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Potential miscanthus' adoption in Illinois: Information needs and preferred information channels

María B. Villamil[a,b,*], *Anne Heinze Silvis*[a], *Germán A. Bollero*[b]

[a]*Department of Human and Community Development, Laboratory for Community and Economic Development, 222 Bevier Hall, 905 South Goodwin Ave., Urbana, IL 61801, USA*

[b]*Department of Crop Sciences, University of Illinois, AW-101 Turner Hall, 1102 South Goodwin Ave., Urbana, IL 61801, USA*

ARTICLE INFO

Article history:
Received 3 September 2006
Received in revised form
28 March 2008
Accepted 2 April 2008
Available online 22 May 2008

Keywords:
Miscanthus × giganteus
Bioenergy
Energy crops
Potential adoption
Farmers' needs
Information channels
Survey methodology
Focus groups

ABSTRACT

This study examined farmers' information needs and concerns and preferred information channels regarding the introduction of miscanthus in their current production systems in the state of Illinois, USA. Surveys and focus groups targeted farming populations from Northern, Central, and Southern regions of the state to evidence regional differences. A secondary objective was to identify potential adopters of miscanthus and to asses the level of awareness regarding miscanthus and the associated possibility of receiving carbon credits. Factor analysis, multivariate ANOVA, and categorical data analysis were the selected statistical tools. Only two out of 313 respondents knew about the existence of the crop before completing the survey. Thirty percent of the respondents were identified as potential adopters of miscanthus with the highest proportion of potential adopters found among farmers in the Northern Illinois region. There are clear differences among the information needs of farmers in each region in Illinois as well as in the preferred channels. Information campaigns aimed to increase awareness and education regarding the use of miscanthus as an energy crop in Illinois, should specifically address these regional information needs and channel them through preferred media.

1. Introduction

Adoption of renewable biomass resources can promote the development of sustainable industrial societies through increasing independence from foreign oil sources and mitigation of greenhouse gas emissions [1]. In the US, power from biomass (biopower) is a proven commercial electricity and heat generation option, currently supplying over 3% of the total energy consumption and surpassing hydropower as the largest domestic source of renewable energy [2]. Following federal initiatives, 23 states have passed legislation which ensures that a minimum and increasing amount of renewable energy is included in the portfolio of the electricity resources serving a state.

The state of Illinois requires that at least 5% of the state's energy production and use will be derived from renewable forms of energy by 2010, and at least 15% from renewable forms of energy by 2020. Illinois' dependence on coal for energy, along with the dominance of row cropping systems and the state's climate, set the conditions for the state as one of the most suitable in the US for bioenergy use [3]. Economic analysis of bioenergy crops in Illinois has shown that these crops can be produced at a profit greater than traditional crops at expected levels of production and crop value [3,4].

*Corresponding author. Current address: CONICET—Departamento de Agronomía, Universidad Nacional del Sur, Av. de los Constituyentes s/n, 8000 Bahía Blanca, Argentina. Tel.: +54 0291 459 5126; fax: +54 0291 459 5127.
E-mail address: mbvilla@criba.edu.ar (M.B. Villamil).

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doi:10.1016/j.biombioe.2008.04.002

Miscanthus is receiving increased attention as a dedicated energy crop in the US and Europe, due to its positive input/output energy balance that makes it an ideal biomass crop [3,5,6]. Management factors affecting miscanthus growth and productivity have been recently summarized by Miguez et al. [7]. Yet, the rate of adoption of this bioenergy crop might be slowed by a significant initial investment and delayed economic returns that limit the number of potential adopters to those who can afford the temporary economic hindrance. Nevertheless, adopters of new technologies or innovators have repeatedly shown to be farm operators on highly productive areas with higher incomes and/or larger farms [8].

Yet economic costs and benefits alone are not sufficient to predict the entire adoption decision process. Other characteristics of the innovation (i.e., technical complexity, perceived risk, compatibility with current operation, etc.), of the media of communication (i.e., mass media, other growers, etc.), and of the potential user (i.e., personality variables, needs, interests, etc.) play an important role [9]. In addition, neighbors' opinions, business partners, landlords, lenders, and the family context itself may be expected to constrain the adoption of alternative cropping enterprises [10,11].

The innovation-decision model introduced by Rogers [9] emphasizes the role of information, risk factors, and the social position of the decision maker in the community. The model depicts the adoption of an innovation as spreading among farmers with different predispositions to innovate. Studies have shown that availability of information to producers and the level of education and experience of prospective adopters are better determinants of adoption than income [12–14]. Adopters were more knowledgeable regarding the specific innovation, had a higher educational level, and less farming experience, i.e., were younger, than non-adopters. The innovation-decision process is not passive; it is basically an information-seeking and information-processing activity in which the individual is motivated to reduce uncertainty about the advantages and disadvantages of an innovation [9].

Farmers' perspectives and goals differ from those of researchers or government agencies; therefore, the availability of information must target the producers' needs and concerns regarding the innovation. The inevitable communication resulting from this process would help to identify obstacles to the use of new technology in the early phases of development [15].

Heaton et al. [3] estimated that 'if only 20% of the 110,000 km^2 of total cropland in Illinois were to produce miscanthus they could provide electricity in excess of current state demand'. By the average size of Illinois farms (152 ha), that 20% of total cropland represents up to 14,473 farmers, each allotting 100% of their land area to miscanthus; or 72,365 producers allocating 20% of their land area to miscanthus. According to the USDA, NASS, Illinois Field Office [16], there were 72,500 farms in IL in 2005. To reach this level of adoption, the diffusion strategy must use efficient communication channels appropriate to each stage of the innovation-decision process to transmit the available information on miscanthus production.

