0.0	0.0	0.0	0.0
Rhizomania	0.0	0.0	5.3	14.3	3.0	3.1

Rhizoctonia solani Kühn, the cause of Rhizoctonia root rot, and the sugar beet cyst nematode, *Heterodera schachtii* Schmidt, were recognized throughout the Big Horn Basin as causing significant disease problems though their rank of importance was heavily influenced by COUNTY and COMPANY (Table 4). Perceived risk to these two pathogens is supported by the fact that 75.0, 96.2 and 76.2% of the respondents in Big Horn, Park and

Washakie Counties, respectively, responded that Rhizoctonia root rot or the cyst nematode were among their three most serious disease problems.

We found that some growers perceived the threat of rhizomania, caused by sugar beet necrotic yellow vein virus (BNYVV), as significant enough to be their second (Table 4) or third most (8.2%) important disease problem. While the fungal vector of BNYVV, *Polymyxa betae* Keskin, is present in some soils in the western plains (Langberg and Kerr 1982), BNYVV has not yet been found in any of the western plains states. The difficulty in controlling rhizomania may necessitate taking fields that are infested with BNYVV out of production indefinitely, should an infestation occur. Growers who rated rhizomania as a significant disease problem in our survey likely are expressing concern over such a potentially drastic scenario.

Some growers in the Big Horn Basin rated powdery mildew and Cercospora leaf spot as their second (Table 4) or third most (5.2%) important disease problems. Our perception, and that of plant managers in the Big Horn Basin, is that neither disease represents a significant threat to sugar beet production. Powdery mildew occurs late in the season and with limited severity in the Big Horn Basin, probably because of distance to overwintering sources of *Erysiphe polygoni* DC (Ruppel et al. 1975). Although yield loss estimates for this disease are not available, our observations and those of others (D. Lindshield and R. Tharp, pers. comm.) suggest that the disease occurs too late in the season to be of economic concern. However, the appearance of powdery mildew on leaves has visual impact, and some growers may be alarmed by the sight of this disease. Likewise, the extended periods of leaf wetness necessary for sugar beet leaf infection by *Cercospora beticola* Sacc. (Ruppel 1986) are very rare in the Big Horn Basin due to the dry conditions and widespread use of furrow irrigation. To our knowledge, economically significant outbreaks of Cercospora leaf spot never have been reported in the Big Horn Basin.

Current IPM Practices and Strategies Being Used

Grower use of nine different IPM practices ranged from being highly influenced to not being influenced at all by biographical variables. IPM practices that were used by most growers and were not influenced by biographical variables were annual soil fertility testing (71%) and use of altered planting dates (76.6%). IPM practices that were rarely used and also were not influenced by biographical data were mapping the location of weeds and diseases in each field (9.7%), using economics when making pest management decisions (37.1%) and testing soil moisture for better irrigation management (13.7%).

IPM practices that were influenced only by COUNTY and COMPANY were the use of regular scouting for diseases, insects, and weeds; use of resistant varieties; and crop rotation to help

manage pest problems. Perceived effectiveness of Wyoming's sugar beet leafhopper monitoring program was also influenced by COUNTY and COMPANY (Table 5). The monitoring program, patterned after the sugar beet leafhopper program of California (Bennett 1971), was initiated in 1987 to monitor sugar beet leafhopper populations in weedy and uncultivated areas throughout the sugar beet producing areas of Park, Big Horn, and Washakie Counties. Insecticides are applied to uncultivated areas if sugar beet leafhopper populations are at least 1.0 leafhopper per sweep.

Table 5. Percent grower response, by county and sugar beet company, of various sugar beet IPM actions.

