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IMPACT ASSESSMENT OF AN IPM RESEARCH AND EXTENSION PROGRAM IN COTTON

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Abstract

The utilization and adoption of the Land Grant University's extension and research program is a fundamental part of the South Carolina cotton IPM program, and is significant in the enhancement of a sustainable cotton industry within the state. The program's research and extension objective is to convey marketable benefit to the growers in the form of enhanced production and quality; reduction in the use of pesticides; and reduction of variable input costs.

To determine the extent of grower adoption of the IPM program and the benefits that they incurred, a mail survey was sent to all cotton growers to examine the utilization of the IPM program. Survey respondents helped us characterize the distribution of IPM adoption by growers within the state.

Introduction

Today State IPM Coordinators and IPM program evaluators face a mounting demand for information on the payback stemming from the outlay of public monies to IPM programs and as a result earlier methods of appraising the State IPM programs now have to be amended. There is a vital need for assessment programs to measure the level of grower adoption of IPM methods that have been established and publicized by state IPM programs, and to measure the returns to growers from the public monies invested by the state in IPM research and extension programs. The Government Performance and Results Act (GPRA) has set out new and more rigorous requirements for reporting on state IPM programs, thus making accountability for these monies even more important. Annual reports for the state IPM program now need to include specific data on grower implementation of IPM, pesticide use, yields, etc. In conjunction with the new state requirements, there is now a need to measure the financial returns to publicly subsidized IPM research and extension programs. Information of this type will help in tackling grower concerns about the effectiveness of implementing IPM practices, and at the same time will help in recognizing the program components or projects that do not provide payoffs.

Since IPM programs rely on a multiple of dynamic biotic and abiotic relations in the agricultural environment, the importance of the land grant university research and extension program has been vital in establishing IPM protocol and the ensuing dissemination of that information and technology to the public. With the numerous changes in cotton pest management technology and practices that have occurred in the past two decades, the crop provides an ideal model for such program evaluation. This has been demonstrated with the South Carolina Cotton IPM Program, which has made available regularly updated pest management guidelines to keep pace with rapid advances in new technology in the cotton industry.

Regrettably, the successes of IPM research and extension personnel are not always acknowledged except when a publicized economic value is attributed to such IPM programs. Numerous economic evaluations of IPM programs have been carried out. They have typically focused on changes in pesticide use, production costs and yields, and have made comparisons in the net returns between users and non-users of IPM programs. Despite the fact that most of this work has reported a positive change in net returns to growers using recommended IPM practices, there has been limited work carried out to determine whether transformation of farmers practices towards IPM resulted from IPM research and extension programs.

Therefore, this project is focused on three questions;

1. What is the level of IPM practiced by growers?
2. What are the benefits to cotton producers who have adopted IPM practices? and,
3. To what degree has the level of IPM adoption and associated benefits been influenced by the state land grant university research and extension programs?

Methods

Data

A list of all the commercial cotton growers in South Carolina was compiled from the states mandated Boll Weevil eradication program. This program requires all cotton growers in South Carolina to register with the Department of Plant Industry in the Division of Regulatory and Public Services, Clemson University, for an annual permit to enable efficient monitoring for the potential threat of boll weevil infestation.

The survey was designed with questions focusing on all areas of cotton production within South Carolina, and was planned with the input from three Clemson experts in the cultivation of cotton . The procedures were based on methods standardized by Dilman (1978).

The survey consisted of 6 sections primarily made up of closed ended questions in which growers had to indicate how frequently they carried out a practice. A number of open ended questions were included to determine the growers understanding of the concept of IPM and to determine what areas the Extension service needed to address to improve the growers business. A summary of the questions can be seen in Table 1, and a complete copy of the questionnaire is available from the author.

Assignment of IPM Categories

As the surveys were received the information was collected in a Microsoft Access database for analysis. The growers' responses were used to provide a summary of the degree of IPM used. Since a level of IPM adoption cannot be based on a single practice or aspect of the crops production, a system was developed to look at and weight the combination of practices carried out by the growers. The measurement method involved quantifying management IPM practices through a weighted analysis. This presented a means for analyzing the impact of the complete integrated pest management system on individual farms (Bauske *et al*. 1998).