Farmers use a wide range of channels for receiving agricultural information; while mass media and face-to-face channels are very important, online methods are increasingly gaining acceptance [17]. In the early stages of the innovation-decision process, mass media is highly useful to create awareness, but it is too general to provide specific how-to answers for which professionals and experienced peers are invaluable sources of knowledge [9]. However, several studies have demonstrated the high variability of preferences of information delivery among farmer audiences, even within relatively small geographic areas [17–21]. At any rate, segmenting this heterogeneous population into more homogenous groups (i.e., by regions) will help increase the efficiency of knowledge communication by targeting each group directly through its preferred channels.

Farmers' acquired knowledge will determine the attitude formed toward the innovation, which in turn will determine the adoption or rejection of the new idea. Perceived need and positive attitudes toward environmentally sound practices have significantly encouraged the adoption of crop rotations [22], sustainable agriculture [23], soil conservation practices [14], and best management practices in dairy farms [24].

Given the significance of knowledge delivery and acquisition in the early phases of technology adoption, the absolute lack of literature from the farmer and potential adopter standpoint is noticeable: What do farmers think about the innovation? What information do they need to consider adoption? Which issues are more important (i.e., economics, production practices, environment, energy security, etc.) when thinking about the innovation? How do they prefer the information be delivered?

This paper seeks to bridge the current gap by addressing these questions in regard to the potential adoption of miscanthus as a bioenergy crop in Illinois.

1.1. *Purpose and objectives*

The purpose of this study was to assess factors associated with the potential adoption of miscanthus in Illinois. The objectives were to: (a) identify farmers' level of knowledge and awareness regarding energy crops and the possibility of receiving carbon credits when including these crops, (b) summarize information needs as growers consider an alternative crop such as miscanthus, (c) identify and profile potential energy crops growers, and (d) outline best methods of providing information to potential growers.

2. Materials and methods

2.1. *Data collection*

Focus groups (FGs) and survey methodology were used to address the objectives of the study. Data were collected between February 2005 and March 2006.

2.1.1. *Focus groups of Illinois farmers*

Three FGs were conducted in three locations around the state to gain greater insight into farmers' information needs regarding miscanthus and preferred channels for that information. FGs were conducted in Winnebago, Sangamon, and Monroe counties, as representative of the Northern,

Central, and Southern regions, respectively. Participant numbers for the three sessions were 12, 7, and 8 farmers, respectively. A brief supplementary survey was administered to each group to collect demographic information, to assess farmers' risk behavior, and to identify preferred channels of information. During the FG discussions, participants were asked an introductory round of general questions about farming and agricultural information gathering and usage and then were asked to read provided 'pro' and 'con' articles on miscanthus. Following this exercise, we encouraged a discussion about the specific information needs of farmers regarding miscanthus and the hopes and concerns about this alternative energy crop. The sessions were then transcribed and analyzed for trends and patterns in the qualitative responses of the participants.

2.1.2. *Survey of Illinois farmers*

The survey instrument is available from María Villamil mbvilla@criba.edu.ar. The target population for this study was all the farmers in Northern, Central and Southern counties. The survey instrument was designed with the input of academics, farmers participating in the FGs, and project partners. An initial survey was developed and pilot tested using an FG in Havana, Illinois, to improve wording and content of the survey. The instrument was examined for content and face validity by faculty members of the Human and Community Development and the Natural Resources and Environmental Sciences departments at the University of Illinois at Urbana-Champaign.

The final instrument consisted of three sections. The first section used a Likert-type scale with 30 items to explore the information needs of farmers if they were to consider the adoption of an energy crop such as miscanthus. Missing item scores were replaced by the item mean value since none of the items showed more than 10% of missing scores [25].

The second part of the survey was designed to identify potential energy crops growers using closed-ended (multiple choice), and yes–no questions. Potential adopters were defined in this study as those farmers who were not only willing to allocate some area to miscanthus within the next five production years, but were also able to keep the area in miscanthus for a period of at least 10 years and, more importantly, were able to afford delayed economic returns. A dummy variable that identified potential adopters was created for statistical purposes. When a respondent fulfilled the three previously mentioned requirements, he/she was categorized as a 'potential adopter' and assigned a value of 1. When any of those conditions were not present, a value of 0 was assigned implying non-adoption. This second part of the survey also included one closed-ended question to evidence awareness of the possibility of receiving carbon credits when including energy crops in the farm operation. Two additional questions in this section aimed to expose the importance of neighbors' opinions which can constrain the adoption of alternative cropping enterprises.

The third section of the survey aimed at collecting demographic information such as age, gender, years of farming full and part-time, area farmed, area owned, partner, and agricultural activities currently on the farm. The survey included a final open-ended question which allowed growers to provide additional comments or thoughts on the subject, suggesting factors and considerations which did not become evident in the survey.

The improved and tested survey was sent to the Northern Illinois farmers using 480 valid addresses from the mailing lists of the Northwest Illinois Ag Coalition. The Illinois Field Office of the National Agricultural Statistics Service, USDA, was responsible for randomly selecting 500 farmers from each of the mailing lists of the Central and Southern regions. The Illinois Field Office was also in charge of mailing the survey to the selected farmers. To increase response rates, all envelopes and letters used official letterhead and first-class stamps; a personalized cover letter accompanied the survey, and a postage paid reply envelope as well as a 'Miscanthus fact sheet' was included. The fact sheet was included to prevent non-response due to lack of knowledge on the subject. A follow-up survey was sent 2 weeks after the first mailing to those not responding. In this way, respondents were categorized as 'early' and 'late' respondents and contrasted on key variables relating to demographics and adopter characteristics. Late respondents were used as a proxy for the profile of non-respondents and the lack of statistical differences between early and late respondents thus justifies generalizing from the respondents to the sample [26,27].

