

Full Length Research Paper

Extent and adoption determinants of floating tray technology by small holder tobacco farmers: A case of Zimbabwe

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The study was on the extent and adoption determinants of floating tray technology by small holder tobacco farmers in Bindura District of Mashonaland province. The objectives of the study were to determine the extent of adoption, identify adoption determinants that influence farmer's decision to take up floating trays. The study aimed also to identify challenges and opportunities of the floating trays. Questionnaires, focus group discussion and observations were used to gather data. The enumerator had face to face interviews with the farmers and clarified areas where the farmers need clarity on issues in the questionnaire. The logit regression model was used to determine the factors that influence adoption decision. Descriptive statistics was also used to analyse the challenges and opportunities. The major challenges were identified as high costs of technology and lack of capital with reduced input costs as an opportunity. Factors that influence farmers' decision to adopt floating tray technology were identified and these include training, educational status and off-farm hours. Age, training and off-farm hours were found to have significant influence on the adoption decision. Results show that training of the household head has a significant impact as shown by the marginal effect of 0.041. Since tobacco seedling using floating tray system is too costly and requires too much capital to establish, the researcher's hypothesis that there are challenges and opportunities in using floating tray system was not rejected. Recommendations made were to advocate for intervention in the provision of low cost or subsidize the floating tray system for the small holder tobacco farmers to increase the adoption of floating tray system.

Key words: Adoption, float trays, logit regression model.

INTRODUCTION

Zimbabwe is an agro based developing economy where agriculture is the vehicle to economic development prospects (GOZ, 2009). It provides employment and incomes for 70% of the population, 60% of the raw materials required by the industrial sector and 45% of

total export earnings and, except in years of severe drought, sufficient food to feed the nation (FAO, 2010). Sustainable agricultural development should be ecologically sound, economically viable and socially responsible. It is through agricultural transformation that

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sustainable economic growth can be achieved (Rukuni et al., 2006).

Zimbabwe is one of the major tobacco exporters in the world. Tobacco (*Nicotiana tabacum*) is of paramount importance to the agriculture sector and the economy of Zimbabwe as it is one of the country's biggest foreign currency earners (FAO, 2010). Increases in both planting areas and yields have contributed to a significant increase in output of tobacco over the past decades. Large-scale commercial farmers used to dominate tobacco production but however this trend has changed with small scale farmers now dominating production (Z.T.P., 2010). The Large scale farmers are characterized by large land holdings, use of modern machinery, and permanent wage labour as compared to their small scale counterparts who are resource constrained (FAO, 2010). Over the past decades, methyl bromide has been used to fumigate tobacco seedbeds. However, the use of this conventional method in seedling tobacco production has been observed to have negative effects to the environment (Z.T.P., 2010). There has been a global call to phase out methyl bromide by 2015. Zimbabwe has specific regulations towards attaining this. Various stakeholders including the Tobacco Research Board (TRB), Agricultural Extension and Technical Services (AGRITEX) and United Nations Industrial Organization have advocated for the use of the float tray system in seedling production as an alternative. Tobacco growers received training in the use of float tray system for tobacco fumigation and have on average invested US\$353 per hectare for the trays which last up to 7 years (Mazarura, 2004). Float tray system is an option of seedling production that has been tried, tested and used successfully in many tobacco growing countries such as Brazil, Malawi and the USA (Mazarura, 2004). Besides being more eco-friendly, the float tray system produces seedlings with intact root system and result in a more uniform crop. It is also notably labour extensive and cost effective as compared to conventional seedling production.

The contribution of new technology to economic growth can only be realized when and if the new technology is widely diffused and used (Namara et al., 2007). In most settings, diffusion of agricultural innovations has been seen as the cumulative or aggregate result of a series of individual calculations that weigh the incremental benefits of adopting a new technology against the costs of change. This is often in an environment characterized by uncertainty (as to the future evolution of the technology and its benefits) and by limited information (about both the benefits and costs and even about the very existence of the technology). There has been an apparent overall slowness and the wide variations in the rates of acceptance of the float tray system by most tobacco farmers in Zimbabwe (Namara et al., 2007). Thus, understanding the workings of the diffusion process is essential to understanding how technological change actually comes about and why it may be slow at times.