Response	Park County	Western Sugar	Big Horn County	Both Companies	Washakie County	Holly Sugar
Scouting for insects, diseases and weeds	77.0	78.7	78.3	62.5	95.0	95.0
Use of resistant varieties	62.3	65.3	78.3	75.0	95.0	95.0
Use of crop rotation	98.4	97.3	82.6	75.0	92.5	92.5

Differences in scouting as influenced by COUNTY and COMPANY were due to a greater than expected response from Washakie County/Holly Sugar producers who had their fields scouted (95.0%). This response may be compared to those from Park County/Western Sugar producers, Big Horn County producers, and producers who contract their sugar beets to both companies of whom 77.0, 78.7, 78.3, and 62.5%, respectively had their fields scouted. Influence of COUNTY and COMPANY on the use of resistant varieties was caused by a high percentage of Big Horn (78.3%) and Washakie County (95.0%) producers as well as Holly Sugar producers (95.0%) who did use resistant sugar beet varieties. Park County/Western Sugar producers, however, indicated that just 62.3 and 65.3%, respectively, used resistant varieties (Table 5). Influence of COUNTY and COMPANY on use of crop rotation was caused by the relatively low response from Big Horn County producers, and producers who contracted sugar beets to both companies, that used crop rotation for pest management (82.6 and 75.0%, respectively).

Growers who lived in Washakie County and/or contracted their sugar beets to Holly Sugar (78.1% for both) as well as those who contracted their sugar beets to both companies (75.0%) believed that the sugar beet leafhopper monitoring program prevented yield loss from curly top. However, just 33.3, 29.7 and 39.1% of those who lived in Park and Big Horn Counties or who contracted their sugar beets to Western Sugar, respectively, believed that this program was effective.

Responses to cyst nematode population assessment were influenced by all biographical variables (Table 6). Differences in nematode population assessment due to COUNTY and COM-

PANY were caused by a low number of Park County/Western Sugar producers who assessed soilborne nematode populations as compared to a high number of Washakie County/Holly Sugar producers who made such assessments.

Table 6. Percentage of growers who assessed soilborne populations of cyst nematode, by county, sugar company, number of years farmed, 1988 acres of sugar beets grown and age.

County	Response	Company	Response	Number of Years Farmed	Response	1988 Beet Acreage	Response	Age (years)	Response
Park County	16.4	Holly Sugar	77.5	1-10	10.4	1-50	0.0	16-25	0.0
Big Horn County	39.1	Western Sugar	21.3	11-20	35.4	51-100	12.3	26-35	26.1
Washakie County	77.5	Both Companies	25.0	21-30	6.3	101-150	20.4	36-45	21.7
				>30	47.9	151-200	6.1	46-55	15.2
						>200	61.2	56-65	34.8
								66-75	2.2

Influence of years farmed on assessing nematode populations was caused by the large percentage of growers who farmed for more than 30 years who checked their nematode populations. Influence of 1988 sugar beet acres on nematode population assessment was caused by the high percentage of growers who produced more than 200 acres and who checked for nematodes. The principal cause for differences in nematode population assessment between age groups was due to a higher than expected response from producers aged 56-65 years who assessed nematode populations.

Worth of and Need for Additional IPM Information

In light of efforts that sugar beet producers and companies have made in implementing IPM, responses concerning the worth of (i.e., willingness to pay) and need for additional IPM information were assessed. We were particularly interested in the growers' need and/or willingness to pay for additional information for topics on which significant IPM efforts are expended, topics on which efforts are not expended, and topics directly related to and consistent with both the perceived problems of growers' operations and their stated goals.

Responses to most topics except nematode management and use of crop rotation were not influenced by biographical data. In addition, few producers indicated that they could not use additional information on most topics.

For most topics that were not influenced by biographical variables, most producers indicated that they needed additional information but few were willing to pay for it. For example, 53.4% of the respondents indicated that they needed more infor-

mation on weed management but just 36.9% were willing to pay for it. In addition, most producers wanted additional information on economics of pest management (66.3%), insect management (61.5%) and irrigation management (53.3%) but just 22.1, 31.3 and 16.7%, respectively, were willing to pay for the additional information. Soil fertility and disease management, however, were two topics on which producers needed additional information (45.3 and 54.3%, respectively) and were willing to pay for it (42.1 and 42.9%, respectively).

Influence of COUNTY/COMPANY on the need for additional nematode management information was caused by a large response (46.7%) from Washakie County/Holly Sugar producers who were willing to pay for this information (Table 7). This may be contrasted to the response from Park County/Western Sugar producers, Big Horn County producers, and those who contracted sugar beets to both companies, of whom just 16.0-28.6% were willing to pay for such information. COUNTY/COMPANY influence on crop rotation could not be identified with any one group.

Table 7. Percent grower perception, by county and sugar company, of the need for and worth of additional IPM information on nematode management and crop rotation.