Of the 1480 surveys sent, a total of 379 were returned, for a response rate of 26%. Out of the total sample pool, 66 persons returned the survey without answering, giving a refusal rate of 4%, with 313 people responding for a total response rate of 21%. The response was in line with expectations of 20% given the length of the questionnaire, the fact that we were necessarily asking for future intentions, and that there was a 'task' associated with the survey (reading the miscanthus fact sheet) with no monetary incentive.

2.2. *Data analysis*

Four dependent variables used in this study were derived from the first part of the survey that measured farmers' information needs when considering the adoption of miscanthus. Principal axis factoring with equamax rotation [28,29] was used to reduce the available 30 information needs items into a smaller set of composite variables for use as dependent variables in multivariate ANOVA. Data were deemed appropriate for factoring as indicated by the high value of the Kaiser–Meyer–Olkin measure of sampling adequacy (KMO, 0.89) and by the Bartlet's test statistic which indicated a significant ($p<0.0001$) departure from orthogonality of the correlation matrix (i.e., the variables are correlated among themselves) [28]. Variables with a minimum loading of 0.45 were selected for inclusion in defined components. Reliability analysis was carried out on the composite variables and since all the measures produced a minimum coefficient α of 0.70 (Table 1), they were regarded appropriate for further analysis [30].

Four factors (F1–F4) emerged from the analysis and were named *Agronomy & Markets*, *Environmental Services*, *Concerns*, and *Inputs Reduction*. Table 1 shows the resulting factors with their corresponding α's, variables, and loadings for each variable. These four factors were used as dependent variables in multivariate ANOVA.

Table 1 – Dependent variables (factors) derived from principal factor analysis (PAF) with their corresponding α's (in brackets), variables, and loadings for each variable

	Loading
F1: Agronomy and markets (α = 0.90)	
Information about harvesting and storage	0.74
Market demand data	0.71
Market prices	0.68
Specific production practices	0.64
Equipment needs	0.63
Existing markets	0.62
Soil fertility requirements	0.56
Availability of material to plant (rhizomes)	0.54
Equipment to grow or harvest miscanthus	0.53
Information about potential pests and diseases	0.48
F2: Environmental services (α = 0.87)	
Reducing carbon dioxide (CO_2) emissions	0.81
Reducing nitrogen (N) runoff	0.79
Improve national energy security	0.75
Producing a visually attractive crop	0.62
Improving soil quality, including building soil organic matter (SOM)	0.55
Effects on water quality	0.47
F3: Concerns (α = 0.76)	
Changing operation's current rotation	0.71
Unfamiliar with growing a perennial crop	0.67
Availability of crop insurance	0.56
Concern about miscanthus becoming a weed	0.49
Experience growing miscanthus in Illinois or in the region	0.47
Existence of long-term contract to grow miscanthus	0.45
F4: Inputs reduction (α = 0.85)	
Reducing wear and tear on equipment	0.76
The opportunity to reduce labor	0.74
The opportunity to reduce inputs of fertilizer, pesticides, and fuel in producing a crop	0.67

Descriptive statistics were used to identify general trends in the data set and to provide information about the variables used in this study. Multivariate ANOVA (for continuous variables) and Chi-square (χ^2) tests (for categorical variables) were used to evidence differences in information needs, attitude, and demographics among farmers from the three Illinois regions surveyed and between the farmers identified as potential adopters and non-adopters. Least significant differences were used for mean comparison purposes setting the probability of type I error or alpha level (α) at 0.05. Statistical analyses were carried out using SAS 9.1 [31] and SPSS 14.0 [32].

3. Results and discussion

3.1. *Demographic regional differences*

Descriptive characteristics of the studied populations are presented in Table 2 for the total sample and for each region. The average age of Illinois farmers and the distribution figures are in agreement with the trends shown by the 2002 Census of Agriculture which indicates a general ageing of farm operators since the 1974 Census [33]. The average age of US farmers was 51.7 in 1974 and it has been steadily increasing to reach 55.3 years old in 2002. Farm operators 65 or older have increased from about 17% to 26% in 2002, while the population of farmers younger than 35 has been declining; currently representing less than 6% of farm operators. While Northern Illinois shows the higher percentage of farmers older than 64, Central Illinois has the highest percentage of farmers in the 55–64 range, and Southern Illinois has the greatest proportion of younger farmers (<54).

Not surprisingly, most of our respondents were males (~97%). Nationwide, women farm operators represent about 11% of the population of farm principal operators, yet they account for 67.2% of farm second operators' population [34].

Farmers in Illinois are experienced farmers, averaging almost 33 years of farming and more than 26 years of full-time farming. The years of full-time farming are significantly lower for Southern Illinois farmers, which concurs with the distribution of age groups. Southern Illinois farmers are younger and therefore less experienced than farmers in the Central and Northern regions.

No differences in area farmed were found among regions and the total average for the population surveyed is very close to that reported for Illinois in the 2002 Census (152.6 ha) [16]. The percent distribution of hectares farmed is, however, different among regions. While Northern Illinois showed the least percentage of big farms (>810 ha), Central Illinois displayed the lowest percentage of small farms (<81 ha), and Southern Illinois the greatest percentage of farms with size between 81 and 202 ha. No differences in the area owned or in the percentage distribution were found among regions. More than 70% of the farmers owned 404 ha or less. Yet significant differences are found when observing the percentages of land owned by the farmers. Central Illinois farmers own a lower percentage of the land they farm (41.6%) compared to Northern (60.4%) or even Southern (52.8%) Illinois farmers. The distribution of that ownership is again statistically significant. About 45% and 38% of the farmers in Northern and Southern Illinois owned more than 75% of the land they farmed, whereas 41% of Central Illinois farmers held less than 25% of the land farmed.