Exploring the determinants affecting choice is essential both for economists studying the determinants of growth and for the creators and producers of such technologies (Mansfield, 1968). For this study, this analysis will be done in the context of tobacco farmers in Bindura District.

Problem statement

Unsustainable tobacco seedling production using methyl bromide is currently used in Zimbabwe's farming communities (Mazarura, 2004). Even though the floating tray has been identified as an option to conventional tobacco seed farming to guard against ozone depletion, the uptake of this technology has been marginal in most small farming communities (Mazarura, 2004). It is therefore imperative to understand challenges and opportunities and the dynamics of adoption of floating tray system.

METHODOLOGY

Description of study area

The study was carried out in Bindura District of Mashonaland Central. Bindura is located in the Mazowe Valley about 88 km North-east of Harare. Bindura is in natural region 2b and receives high rainfall. The area experiences warm summers and cool winters. Rainfall ranges between on average 700 and 1000 mm per annum and effective rainfall is 500 to 635 mm (AREX, 2008). This is enough for intensive crop production. The main crops grown include tobacco, maize, soya beans and winter wheat. Intensive livestock production is also practiced.

Data collection techniques

Both qualitative and quantitative data were collected using a number of approaches and tools. These techniques allow the researcher to systematically collect information about objects of the study (people, objects, phenomena) and about the settings in which they occur (De Vaus, 1996). Structured questionnaires, structured interview guide and observations were used for primary data collection. The researcher also conducted one focus group discussion to triangulate data collection. Stakeholders such as AGRITEX and TRB were interviewed to get their views on the topic. The researcher took into account ethical considerations to minimize the issues of bias information by conducting focus group discussion.

Sampling procedure

Purposive sampling was initially used to identify tobacco farmers in ward 3 Bindura district where tobacco production is extensively done. The sampling frame comprised of 115 farmers of which 23 were adopters and 92 non-adopters. Proportionate random sampling was used with adoption being the stratum. From the sampling unit, 47 farmers with 5 and 42 adopters, respectively became a sampling unit. This allowed generation of a representative sample since the proportions of adopters and non-adopters were different. Snow balling sampling was also employed. The random selection meant that there were equal chances of

Table 1. Description of floating tray adoption variables.

Variable	Description	Units	Adopters		Non-adopters	
			Mean	SD	Mean	SD
Age	Age of household head	Year	32		50	
Household size	Number of family members	Number	5.4	1.3	3.8	0.8
Number of years in school	Years of schooling by household age	Number	13.8	1.7	8.1	1.5
Land size	Size of arable land	Hectare	3.3	1.2	1.9	0.7
Off farm activities	Access to off farm activities	percentages	5.1	11.9	6.7	13.8

Source: SPSS.

Table 2. Gender in tobacco farming.

Gender	Percentage
Male	66
Female	34

selection for each farmer into the sample. Farmers were free to participate and were not coerced.

Data analytical tools

Logit model

Since in this study, the dependent variable (adoption) has only two possible values for either adopting or not adopting, the logistic regression model was used. Without any loss in generality, the researcher coded these two outcomes as ($Y = 1$ for adoption) and ($Y = 0$ for not adopting) thus giving rise to a binary dependent variable. Since the response was qualitative in nature, the researcher used qualitative response model, (the logit model), which is a nonlinear model since binary dependent model ("dummy Ys") cannot be used freely in linear regression models. The aim was to find the conditional expectation of the dependent variable given more than one conditional variables. The likelihood of observing the dependent variable (P) was tested as a function of variables which include gender of household, age of household and training of the household.

$$Z_i = \text{Log} (P_i/1-P_i) = \alpha_0 + \alpha_1 X_1 + \alpha_2 X_2 + \dots + \alpha_n X_n + \epsilon$$

Where: X_1 = Training, X_2 = number of years in schooling, X_3 = off farm activities, X_4 = land size, X_5 = age, X_6 = household hold size, ϵ = Error term.

Most of the smallholder farmers received training on how the float tray system works. The researcher was interested in the number of farmers who received training on the use of float tray system in the production of tobacco. The level of education is also a major determinant in the adoption of technology by the smallholder farmers. In theory, it is believed that those who are educated will adopted the technology faster than those farmers who are well educated. The smallholder framers are not only into the production of tobacco, there are other off farm activities which they are involved in, these off farm activities is also a major determinant on the adoption of new technologies by the smallholder farmers in Zimbabwe. Farmers will prefer a technology which will leave them with time to do other activities.