Distinctive differences were determined by means of a weighting system that was assigned to each IPM practice that was asked of the grower in the questionnaire. Values assigned to questions were based on its perceived level of IPM importance assigned to it by the state experts (i.e 1= low IPM significance; 4 = high IPM significance). The IPM experts assigned higher weights to the IPM practices that they felt were more important. It was decided that the members of the state cotton program had considerable expertise in their relative fields and that their information had been incorporated into the survey through this weighting system. Growers then received points based on the frequency with which they carried out each practice (i.e., never = 0, seldom = 1, often = 2, always = 3). In the database each weighted question was automatically multiplied by the frequency value selected by the grower. These products were summed for each section and as an overall total to arrive at a section and total survey score, respectively. Categories were determined for low, medium and high IPM adopters using the question weighting and the frequency scores. It was decided to assign categories by the weighting system because this would be more representative than arbitrary percentage rankings.

Results and Discussion

A total of 162 growers replied to the cotton survey. The majority of the respondents (67%) were sole owners of the farm, 28% indicated that they were partners in the farm while less than 5 % indicated that they were employees. The average number of acres of cotton grown in 2001 was 516 acres, with the smallest farmer growing 6 acres and the largest growing 3050 acres.

The overall level of IPM adoption by the growers was the foremost reason of this survey. These results would then be used to determine the impact or influence that the Land Grant University in South Carolina has over the IPM decisions made by a grower. The results of the survey indicate that research and extension is important for South Carolina cotton growers in their decision-making and consequently their involvement in IPM practices. A summary of the scores associated to the survey and the total assigned IPM ranking scores and their associated categories of either low, medium or high IPM ranking are shown in Figure (1). These results indicate an encouraging overview of the IPM practices being carried out within South Carolina. A score of between 0 – 165 placed a grower in a low IPM ranking, 166 – 330 placed a grower in a medium IPM ranking and 331 – 495 ranked a grower in the high IPM ranking.

The majority of growers (80%) fell into the medium IPM ranking with the remaining 20% attaining scores that place them in the high IPM ranking. None of the growers' scores fell within the low IPM score range. The highest score achieved by a grower was 415 of a total possible score of 495, and the lowest score was 190.

The level of IPM adoption in each section of the questionnaire was also examined to determine if there was any variation in the level of IPM approach among different practices. Table 2 shows the growers scores for all the sections in the questionnaire. In the cultural and management practice sections a score of "0 –30" placed a grower in a low IPM ranking, a score of "31 – 60" in the medium IPM ranking, and a top score of "61- 90" put a grower in the high IPM ranking. For the chemical usage and chemical application practice sections a score of "0 –46" placed a grower in a low IPM ranking, a score of "47 – 92" in the medium IPM ranking, and a top score of "92 - 138" put a grower in the high IPM ranking.

In all the sections the majority of growers fell into the medium or high IPM ranking. This was consistent with the overall IPM ranking (Figure 1) in that the greater part of the survey population fell into the same respective categories. Apart from the cultural practices category, most of the categories shared a comparatively even split between the percentage of medium and high adopters. The major difference in the cultural practices was that the majority of growers (87%) fell into the medium ranking, indicating they "often" used IPM practices while only 7% indicating they "always" used IPM practices. In the management practices, chemical usage and chemical application sections the differences between the two levels was closer with each section attaining grower percentages in the medium and high ranking of; 54% and 41%, 60.5% and 37%, and 46.5% and 52%, respectively.

To determine how much influence the extension program had with the farmers, growers were asked if they followed some of the more important IPM practices recommended by the University. Table 3 shows the level of adoption by the growers on some of the more important recommended IPM practices, namely chemical programs, insect thresholds and best management practices.

The majority of growers indicated that they followed the extension guidelines for chemical treatments "often" or "always" (71 % and 17.9%, respectively). Similarly, 66.7% "often" and 26.5% "always" followed the university insect threshold levels, while, 58% and 13% "often" or "always" respectively, followed the best management practices set out by the university. There is therefore a definite dependency by the South Carolina growers for information from the states extension and research experts and this shows that there is a high degree of influence and interaction by the land grant university's extension and research programs and the grower. Despite this very positive outcome there would be no incentive for growers to adopt these recommended practices unless there is a benefit derived from the IPM program. .