Farming in Central Illinois is less diversified than in the Northern and Southern regions. Of the farmers in Central Illinois, 74% reported running two or fewer agricultural activities on their farms per year. In contrast, 61.7 and 69.1% of the farmers in Northern and Southern Illinois, respectively, reported having three or more activities at any point during the farming year. Corn and soybeans are the major field crops grown. There is an important contribution of wheat in Southern Illinois farms and of livestock and forage crops mainly in Northern Illinois, although livestock and forage are important for southern farmers, too. The percentage of 'other' activities includes barley, oats, nursery production, and even CRP land, and the joint contribution is clearly more important for Northern Illinois farmers.

In Central Illinois, about 65% of the farmers reported not having any kind of partnership. For those that farm in partnership, other relatives are the most important category.

Table 2 – Demographic characteristics of Illinois farmers and number of potential adopters and non-adopters by region

Variable	Total	Northern	Central	Southern	Sig[a]
Respondents					
Count	313	60	154	99	
Percent	100	19.2	49.2	31.6	
Age					
Mean	55.6	56.5	56.3	53.9	0.253
Standard error	(0.6)	(1.6)	(0.9)	(1.0)	
Percent distribution					0.148
<34	1.9	3.3	1.9	1.0	
35–44	9.8	5.5	9.5	12.8	
45–54	34.7	35.1	30.2	41.5	
55–64	36.3	29.8	40.3	34.0	
>64	17.3	26.3	18.1	10.6	
Gender (%)					
Male	97.1	98.3	97.4	95.9	0.640
Female	2.9	1.7	2.6	4.1	
Years of farming					
Full-time	26.7	27.6	28.7	22.7	0.029
Mean					
Standard error	(0.9)	(2.1)	(1.2)	(1.7)	
Part-time					
Mean	6.2	6.6	4.8	8.2	0.111
Standard error	(0.6)	(1.5)	(0.8)	(1.2)	
Total					
Mean	32.8	34.2	33.5	30.9	0.276
Standard error	(0.7)	(1.8)	(0.9)	(1.2)	
Percent distribution					0.372
1–15	6.1	6.8	4.8	7.9	
16–30	41.7	40.7	40.1	44.9	
31–45	37.6	30.5	40.1	38.2	
>46	14.6	22.0	15.0	9.0	
Area farmed (ha)					
Mean	363.5	355.7	385.8	331.6	0.690
Standard error	(18.8)	(51.4)	(23.9)	(34.9)	
Percent distribution in ha					0.078
<81	11.3	18.5	8.1	12.2	
81–202	27.4	20.4	24.3	36.7	
203–404	26.7	29.6	26.4	25.6	
405–810	23.3	24.1	28.4	14.4	
>810	11.3	7.4	12.8	11.1	
Area owned (ha)					
Mean	139.4	161.3	126.7	146.3	0.263
Standard error	(9.8)	(22.0)	(13.8)	(18.2)	
Percent distribution in ha					0.499
<81	47.0	43.1	48.9	46.2	
81–202	31.9	31.4	32.8	30.8	
203–404	14.3	13.7	12.4	17.6	
405–810	5.4	11.8	4.4	3.3	
>810	1.4	0	1.5	2.2	
Land owned (%)					
Mean	48.5	60.4	41.0	52.8	0.018
Standard error	(2.2)	(5.3)	(3.0)	(3.6)	
Percent distribution					0.021
<25	33.0	26.4	41.6	23.9	
25–49	20.6	13.2	20.4	25.0	
50–74	15.6	15.1	14.6	17.4	
>75	30.9	45.3	23.4	33.7	

Table 2 (*continued*)

Variable	Total	Northern	Central	Southern	Sig[a]
Agricultural activities (% of area)					
Corn	34.9	31.4	40.7	29.9	
Soybeans	34.0	27.6	40.4	30.2	
Forage crops	5.9	8.1	4.4	6.3	
Wheat	10.8	5.4	5.2	20.9	
Fruits and vegetables	1.4	4.3	5.3	0.3	
Other	3.8	9.2	2.2	2.3	
Livestock	9.3	14.1	6.3	10.0	
Number of activities					
Mean	2.7	3.1	2.4	3.1	0.001
Standard error	(0.1)	(0.2)	(0.1)	(0.1)	
Percent distribution					
2 or less	53.7	38.3	74.0	30.9	0.001
3 or more	46.3	61.7	26.0	69.1	
Partnership (%)					
Yes	44.9	59.6	35.5	51.0	0.003
Spouse	31.6	47.4	24.6	28.8	
Son or daughter, son- or	24.1	21.1	29.5	20.3	
Daughter-in-law	38.6	28.9	39.3	44.1	
Other relatives	5.7	2.6	6.6	6.8	
Other non-relatives	55.1	40.4	64.5	49.0	
No					
Neighbors' opinions (%)					
Not important	74.5	71.7	72.4	79.6	0.153
Important	22.9	28.3	23.0	19.4	
Very important	2.6	0	4.6	1.0	
Orderly rows (%)					
Not important	69.2	75.0	70.6	63.6	0.094
Important	25.3	25.0	21.6	31.3	
Very important	5.5	0	7.8	5.1	
Potential adopters					
Count	94	25	42	27	0.092
Percentage of respondents	30.0	41.7	27.3	27.3	

[a] Significance of the multivariate F test (in italics) for continuous variables and of the χ^2 test (in normal font) for categorical variables.