Size of the land available is another determinant of the adoption of a technology by the smallholder farmers. If the size of the land is huge, farmers would want a technology that will save them time and which does not require many labour days. The size of the arable land available will determine the adoption of technology by the smallholder farmers. The major source of labour in the smallholder sector is the family. The size of the household will also determine the level of adoption by the smallholder farmers in Zimbabwe. If the household is large then the family can adopt a labour intensive technology and if the household size is small then the family will not adopt a labour intensive technology. Household size is a major determinant of the adoption of a technology by the smallholder farmers in Zimbabwe.

RESULTS

Demographic information of small holder tobacco farmers

Most smallholder tobacco farmers in Bindura are male and they constitute more than half of the farmers in the district (AREX, 2012). A range of about 40 and above years is dominating smallholder tobacco farming in the district. The results show that most farmers at least attended ordinary level of education (Tables 1 and 2).

The results in Figure 1 indicate that 66% and 34% were trained and untrained on using the floating tray system respectively. Therefore, there has been increased awareness among farmers of this environmentally friendly method of raising tobacco seedlings instead of using methyl bromide.

Despite the training exposed to farmers (Figure 1) to gain knowledge on the use of float tray system Figure 2 clearly show the low uptake of this system of raising tobacco seedlings. Therefore, the research needed to explore the determinants affecting float tray system adoption.

Adoption determinants

From Table 3, variables were captured and among them number of year in school, size of the household, training and farm size have valid marginal effect on the decision

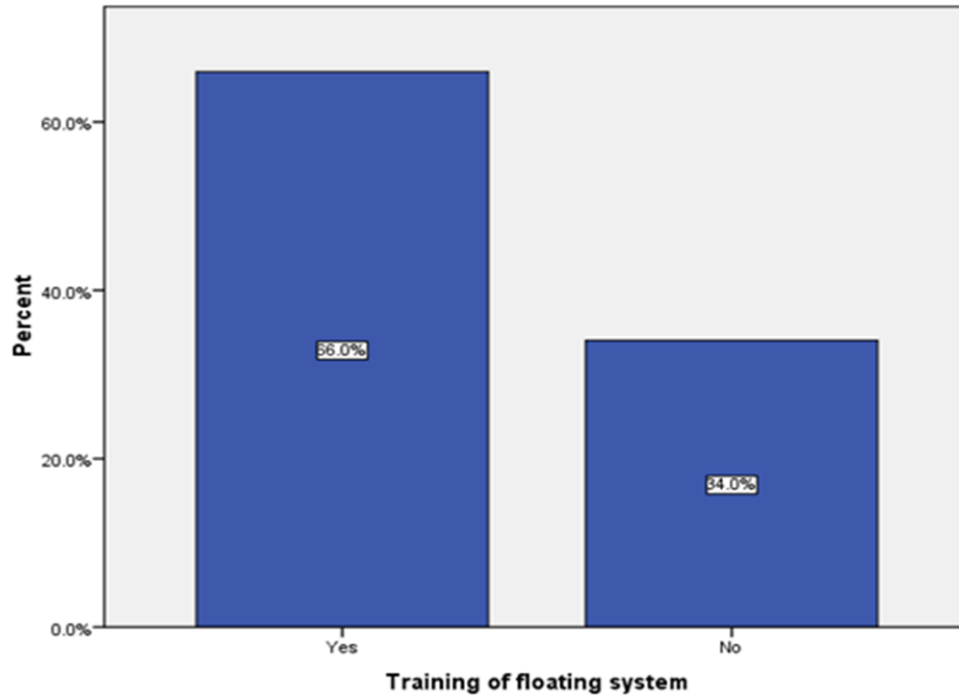


Figure 1. Training of floating trays of farmers in Bindura District, ward 3.