Therefore, the average yields of the growers who "never", "seldom", "often" and "always" used the university's recommendations for chemical programs, insect threshold levels and best management operations were compared (Figure 2). Growers who "often" or "always" followed the extension recommendation for chemical program and insect threshold levels attained higher yields than those who "never" or "seldom" used these recommendations. However, growers who "seldom" or "often" followed best management recommendations obtained higher yields. The latter results possibly indicate an area for further research by the university.

Variety choices play a significant role in cotton IPM programs. Despite some notable limitations with the biotechnologically derived cotton, such as the inability of the *Bt* toxin in Bollgard to successfully control high populations of bollworm, these varieties have a significant impact in low and medium insect population pressures. In conjunction with these benefits the Bt toxin has been shown to have excellent control against some of the other key pests such as tobacco budworm and pink bollworm (Gore *et al*. 2001). Therefore, the new genetically modified varieties offer the grower new methods to manage pest threats. Cotton varieties stacked with the Bollgard insect resistance gene and a herbicide tolerance gene (specifically the Roundup Ready ® gene), have been available in the United States since 1997, and tend to be the primary choice of variety by the growers. Figure 3 illustrates the significant role that GM varieties play in the state's IPM program. Approximately 58% of South Carolina cotton growers select stacked varieties. These stacked varieties effectively control and reduce pesticide applications and therefore play a beneficial role in the states overall IPM strategy because they allow growers to substantially reduce the negative impacts of certain biotic factors. Therefore, this promotes crop profitability and improved environmental health through the reduction of harmful pesticide applications (Edge *et al*.2001). Varieties with either the Bollgard insect resistance gene only, or the Roundup Ready® tolerance gene only, constitute approximately 2.3% and 27% of the acreages grown, respectively. Consequently nearly 87 % of all the cotton grown in South Carolina is genetically modified compared to 13% for conventional varieties. The top three varieties grown in 2001 (Table 4) were DPL 458BGRR, DPL 5415RR,and Stoneville 4892BGRR with percentages of the total acreage of 15.64%, 14.22% and 13.74% respectively.

Unlike the new technology of GM varieties, scouting is not a new tool, however it does enable growers to accomplish a higher degree of precision when it comes to their pest management. The majority of growers (78.4%) "always" scout, for insect pressure (once a week or more), while the remaining growers (19.2%) indicated they "often" survey for insects. This trend continued through in surveying for weeds 51% and 36% respectively, and in the surveying for diseases 48% and 26 %, respectively. Insect scouting was perceived by the growers to be the more important scouting practice, with 98% of growers indicating that they either "often" or "always" scouted for insect pests. This was more prevalent than the scouting for weeds (87%) and for disease (74%), although both of the fore-mentioned are regarded as serious threats (Figure 4).

In addition, most growers indicated that they pay for professional scouting or will scout their fields themselves rather than relying on employees or industry personnel (Figure 5). Over 60 % of growers indicated that they would pay for a professional consultant to carry out scouting on their farm and over 80 % indicated that they would never rely on an employee to carry out their scouting. This is probably because growers realize that the additional total season cost of an intensive scouting program is far less than the cost of a single insecticide application, and inadequate scouting results in insufficient information for a treatment decision. Significant economic loss can occur when a damaging infestation is not detected in a timely manner. Therefore, the majority of growers are willing to pay increased scouting fees in return for more detailed and/or more frequent scouting information, in an effort to reduce the rising costs of control.

Insect pests remain the most significant problem that growers encounter in the production of their cotton crop. Growers reported that stink bug (71%) was the major pest, while 61% reported bollworm, 32% budworm, and 19% thrips were their major pests (Table 5). This is possibly a negative spin off of the introduction of Bt varieties into the commercial market, i.e. it has lead to the increase in damage by some secondary pests, especially stink bugs. Previously, this pest was typically held to sub-threshold levels in conventional cotton that had been treated with insecticide sprays for bollworms.

A possible means to controlling this pest lies in cultural practices that promote early maturity. Providing stink bugs older, damage-resistant bolls, is the primary defense against this pest. One such practice is early planting, but only 44% of growers indicated that “often” or “always” adjust planting dates to reduce pest damage. Similarly, another defense mechanism lies in the well-calculated use of nitrogen to limit plant height and to promote earlier maturation, but 46% of growers said they “never” and 35% said they “seldom” adjust their fertilizer rates to reduce potential for pest damage.