In contrast, 59.6% and 51% of farmers in Northern and Southern Illinois reported having a partner in their farming enterprises. However, while the spouse was the main partner for Northern farmers (47.4%), other relatives accounted for 44.1% of the partnerships for Southern Illinois farmers.

The similarity of the demographic findings with the data reported in the 2002 Census of Agriculture [16,33] allows us to generalize our results to the whole population of Illinois farmers.

Regarding social control and its influence on farmers' decisions, it seemed that farmers may have considered the influence of others in relation to decisions they had already made, yet not in relation to future intentions. An average of 74.5% of the farmers regarded neighbors' opinions about their farming operations as 'not important'. Visual appearance of the crop, i.e., orderly rows and weed-free fields, are examples of the visual indicators that society uses to judge the 'success' of a farmer which may constrain farmers' innovation [11]. Again, societal control, now defined as 'orderly rows' was also regarded 'not important' for 69.2% of the total population of farmers. This esthetic factor was more influential for Southern Illinois farmers, where more than 31.3% of the farm operators qualified it as 'important' and 1% as 'very important'. Cutforth et al. [22] found that social norms highly influenced farmer's future intentions but farmers did not perceive the external influences in previously taken decisions. It is likely that uncertainty about future plans moves the farmer to rely more on other people to inform future decisions.

Following the selection criteria mentioned in the materials and methods section, 30% of the respondents were identified as 'potential adopters' of miscanthus, with the highest proportion of potential adopters found among farmers in the Northern Illinois region. While 41.7% of Northern Illinois farmers were categorized as 'potential adopters', only 27.3% of the populations surveyed in each Central and Southern Illinois were included in that category.

3.2. *Profiling potential adopters*

The demographics of the identified potential adopters did not differ among regions and there were only a few differences

between the two categories (Table 3). Potential adopters have less farming experience and farm more hectares than potential non-adopters. Providing the existence of markets for miscanthus, the two main reasons why potential adopters will consider growing energy crops were as a supplement to their current income (43.6%) and as partial replacement of their current area (36.2%). Awareness regarding the possibility of receiving carbon credits when growing energy crops was significantly higher ($p<0.0001$) for potential adopters (43.6%) than for non-adopters (25.7%).

Fig. 1 shows the possible distribution of land allocated to miscanthus by potential adopters. Next growing season,

Table 3 – Demographic characteristics of Illinois farmers identified as potential adopters and non-adopters

Variable	Potential adopters	Potential non-adopters	Sig[a]
Respondents			
Count	94	219	
Percent	30.0	70.0	
Age			
Mean	54.9	55.9	0.259
Standard error	(1.0)	(0.8)	
Percent distribution			0.715
<45	10.0	12.4	
45–54	37.8	33.3	
55–64	37.8	35.7	
>64	14.4	18.6	
Gender (%)			
Male	96.8	97.2	0.837
Female	3.2	2.8	
Years of farming			
Full-time			
Mean	24.5	27.6	0.155
Standard error	(1.6)	(1.1)	
Part-time			
Mean	6.0	6.2	0.890
Standard error	(1.1)	(0.8)	
Total			
Mean	30.5	33.9	0.043
Standard error	(1.1)	(0.9)	
Percent distribution			0.026
1–15	9.9	4.4	
16–30	45.1	40.2	
31–45	38.5	37.3	
>46	6.6	18.1	
Area farmed (ha)			
Mean	378.1	356.8	0.087
Standard error	(37.7)	(21.3)	
Percent distribution in ha			0.708
<81	12.0	11.0	
81–202	22.8	29.5	
203–404	29.3	25.5	
405–810	26.1	22.0	
>810	9.8	12.0	
Area owned (ha)			
Mean	154.4	132.4	0.267
Standard error	(16.6)	(12.2)	
			0.326
Percent distribution in ha			
<81	39.3	50.5	
81–202	36.0	30.0	
203–404	19.1	12.1	
405–810	4.5	5.8	
>810	1.1	1.6	
Land owned (%)			
Mean	53.6	46.2	0.358
Standard error	(3.8)	(2.6)	
Percent distribution			0.520
<25	27.0	35.8	
25–49	21.3	20.2	
50–74	16.9	15.0	
>75	34.8	29.0	
Agricultural activities (% of area)			
Corn	33.1	35.7	
Soybeans	32.3	34.8	
Forage crops	9.0	4.4	
Wheat	9.4	11.4	
Fruits and vegetables	2.3	1.0	
Other	4.1	3.7	
Livestock	9.8	9.0	
Number of activities			
Mean	2.8	2.7	0.610
Standard error	(0.1)	(0.1)	
Percent distribution			
2 or less	48.9	55.8	0.268
3 or more	51.1	38.9	
Partnership (%)			
Yes	49.5	42.9	0.291
Spouse	38.5	28.3	
Son or daughter, son- or daughter-in-law	15.4	28.3	
Other relatives	38.5	38.7	
Other non-relatives	7.7	4.7	
No	50.5	57.1	
Neighbors' opinions (%)			
Not important	74.5	74.5	0.510
Important	24.5	22.2	
Very important	1.1	3.2	
Orderly rows (%)			
Not important	76.6	66.1	0.157
Important	20.2	27.5	
Very important	3.2	6.4	

[a] Significance of the multivariate *F* test (in italics) for continuous variables and of the χ^2 test (in normal font) for categorical variables.