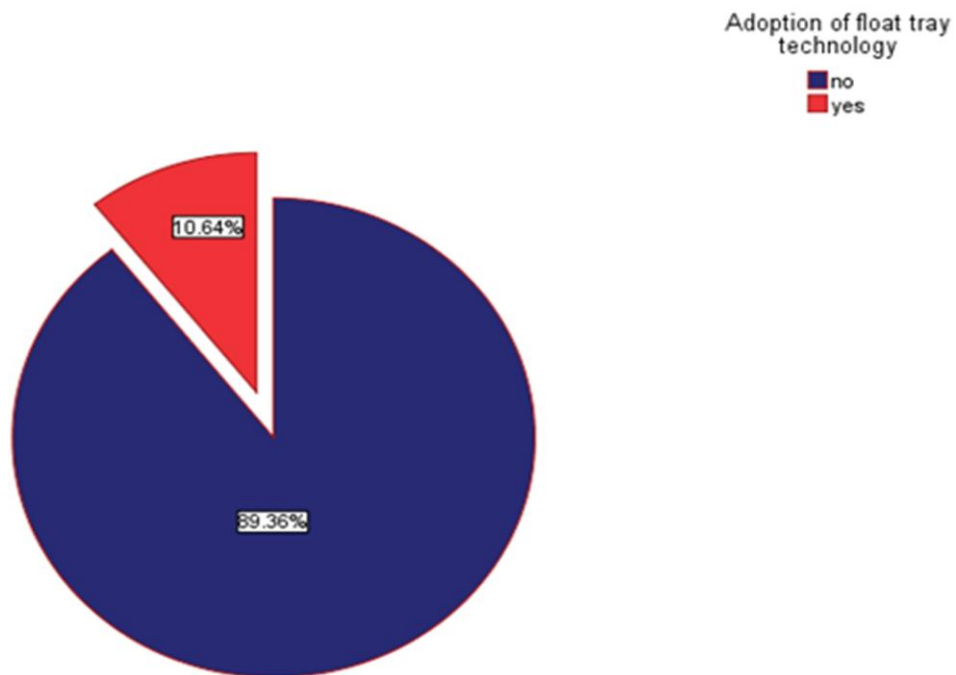


Figure 2. The percentage of adopters and non-adopters of floating tray system in small scale tobacco production.

of a farmer to adopt floating tray system. The t-ratio and the coefficient of variables help to explain and interpret the significance of the variables.

The research (Figure 3) showed that the float tray system uptake by farmers has been quite low because cost of the technology is high therefore the smallholder

Table 3. Effect of factors affecting floating tray system adoption.

Variable	Coefficient	T-ratio	Marginal effect
Age	-0.0034	-0.0029 ^a	-0.084
Dependency ratio	0.0091	-0.178	-0.0012
Size of household	0.555	1.562 ^b	0.173
Gender	0.026	0.012	-0.0048
Education level	-0.355	1.127 ^b	0.041
Training	2.121	1.892	0.4333
Farm size	0.733	1.969 ^b	0.0913
Duration	0.0812	1.591 ^a	0.0066
Off farm hours	-1.611	0.065 ^a	0.0012
Constant	-8.29	1.391	-0.7013
Log likelihood		-60.774	
X ² (d.f.)	115 ^b (46)		

Notes: ^a significant at 10%, ^b significant at 5%; The significance is based on p-value, (sig); P-value of the whole model= -2.669; The dependent variable is log (probability of the "adopter"); R² = 0.76; Adjusted R² = 0.66.

farmers lack initial capital to establish the technology. In addition, the farmers also found the technology to be too technical and complex. Other factors include, lack of knowledge, lack of training, input costs and lack of information.

DISCUSSION

Extent and adoption determinants

Training has shown a valid marginal effect (0.43) in the model meaning that it has great impact in the decision of a farmer to take an innovation. On average, untrained farmers are less likely to participate in float tray seed production as most of them are conservative.

The other factor that affects adoption of the innovation is the level of income a household has. As the farmers' access to income from off farm and non-farm sources increases, the likelihood of participation increases up to some point (Namara et al., 2007). This can mean that an increase in off-farm income, farmers will not willing to adopt new innovations in agricultural productivity as they have the marginal effect of 0.0012. This shows the importance of cash (for leverage in the initial participation decision of farmers). However, at higher levels of off-farm and non-farm income, the farmers are less likely to participate in float tray technology because they have enough money to finance their farming activities and still remain with enough for contingencies. This means that farmers have other sources of income that can be used to cope up with other livelihood option which might be from other enterprises such as soya bean and maize production.

Duration in agricultural activities significantly influences the farmers' decision to use float trays in tobacco

seedling. In the context of the studies such as conservation and sustainability, most farmers had on average five seasons under contract. This is constructed in the social dynamics of the communities under review where there are observable trends of dependency on agriculture for survival.