After stink bugs, bollworm and budworm are considered to be the next major threat to production despite the high use of GM varieties. Research suggests that release of Bollgard II varieties will reduce this problem.

An interesting fact derived from the survey was that, overall, there was no considerable difference between the mean numbers of chemical applications carried out for the growers who were classed as high IPM adopters compared to those who were classed as medium IPM adopters (Table 6). This indicated that the other IPM practices asked of the growers in the survey resulted in the differing scores in the overall IPM ranking (Figure 1). The mean number of applications was consistent, thus indicating that growers followed the land grant universities recommendations in regards to chemical applications.

In order to determine what the relationship of the respondent to the farm or cotton crop could have on the level of IPM adoptions, the frequency that the key IPM practices were carried out with was compared to the respondents’ relationship to the farm. The majority of the respondents were either sole owner or partners; there was no other significant category. The frequency that a grower utilized the land grant university recommendations for chemical recommendations, threshold levels and best management practices respectively was determined (Table 7, 8 and 9). In all three of the IPM disciplines there was relatively little difference between either type operators (owners, and partners). Similar percentages in both groups “often” utilized the land grant university information. A greater percentage of sole owners “always” carried out the recommended practices compared with those that are in partnership, (31% versus 8.9%, 30.6% v ersus15.6% and 15.7% versus 6.7% for chemical recommendations, insect threshold levels and management practices, respectively).

Comparing grower returns above the variable costs (Table 10), it was found that adopters of Bt cotton appear to have significantly higher yields than nonadopters and yield differences between adopters and nonadopters of herbicide-tolerant cotton are significantly lower in the adopters’ category. These findings are comparable to the outcomes of work carried out by (Culpepper and York, 1998; Marra, Carlson, and Hubbell, 1998), in which it was found that the adoption of the herbicide-tolerant varieties did not necessarily translate into yield gains. Alternatively, Klotz-Ingram *et al.* (1999) reported cases where adopters of Bt cotton appear to have statistically significantly higher yields than nonadopters.

Despite the similarities in these findings further study that considers the yield differences that can be attributed to the various exogenous factors, some of which include irrigation and weather (USDA, 1999), may be a more exact procedure for determining yield impacts.

Conclusions

This survey research clearly showed that farmers in South Carolina are strongly influenced by the land grant university’s IPM research and extension programs, and that many of the growers’ decisions are based on data generated through the personnel involved with these programs.

Although the survey did not look at the philosophical attitudes of the growers towards IPM practices, the methods and questions used enabled the quantification of the growers’ practical approaches towards the growing of their cotton crops. An approach of this nature ensures greater reliability of information since respondents are able to accurately and completely measure the practices they used.

Future work can look at the philosophical attitudes of the growers towards IPM practices, and compare them to the actual practices carried out by the growers.

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Table 1. Survey Questions.

Section	Description
1) Demographics	The first section focused on questions about the farm and grower (i.e., county, farm ownership, age, gender, acreage, varieties grow).
2) Cultural practices	Section 2 focused on questions about cultural practices used with specific attention on those that would reduce the reliance on inorganic compounds
3) Management practices	This short section was focused on the record keeping qualities of the grower along with pertinent scouting questions.
4) Chemical usage	Section 4 was used to determine number of pesticide applications and combining of cultural practices in the chemical application.
5) Chemical Application	Section 5 was used to determine grower practices in applying chemicals.
6) Other	This section was used to determine any other relevant information that did not pertain to the other section (general open ended questions).

Table 2. Grower scores for the main sections in the questionnaire.

Questionnaire Sections	Integrated Pest Management Ranking					
	% Growers	Low IPM Score	% Growers	Medium IPM Score	% Growers	High IPM Score
Cultural Practice	6	0 - 30	87	31 - 60	7	61 - 90
Management Practices	5	0 - 30	54	31 - 60	41	61 - 90
Chemical Usage	2.5	0 - 46	60.5	47 - 92	37	92 - 138
Chemical Application	1.5	0 - 46	46.5	47 - 92	52	92 - 138

Table 3. Level of grower adoption of IPM practices (%) as advised by the Land Grant University.