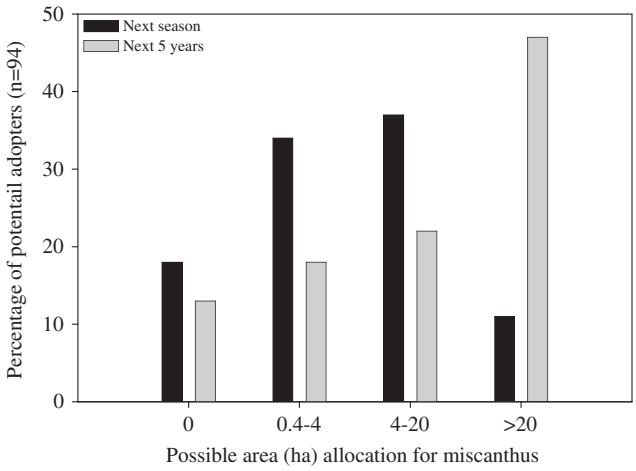

Fig. 1 – Possible land allocation for miscanthus by potential adopters during next growing season and the next 5 production years.

34% of the potential adopters would be willing to allocate between 0.4 and 4 ha, and about 37% would allocate 4–20 ha for miscanthus production. Considering a more extended time frame, the allocation of land to miscanthus is more gradual, yet 47% of the potential adopters plan to allot more than 20 ha to miscanthus production. These figures may represent up to 134,422 ha of miscanthus planted next growing season and more than 233,432 ha in the next 5 production years in the state of Illinois. Following the estimations of Heaton et al. [3], this supply of miscanthus biomass can provide up to 10% of the current state energy demand. It is, however, important to underline that we are referring to impending behavior and none of the categories have been observed for miscanthus. In fact, hardly any respondent was aware of the existence of this crop (2 of 313 respondents) before completing the survey.

A cautionary note is appropriate at this point. Miscanthus may be considered an environmental innovation since, in contrast to commercial innovations, it benefits the society but it is not in the farmer's self economic interest. Vanclay [34,35] conceptualizes many important points which make non-adoption of environmental practices a very rational alternative, if not the only one. As a result, large-scale non-adoption of environmental practices might be expected unless there is sufficient social interest in the innovation. Lack of a supportive social infrastructure was the main reason that led to the failed development of a biomass electricity plant in the UK [36]. The environmental justification of biomass energy at the national level was not sufficient to convince local residents and, as the authors reflected, promoting biomass energy requires interactive communication, public participation, and collective learning among all the stakeholders. In Vanclay's [35] words, "when environmental thinking enters the social infrastructure, mass adoption is likely irrespective of the disadvantages" of the innovation.

3.3. *Information needs*

Adoption is also conditioned upon attending to farmers' concerns and opinions. Environmental campaigns aimed to increase awareness and education on energy crops such as miscanthus should be targeted to the interests and characteristics of each regional audience with their specific demands of information.

Fig. 2 shows the differences found in information needs among regions (Fig. 2a) and between potential adopters and non-adopters (Fig. 2b). Factors are standardized variables (mean 0, std dev 1) thus values range from −3 to 3 and since all meaningful factor loadings were positive (Table 1), higher factor means represent a greater contribution of a particular factor toward the information needs of a region or adopter category.

There are clear differences among the information needs of each region in Illinois regarding the use of miscanthus as an energy crop. While Northern Illinois farmers focus on the need for information regarding *Agronomy & Markets* alone, farmers from Southern Illinois centered their interests in the possibility of *Inputs Reduction* with the inclusion of miscanthus in their operations. Central Illinois producers are equally interested in a variety of information to make the decision of including miscanthus in their operations. Central Illinois farmers are asking for more knowledge regarding specifics on *Agronomy & Markets* for miscanthus, the *Environmental Services* that miscanthus can allegedly provide, and the possibility of *Inputs Reduction* with miscanthus adoption. Information on *Agronomy & Markets* ranked last for Southern Illinois farmers, which significantly differed from the other regions. Interest in the *Environmental Services* provided by energy crops is

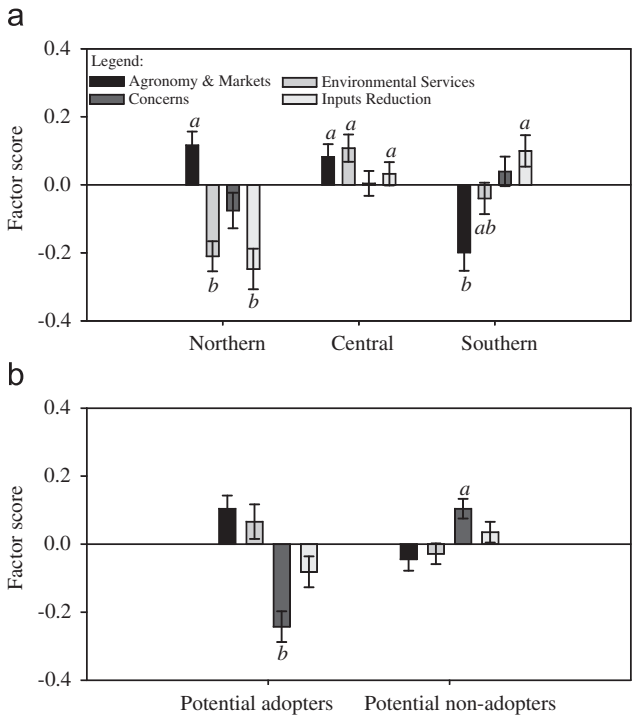

Fig. 2 – Differences in information needs (a) among regions and (b) between potential adopters and non-adopters. For a given factor, different lowercase letters indicate statistical differences ($\alpha = 0.05$).

greatest in Central Illinois, which differed from Northern Illinois farmers but not from their southern counterparts. Central Illinois interest in *Inputs Reduction* is shared with Southern Illinois farmers but not with Northern agricultural producers.