Need	Worth	Park County	Western Sugar	Big Horn County	Both Companies	Washakie County	Holly Sugar
			Nematode Management				
Yes	will pay	17.1	16.0	18.8	28.6	46.7	46.7
Yes	Will not pay	51.2	56.0	62.5	57.1	43.3	43.3
No	n/a	31.7	30.0	18.8	14.3	10.0	10.0
			Crop Rotation				
Yes	will pay	12.7	10.7	0.0	0.0	0.0	0.0
Yes	Will not pay	51.1	48.2	43.8	57.1	79.3	79.3
No	n/a	36.2	41.1	56.2	42.9	20.7	20.7

Given the perceived need for additional information on soil fertility, we expected to see an equivalent importance placed on irrigation management because the amount and availability of several soil nutrients is closely related to water movement through the soil (Duke and Scott 1987). This, however, was not the case.

Essentially all water that is supplied to sugar beets in the Big Horn Basin during the growing season is through irrigation. Failure to supply the proper amount of water to the proper soil depth at the correct times wastes valuable water and soil nutrients and may contribute to increased levels of subsoil water contaminants. However, we could not determine whether the responses to this topic reflected a fundamental failure to relate good irrigation management with soil fertility or a confidence among growers in their ability to closely monitor and manage water.

Economics of pest management decisions was identified as a topic on which more information was needed (66.3%) but was not of high worth, inasmuch as 22.1% of the producers indicated a willingness to pay. This result was not consistent with the clearly stated primary goal of producing as much sugar per acre while keeping costs as low as possible. Presently, we have no explanation for this apparent discrepancy.

Sources of Sugar Beet IPM and Production Information

Producers indicated that the sugar beet company employees (agriculturists) who scout their fields, identify pest management and production problems and make management recommendations were the primary sources of information about sugar beet IPM and production (72.3%). After the agriculturists, producers consulted chemical company sales representatives (21.1%) and farm supply dealers (19.0%). The third most frequently used information source included neighbors (18.5%), chemical company sales representatives (16.3%) and Wyoming Weed and Pest District Supervisors (14.3%). University of Wyoming Cooperative Extension Service County Agents and Specialists were identified by few producers as a source of sugar beet IPM and production information, as were the university Cooperative Extension publications.

One reason why most sugar beet producers do not make use of university Cooperative Extension publications may be the paucity of such publications on sugar beets. A survey of available University of Wyoming Cooperative Extension publications (bulletins, research journals and miscellaneous publications) indicated that just 7 of 142 (4.9%) were on sugar beets, whereas 9 (6.3%) were on wheat and 12 (8.5%) were on alfalfa. Some publications (19%) provided information on non-crop topics, such as the robber flies of Wyoming, while the majority (31%) provided information on lawns, gardens, and horticulture.

A high percentage (66.4%) of responding sugar beet producers have touch-tone telephones, but those who use computers on their farms varied from the Park County/Western Sugar producers (32.0 and 31.6%, respectively) to the Washakie County/Holly Sugar producers (just 9.8% for each). Thus, delivery of information to producers may be accomplished through computers or other equipment that is activated by a touch-tone telephone. Also, development of information delivery and decision-support software for producers' computers may be warranted.

Grower Interest in the IPM Program and Cooperative Research

Most producers (78.3%) were interested in learning more about a proposed sugar beet IPM program; however only 37.3% were interested in cooperative research with the University of Wyoming.

Design of an IPM Program for the Big Horn Basin

From the questionnaire's results, we conclude that the design of any IPM program in the Big Horn Basin must be flexible so that pest management and production problems may be separately addressed for Park County/Western Sugar, Big Horn County and Washakie County/Holly Sugar producers. Such a program should focus on educational programs and research projects, because the company agriculturists already concentrate on scouting. Emphasis should be placed on management of key pests such as curly top, sugar beet leafhopper, Rhizoctonia root rot and cyst nematode, and weed management, soil fertility and irrigation management. Research efforts should be directed towards determining the economic impact of these pests and production problems and the economic returns gained (or lost) by various management decisions. Because some growers are now using computers in their sugar beet production operation, software development that would deliver information to and aid growers in their decision-making could help provide them with a competitive edge in their sugar beet-producing operations.

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