Recommendations Followed	Never	Seldom	Often	Always
Chemical Programs	3.1	8.0	71.0	17.9
Insect Threshold Levels	2.5	4.3	66.7	26.5
Best management Practices	8.0	21.0	58.0	13.0

Table 4. Top 10 Variety Technology as a percentage of the total acreage reported in SC crop.

Stacked (BG/RR)		Roundup Ready® (RR)		Bollgard (BG)		Conventional	
VARIETY	*%*	*VARIETY*	*%*	*VARIETY*	*%*	*VARIETY*	*%*
DPL458BGRR	15.64%	DPL5415RR	14.22%			PSC355	3.32%
STONEVILLE4892BGRR	13.74%	DPL5690RR	4.27%				
DPL451BGRR	6.87%	STONEVILLE 4793RR	2.61%				
SUREGROW501BGRR	5.92%						
DPL655BGRR	2.84%						
SUREGROW521BGRR	2.84%						

Table 5. Major problems faced by South Carolina cotton growers.

	1st		2nd		3rd		4th	
Problem	**Type**	*%*	**Type**	*%*	**Type**	*%*	**Type**	*%*
Insects	Stink Bug	71%	Bollworm	61%	Budworm	32%	Thrips	19%
Pathogens	Seed Borne	23%	Nematodes	12%	Boll rot	6%	Viral	2%
Other	Water	64%	Weed control	19%	Yields	11%	Prices/Input costs	11%

Table 6. Mean IPM score related to number of pesticide applications.

	IPM Score		Insecticide		Herbicide		Fungicide	
Overall IPM Ranking	**Mean Score on Survey**	**SD**	**Mean no. of applications**	**SD**	**Mean no. of applications**	**SD**	**Mean no. of applications**	**SD**
Medium	283.8	31.9	2.6	1.5	2.7	1.2	0.3	0.5
High	356.1	24.3	2.5	1.2	2.7	1.3	0.4	0.5

Table 7. Ownership type percentages and utilization of land grant university chemical recommendations.

Ownership	**Sole Owner**	**Partner**	**Sole Owner**	**Partner**	**Sole Owner**	**Partner**	**Sole Owner**	**Partner**
Selection	Never		Seldom		Often		Always	
Percentage	2.8	2.2	6.5	8.9	69.4	75.6	31.0	8.9

Table 8. Ownership type percentages and utilization of land grant university insect threshold levels.

Ownership	**Sole Owner**	**Partner**	**Sole Owner**	**Partner**	**Sole Owner**	**Partner**	**Sole Owner**	**Partner**
Selection	Never		Seldom		Often		Always	
Percentage	2.8	2.2	3.7	4.4	63.0	77.8	30.6	15.6

Table 9. Ownership type percentages and utilization of land grant university best management practices.

Ownership	**Sole Owner**	**Partner**	**Sole Owner**	**Partner**	**Sole Owner**	**Partner**	**Sole Owner**	**Partner**
Selection	Never		Seldom		Often		Always	
Percentage	5.6	8.9	21.3	24.4	57.4	60.0	15.7	6.7

Table 10. Yield, revenue, variable costs, and returns above variable costs, per acre, by seed technology.

Technology	**Break-Even Yield**	**Average Yields lbs/acre)**	**Revenue @ 0.65 $/lb ($/acre)**	**Variable Costs ($/acre)**	**Returns above VC ($/acre)**
Bt	535	839	545-35	411-50	133-85
BtRR	533	752	492-56	410-40	82-16
RR	534	715	468-33	411-04	57-29
Conv	526	778	509-59	413-35	96.24