There were no differences among the regions in the weight given to the need of information attending concerns and potential problems brought about by the introduction of miscanthus in their farming operations. The importance of the *Concerns* factor is not less but equal among regions and its significance becomes clear when considering the information needs of potential adopters and non-adopters (Fig. 2b). *Concerns* was the only factor that evidenced the differences between potential adoption behaviors. Throughout the state, potential non-adopters focus on the risk encompassed by the adoption of miscanthus.

3.4. Preferred information channels

The identified information needs should be channeled through appropriate and preferred means to be effective. FGs were conducted in the different regions to address this issue. General demographic characteristics of the FG participants were similar to the averages presented for the region in which they farmed. However, there were two important differences that make them resemble our 'potential adopters' category. Participants were younger (48.4, $p<0.003$) and farmed more area (536.9 ha, $p<0.001$) than their survey counterparts averages for each of the regions or for the total sample.

None of the FG participants had previous knowledge of miscanthus and that was mentioned as the main reason for not growing it. Of the 26 FG participants, 21 considered growing miscanthus a 'moderate risk' enterprise while it was rated as 'big risk' for the remaining farmers.

Table 4 summarizes the findings regarding preferred information channels identified by the FGs. Farmers use a wide range of channels for receiving agricultural information and differences among channel preferences were observed among the three regions. Other studies have also reported variability in the use and preferences of information channels by farm audiences for even small geographic areas [17–21].

More than 65% of all respondents identified Farm/Ag organizations, Ag newsletters, other farmers and neighbors, the internet, and newspapers as the top five information channels. Northern Illinois participants identified Farm/Ag organizations as the single most important communication channel for accessing agricultural information. In Central Illinois, Farm/Ag organizations, Ag newsletters, and other farmers and neighbors shared the top position whereas farmers in Southern Illinois unarguably selected Farm/Ag organizations and other farmers and neighbors as the main channels of agricultural information. Differences among regions become more evident when examining the rankings of additional channels, which may arise from different quality of farm radio/TV programming, and trade shows. Besides, conferences may not be appropriate or even available in all the regions and the presence of an involved community is crucial when considering the influence of community meetings on the agricultural decision-making process. The high percentage of selection of these channels and of trade shows for the Southern Illinois participants in comparison with the producers of the other areas may also be reflecting a more affluent group of farmers, with the means to attend conferences and trade shows as well as to mobilize their own community members to form community meetings.

4. Conclusions

Findings from this study have important implications for extension practitioners, researchers, and policy makers. Providing the existence of markets and social infrastructure for miscanthus production, 30% of farmers in Illinois may adopt this energy crop, potentially supplying about 10% of the state energy demand in the next 5 years.

If an environmental informational campaign addressing the use of miscanthus as energy crop is to be successful in Illinois, the information needs of farmers from different regions should be specifically addressed and channeled through their preferred media. Farmers in Northern Illinois

Table 4 – Preferred information channels identified by the focus groups conducted in the different IL regions

Preferred information channels	Total	Northern	Central	Southern
Farm/Ag organizations	88.5	81.8	85.7	100
Ag newsletters	76.9	63.6	85.7	87.5
Other farmers and neighbors	76.9	63.6	85.7	100
Internet	73.1	63.6	71.4	87.5
Newspapers	65.4	45.5	71.4	87.5
Trade shows	53.8	45.5	42.9	75
TV	38.5	45.5	42.9	25
e-mail	38.5	27.3	42.9	50
Community meetings	38.5	27.3	14.3	75
Conferences	34.6	18.2	28.6	62.5
Radio	34.6	36.4	57.1	12.5

require information on the agronomy and markets of miscanthus that should be channeled mainly through Farm/Ag organizations. Central Illinois farmers preferred a variety of information be delivered by Farm/Ag organizations, Ag newsletters, and other farmers and neighbors, while farmers in Southern Illinois use a wider variety of channels and their interests are focused on the possibility of lowering inputs with miscanthus inclusion in their systems. Concerns regarding miscanthus should be addressed equally in the three regions, since it is one of the most important deterrents for considering miscanthus adoption.

Acknowledgements

Funding for this project was provided by the Illinois Council on Food and Agriculture Research under Project 04-SRI-036. The authors wish to thank members of the University of Illinois Biomass Energy Crops project team headed by Dr. Steven Long, and Dr. Iris. Lewandowski, Universiteit Utrecht, and Dr. Leslie Cooperband, University of Illinois, for their comments on the survey instrument. We gratefully acknowledge our colleague Dr. Fernando Miguez, for his thorough revision of the present manuscript.