Farmer's age had the expected negative and significant influence on the chances of farmers to use float tray system in tobacco farming. The negative sign for the age variable (-0.0029) could be understood from the commonly observed negative correlation between the age and adoption decision for most technologies in dynamic economic environments. In other words, younger farmers tend to be more willing to adopt than their older counterparts. In most adoption studies, old farmers constitute most of the laggards as much as technology or innovation adoption is concerned. With increase in age farmers tend to shun new farming practices for less demanding procedures and technical skills with low transactional cost associated with them.

Furthermore, older farmers tend to be risk adverse and may avoid innovations in an attempt to avoid risk associated with the initiative. This is because some of the technologies to be used, sunk costs have to be incurred. For example, float tray technology requires more capital to establish as compared to the conventional system, but said to be less costly with time of their use (Mazarura, 2004). So this might discourage older or even some the younger farmers to take up new technologies or innovations. This idea is supported by Rukuni et al. (2006) who argued, that being older creates a conservative feeling among farmers and hence resistance to change. In this study, Baudron (2001) however observed that chances of participation in conservation farming increased with age because youths have little appreciation on the importance of agricultural

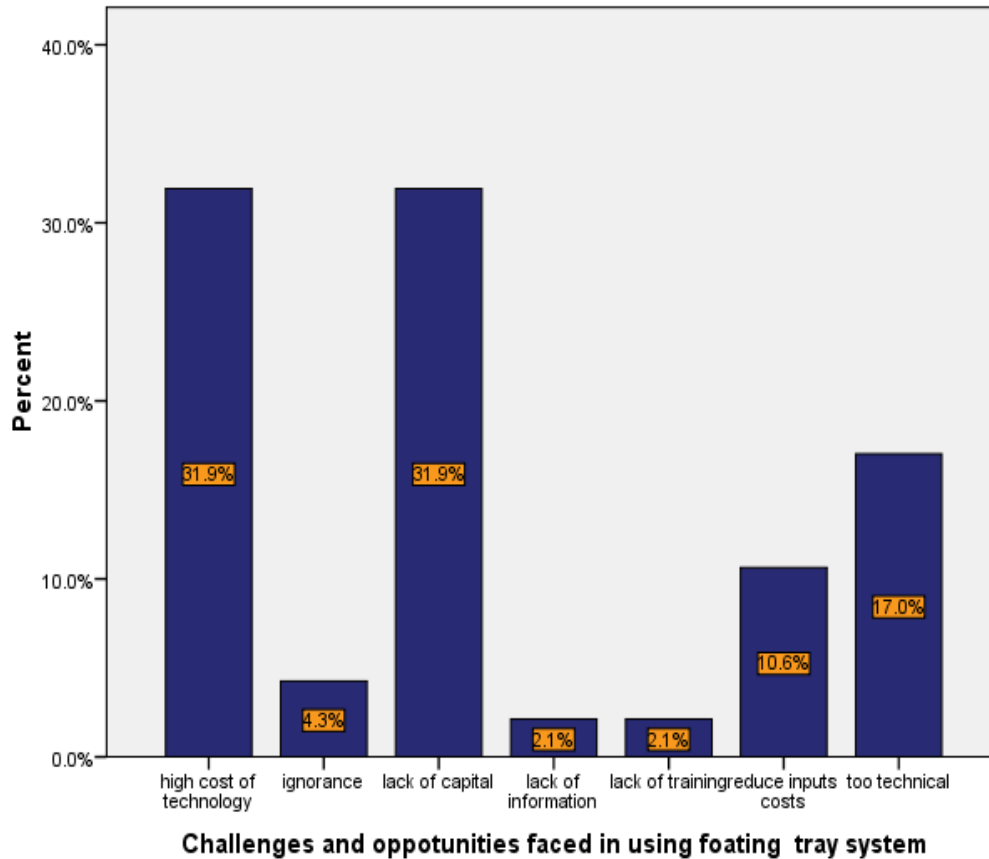


Figure 3. Challenges and opportunities faced by farmers in using the float tray system.

activities in most rural set ups and will take marginal effort to expand these activities. This becomes very relative and similar to those farmers doing tobacco farming.