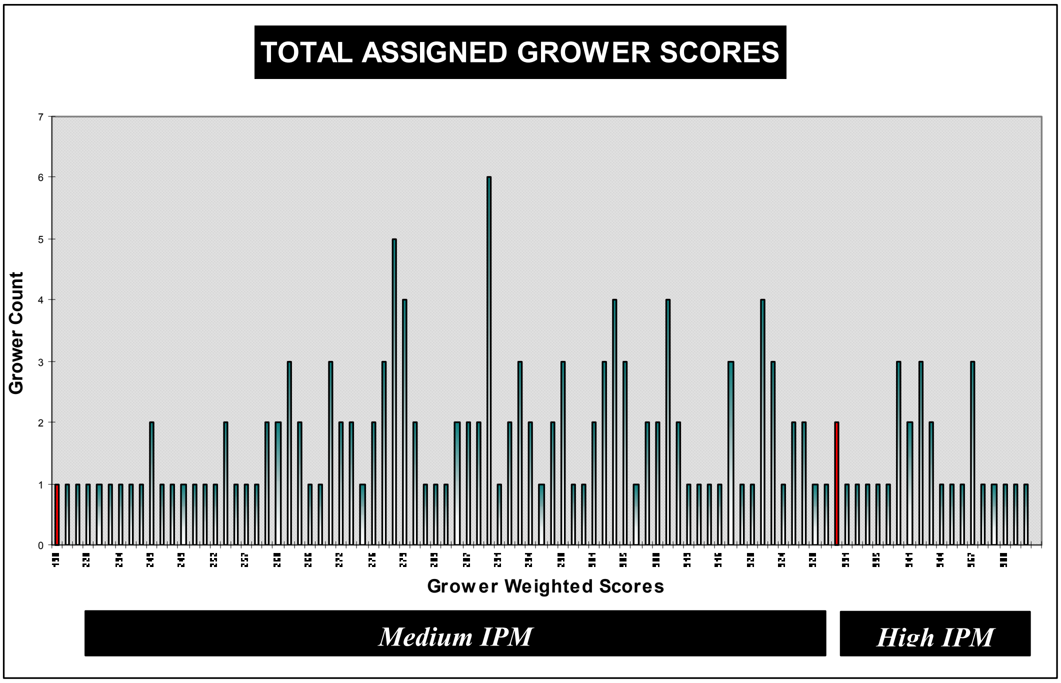
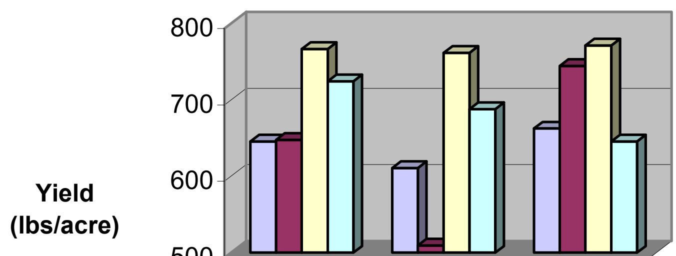


Figure 1. Level of IPM adoption in cultural practices by SC cotton growers.



	Chemical Programs	Insect Threshold Levels	Best Management Operations
Never	646	611	663
Seldom	648	510	744
Often	767	762	771
Always	724	688	646

Figure 2. Level of Grower Utilization Of Clemson Extension Recommendations and their Associated Average Yields.

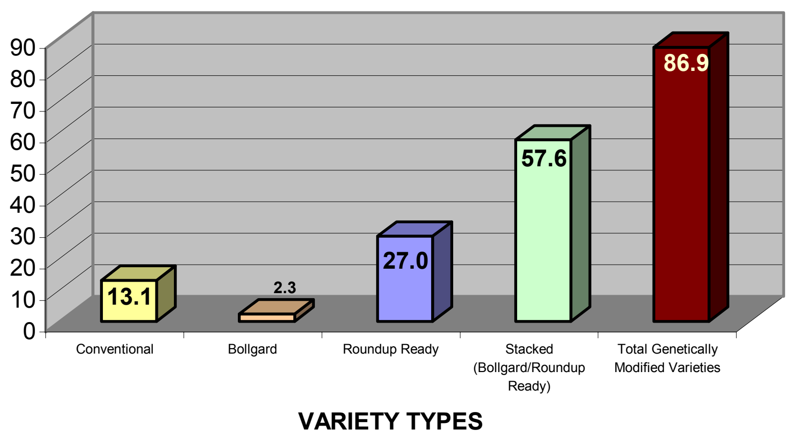


Figure 3. Variety Technology as a percentage of the total acreage reported.