REFERENCES

[1] Ragauskas AJ, Williams CK, Davison BH, Britovsek G, Cairney J, Eckert CA, et al. The path forward for biofuels and biomaterials. Science 2006;311:484–9.
[2] Perlack RD, Wright LL, Turhollow AF, Graham RL, Stokes BJ, Erbach DC. Biomass as feedstock for a bioenergy and bioproducts industry: the technical feasibility of a billion-ton annual supply. Oak Ridge: TN Oak Ridge National Laboratory; 2005 DOE/GO-102995-2135, ORNL/TM-2005/66.
[3] Heaton EA, Clifton-Brown J, Voigt T, Jones MB, Long SP. Miscanthus for renewable energy generation: European Union experience and projections for Illinois. Mitigation and Adaptation Strategies for Global Change 2004;9: 433–51.
[4] Walsh ME, de la Torre Ugarte DG, Shapouri H, Slinsky SP. Bioenergy crop production in the United States: potential quantities, land use changes, and economic impacts on the agricultural sector. Environmental and Resource Economics 2004;24:313–33.
[5] Heaton E, Voigt T, Long SP. A quantitative review comparing the yields of two candidate C4 perennial biomass crops in relation to nitrogen, temperature and water. Biomass and Bioenergy 2004;27:21–30.
[6] Lewandowski I, Scurlock JMO, Lindvall E, Christou M. The development and current status of perennial rhizomatous grasses as energy crops in the US and Europe. Biomass and Bioenergy 2003;25:335–61.
[7] Miguez FE, Villamil MB, Long SP, Bollero GB. Meta-analysis of the effects of management factors on Miscanthus W giganteus growth and biomass production. Agricultural and Forest Meteorology 2008 (in press).
[8] Wolf SA, Nowak P. Institutional failure in agro-environmental management. Research in social problems and public policy 1999;7:293–310.
[9] Rogers EM. Diffusion of innovations. 4th ed. New York, NY: The Free Press; 1995.
[10] Carolan MS. Barriers to the adoption of sustainable agriculture on rented land: an examination of contesting social fields. Rural Sociology 2005;70:387–413.
[11] Salamon S, Farnsworth RL, Bullock DG, Yusuf R. Family factors affecting adoption of sustainable farming systems. Journal of Soil and Water Conservation 1997;52:265–71.
[12] Caviglia JL, Kahn JR. Diffusion of sustainable agriculture in the Brazilian tropical rain forest: a discrete choice analysis. Economic Development and Cultural Change 2001;49:311–33.
[13] Fischer AJ, Arnold AJ, Gibbs M. Information and the speed of innovation adoption. American Journal of Agricultural Economics 1996;78:1073–82.
[14] Upadhyay BM, Young DL, Wang HH, Wandschneider P. How do farmers who adopt multiple conservation practices differ from their neighbors? American Journal of Alternative Agriculture 2003;18:27–36.
[15] Waller BE, Hoy CW, Henderson JL, Stinner B, Welty C. Matching innovations with potential users, a case study of potato IPM practices. Agriculture, Ecosystems & Environment 1998;70:203–15.
[16] USDA, NASS. Illinois field office. Springfield, IL: Illinois Agriculture; 2006.
[17] Tucker M, Napier TL. Preferred sources and channels of soil and water conservation information among farmers in three midwestern US watersheds. Agriculture, Ecosystems & Environment 2002;92:297–313.
[18] Gloy BA, Akridge JT, Whipker LD. Sources of information for commercial farms: usefulness of media and personal sources. The International Food and Agribusiness Management Review 2000;3:245–60.
[19] Lasley P, Padgitt S, Hanson M. Telecommunication technology and its implications for farmers and extension services. Technology in Society 2001;23:109–20.
[20] Patrick GF, Ullerich S. Information sources and risk attitudes of large-scale farmers, farm managers, and agricultural bankers. Agribusiness 1996;12:461–72.
[21] Wilson P, Hadley D, Asby C. Identifying the audience and the media of communication; targeting technology transfer in the UK cereals industry. Outlook in Agriculture 2000;29:185–92.
[22] Cutforth LB, Francis CA, Lynne GD, Mortensen DA, Eskridge KM. Factors affecting farmers' crop diversity decisions: an integrated approach. American Journal of Alternative Agriculture 2001;16:168–76.
[23] Beus CE, Dunlap RE. Agricultural paradigms and the practice of agriculture. Rural Sociology 1994;59:620–35.
[24] Eady J, Fisher B. On-farm adoption model resulting in improved environmental actions and outcomes. Australian Journal of Dairy Technology 2004;59:142–5.
[25] Downey RG, King CV. Missing data in Likert ratings: a comparison of replacement methods. Journal of General Psychology 1998;125:175–91.
[26] Lindner JR, Wingenbach GJ. Communicating the handling of nonresponse errors in the *Journal of Extension* research in brief articles. Journal of Extension 2002.
[27] Miller LE, Smith KL. Handling non-response issues. Journal of Extension 1983.
[28] Sharma S. Applied multivariate techniques. Hoboken, NJ: Wiley; 1996.
[29] Johnson DA, Wichern RA. Applied multivariate statistical analysis. New Jersey: Prentice Hall; 2002.
[30] Mueller DJ. Measuring social attitudes. New York, NY: Teachers College Press; 1986. p. 122.
[31] SAS Institute. SAS system for windows. Release V9.1. Cary, NC: SAS Institute; 2002.
[32] SPSS version 14. SPSS Inc., Illinois, Chicago.
[33] Allen R, Harris G. What we know about the demographics of US farm operators. In: Agricultural outlook forum. National Agricultural Statistical Service, USDA; 2005.

[34] Vanclay F. Social principles for agricultural extension to assist the promotion of natural resource management. Australian Journal of Experimental Agriculture 2004;44: 212–3.
[35] Vanclay F, Lawrence G. Farmer rationality and the adoption of environmentally sound practices; a critique of the assumptions of traditional agricultural extension. European Journal of Agricultural Education and Extension 1994;1:59–90.
[36] Upreti BR, van der Horst D. National renewable energy policy and local opposition in the UK: the failed development of a biomass electricity plant. Biomass and Bioenergy 2004;26:61–9.