Education level (as measured by the number of years of schooling by household head) significantly influence farmers' participation but with more years in schooling probability of participation tends to decrease (0.041). A possible explanation to this is that educated people tend to shun agriculture for white colour jobs in Bindura Town and surrounding areas. Some households are more concerned with time value of money and will prefer projects with quick return and profitable like broiler production. However, Thomlow (2007) asserted that education influences household to process information and causes farmers to have better access to understanding and interpretation of information. This tends to differ from what the researcher observed in the field, Ward 3, Bindura district. The researcher observed that farmers who have most number of years in education are not taking up the technology. This may be due to the reason that they have more income generating sources. These farmers tend not to be more concerned about the floating tray system than their little educated counterparts.

Land size significantly influenced farmer decision to use float tray system in tobacco production. A possible explanation to this could be that farmers with large arable land size have the opportunity to spare some sections to try out new practices at less risk. Rogers (1995) supported this by stating that the size of the land is important because the transactional costs are largely fixed cost that are spread across more potential output on large farms. There are also observable indications that highlighted that an increase in participation in tobacco production using floating trays seed is a function of land productivity. Large land size also implies that farmers can use both the conventional and floating tray systems in tobacco seedlings and reduce the inherent risk that is in agricultural tobacco production. This may because some of the farmers want first to try the technology before implementing it as a normal practice in the production. Dependency ratio (that is, the proportion of family members whose ages are less than 14 or more than 65), was introduced into the model as a surrogate for household size to indicate the status of labour availability in the household.

The variable had a positive and insignificant effect on the participation decision. The higher the effective labour available the more likely the household is to participate

since chances of labour shortages during peak times are low. This enhances the chances of favourable seedlings. In most households, adoption of new innovations might be due to avoid labour shortages, since innovations are believed to demand few labour requirements. As household size increases, farmers' chances to adopt new innovations will be reduced.

Gender also has a strong bearing on the adoption decision and women who do much of the farming in the communal setup always tend to opt for less labour intensive farming methods. In the study, results show that young female farmers have higher chances of adopting micro irrigation as compared to older males.

Challenges and opportunities faced by tobacco farmers

Major challenges that faced smallholder tobacco farmers are high cost of technology and lack of capital. Most of the farmers did not adopt the float tray systems because of high costs of the innovation. This may be due to very high entry costs of the innovation. Economic theory suggests that a reduction in price of a good or service can result in more of it being demanded. Therefore, adoption can be expected to be dependent on cost of a technology and on whether farmers possess the required resources. The farmers may not understand that floating tray system is associated with sunk costs. This can be contributed by the age of a farmer who, most of them think that new innovations are very expensive before they even tested it. As supported by Khanna (2001). Technologies that are capital-intensive are only affordable by wealthier farmers and hence the adoption of such technologies is limited to larger farmers who have the wealth.

In addition, changes that cost little are adopted more quickly than those requiring large expenditures; hence both extent and rate of adoption may be dependent on the cost of a technology. In the study area, most of the non-adopters did not take up the technology may be due to fear of the technology expenses. Because the technology is capital intensive, farmers are regarding it as the continuous costs of the system in its life span.

One of the major constraint to the adoption of the technology is this study was its complexity. This is the degree to which an innovation is perceived as difficult to understand and use. Most of the non-adopters believe that the floating tray system is too technical. This may be caused by the interaction between age and educational status variables. For those farmers who had few numbers of years in schooling, had low or no adoption of the technology. The reason may be that, they do not want to continue to acquire new skills and knowledge. In addition, old farmers do not want to take new innovations believing the complexity of the floating tray system.

Furthermore, Rogers (1995) suggested that new innovations may be categorized on a complexity-

simplicity continuum with a qualification that the meaning (and therefore the relevance) of the innovation may not be clearly understood by potential adopters. When key players perceive innovations as being simple to use the innovations will be more easily adopted.

The small scale tobacco farmers are resource constraint. The indication of the constraint of lack of capital was found on non-adopters. Technologies that are capital-intensive are only affordable by wealthier farmers and hence, the adoption of such technologies is limited to larger farmers who have the wealth (Khanna, 2001). As a major constraint farmers who do not use the float tray system in the study area presented that the technology was capital intensive. This may be due to limited off-farm activities. There are some activities that generate more income than tobacco farming. These activities would allow farmers to have enough capital to invest in new innovation. Capital is therefore a major constraint that has a serious impact on floating tray system adoption.