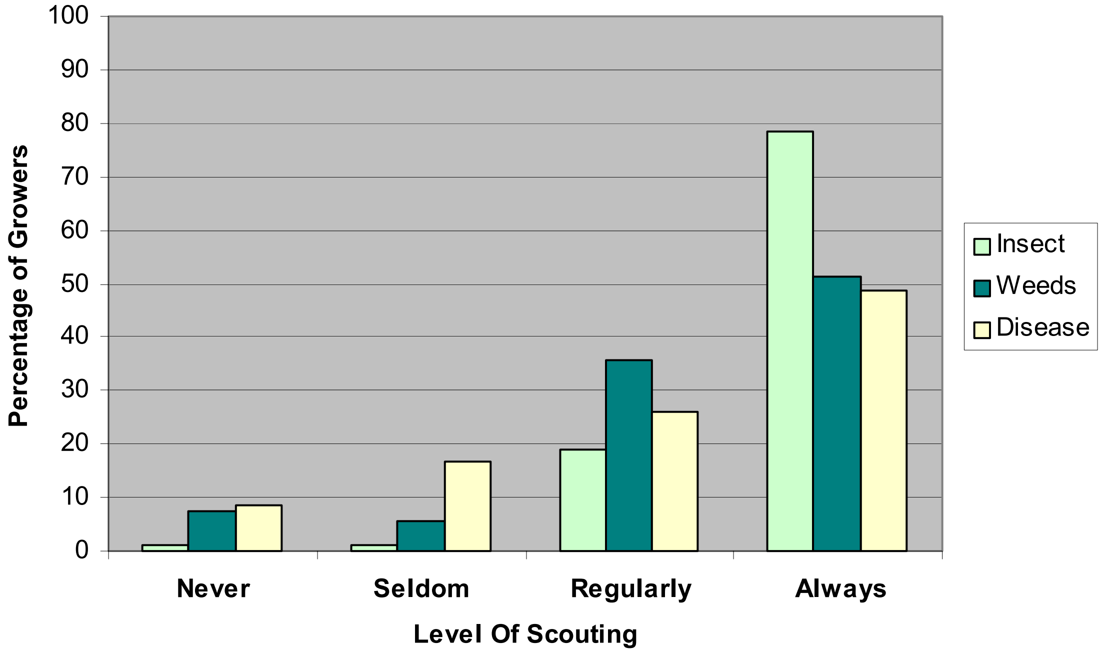


Figure 4. Frequency of scouting (once or more a week) for insect, weed and disease pressure.

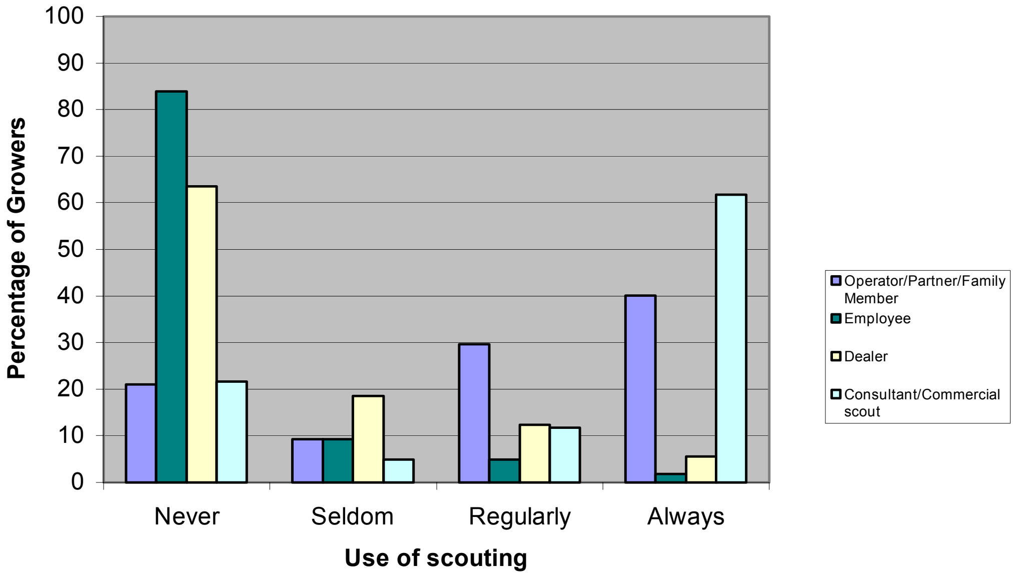


Figure 5. Personnel involved in the scouting operations.