Information reduces the uncertainty about a technology's performance hence may change individual's assessment from purely subjective to objective over time (Caswell et al., 2001). So, a farmer must have access to various sources of information about an innovation. This information should be complimented with training of the innovation. The combined effect of information and training is a prerequisite to technology adoption. Good training programs and contacts with producers are a key aspect in technology dissemination and adoption. In the case of Bindura District, Ward 3, the researcher found lack of information and training as some of the valid constraints in floating tray system adoption. This may be due to how often the training programs of floating tray system use were being conducted. Farmers presented these constraints; the reason was that when trainings were done they were not yet tobacco growers. They might have tried the technology but failed to use it due to lack of training.

Challenges faced by adopters

Floating tray system may not always be readily adopted by smallholder farmers because it conflicts with convectional seed bed practices which are inherent in farmers (that is, these practices are mutually exclusive). Some of the problems arise from deep socio-cultural beliefs and downgrading of floating tray technology. Below are some of the challenges faced by farmers:

- i. There are labour constrains in the first years of floating tray seed farming. Bed construction includes labour intensive tasks and heavy work for those physically challenged,
- ii. Lack of self-confidence: Farmers felt that they may not be able to handle the floating tray system. This is because most of them are resource constrained hence they aim lower production level,

- iii. Lack of finance to purchase adequate inputs (pine bark, float trays, and black plastic),
- iv. Inability to construct durable and suitable beds,
- v. Attack of seedlings by crickets at vegetative stage,
- vi. High weed and pest infestations in the first year,
- vii. Accumulation of algae in the seed beds in the first year,
- viii. Unavailability of pine bark,
- ix. Long distance from the research station,
- x. Very high initial costs to establish the system.

Opportunities lost by non-adopters

The float tray seedling production system has several advantages over the conventional system:

- i. Use of fewer chemicals and smaller quantities,
- ii. Employs economical integrated management of diseases and pests,
- iii. Uses less water and fertilizers,
- iv. Produces superior and more uniform drought tolerant seedlings,
- v. Facilitates easier field management, arising from a more uniform crop,
- vi. Yield and quality from float seedlings are similar or better than conventionally-produced seedlings.

Conclusions

Extent of adoption

The study indicates that there is low adoption of floating tray system in Bindura district, Ward 3. This came as a result from the one sample t-test employed to compare the means. There was no significant difference between the means, hence accepting of the hypothesis that there is low adoption. A number of factors including age, years in schooling and dependency ratio significantly affect the probability of adopting conservation farming technologies. This therefore, means farmers need to be educated or trained more for them to accept the technology of conservation farming.

As the level of education of the household head increases the likelihood of adopting floating tray technology increases. This confirms the fact that floating tray system need special technical and managerial skills for proper utilization. Costs, capital and training issues are the most constraints that affect adoption of float trays. This highlighted the need for institutional support to the resource constraint farmers.

Recommendations

The researcher recommends that smallholder farmers should be educated on sustainable economic technologies

in agricultural production such as floating tray technology. This has long term benefits in sustaining production of those who are resource constrained. It is also worth investing in establishing an innovation platform for tobacco seedling technologies. Research institution in this case TRB can review the efficiency of unsubsidized floating tray system to these smallholder tobacco farmers.

The researcher recommends TRB and AGRITEX to mainly focus on senior farmers in training of new innovations since they have a long time in farming tobacco. This is because, in the study, farmers who have more years in tobacco production are non-adopters of the floating tray technology. To reduce transport costs and uncertainty, the researcher recommends TRB to introduce outlets for provision of floating tray equipment in Bindura district. Challenges and opportunities are some of the variables that influence float tray technology adoption decisions of farmers. If Challenges and opportunities alone is the main determinant of adoption, float tray would have dominated the conventional way of seedling. The successful adoption of floating tray system requires, in addition to challenges and opportunities, two additional preconditions were included:

1. The target beneficiaries need to be aware or knowledgeable about the challenges and opportunity superiority of the technology. This may be achieved through extension services in the form of demonstrations, workshops, etc. Farmers' own attributes such as level of education may also augment or complement the public extension services, as educated farmers are active information seekers and experimenters,
2. The technology need to be accessible to the potential users. Awareness or knowledge does not guarantee actual adoption unless the technologies are made accessible to the farmers through institutional support systems.

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