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Impacts of the training and visit extension system on farmers' knowledge and adoption of technology: Evidence from Pakistan

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Abstract

This paper provides quantitative evidence on the impact of the Training and Visit (T&V) extension system in the irrigated Punjab of Pakistan. Three models are analyzed using limited dependent variable regressions: the impact of T&V on the number of extension contacts with farmers; the effect of extension contact on farmers' knowledge of wheat technology; and the impact of T&V on the adoption of improved wheat technology. The first model analyzes the impact of T&V on the *quantity* of extension contact and the latter two models analyze the effect on the *quantity and quality* of extension contact. It is concluded that T&V has increased the quantity but not the quality of extension contact and this, in turn, has increased farmers' knowledge and adoption of technology. However, the overall impacts have been small relative to those observed in a similar area in India.

Introduction

After a period in the 1960s and 1970s of declining interest in the role of extension in agricultural development, investment in extension systems increased dramatically in the 1980s. Much of this increase was due to efforts by the World Bank to revamp extension systems using the Training and Visit System (T&V). The T&V system designed by Benor and others (1984) advocated a more disciplined and focused approach to extension through the following measures: (a) removal of non-extension duties (e.g., supply of inputs and collection of agricultural statistics) so that village-level extension agents can focus on information transfer; (b) increased extension–farmer contact through a well-programmed schedule of 2-weekly visits, often accompanied by an increase in the ratio of extension workers to farmers; (c) use of 'contact' farmers with close links to extension and who are responsible for passing extension messages to other farmers; (d) increased training of village extension workers through regularly conducted courses; and (e) close links between extension and research to ensure the relevance of extension messages to farmers' needs.

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Although the T&V system has been implemented in over 40 countries, including the major countries of Asia and Africa, there has been surprisingly little rigorous evaluation of its effectiveness. Some qualitative evaluations have questioned the approach of T&V as being 'top down' and lacking a means for organizing farmers to express their own demands for extension advice (e.g., Axinn, 1988; Roling, 1988). Others have noted problems in implementation of T&V, especially the choice of contact farmers (Moore, 1984), poor research–extension links (Chapman, 1988; Goodell, 1983), and weak linkages with farmers at the field level (Dejene, 1989). In other cases, the information content of extension messages given to contact farmers is not disseminated to neighboring farmers in the area (Luhe, 1991).

A few studies have made a somewhat more quantitative assessment of the impacts of T&V, noting improvement in the number of extension contacts (e.g., Dejene, 1989) and, in some cases, increases in technology adoption and yields (Due et al., 1987). However, none of these studies has attempted to isolate the effects of extension from the effects of other factors that may influence extension contact and adoption, [1] or even to compare changes in technology adoption or productivity with the situation that might have prevailed in the absence of implementation of the T&V system.

Only one study has made a rigorous quantitative analysis of the impacts of T&V extension by comparing the degree of farmer–extension contact and farmers' knowledge and productivity in two adjacent areas of northern India – one area with 4 years of experience with the T&V system, and one area using the traditional system of extension (Feder, Slade and Sundaram, 1986; Feder, Lau and Slade, 1985; Feder and Slade, 1986; henceforth collectively referred to as F&S). That study concluded that the T&V system increased extension contact and led to more rapid diffusion of knowledge in the area served by the T&V extension approach relative to the adjoining non-T&V area. F&S estimated an increase of at least 7% in wheat productivity as a result of T&V extension.

The objective of this paper is to provide further quantitative evidence of the impacts of T&V extension from the Punjab of Pakistan in an irrigated cropping system in the post-Green Revolution phase of development. The setting is quite similar agroclimatically to the area studied by F&S in northern India and the cropping system also focusses on wheat. Also, as in northern India, the T&V extension approach was first introduced in the Pakistan Punjab in 1979. Early indications, however, suggest that T&V extension was not successful in increasing farmer contact, adoption rates or yields in the Pakistan Punjab (Khan et al. 1984). Data for the analysis of this paper provide a somewhat longer period for evaluation of the impacts of T&V.

2. Model and data sources

T&V extension may affect both the quantity and quality of extension advice, which in turn affect farmers' technical knowledge and skills to directly increase productivity (through higher technical efficiency in using existing inputs) or to indirectly increase productivity (through changes in input levels, i.e., higher allocative efficiency). At the same time, the quantity and quality of extension advice should not be seen as being entirely exogenous; rather these variables may themselves be a function of farmers' characteristics, especially education, farm size, infrastructure, etc., which determine demand for extension advice. Analysis of all these possible influences on productivity is a complex task. In this paper, our data set enables an analysis of (a) determinants of the quantity of extension contact, (b) determinants of farmers' technical knowledge, and (c) determinants of the adoption of improved technology being recommended by the extension service. Unlike F&S we are unable to assess the effects of T&V on productivity, since the data set employed was designed to measure the factors

[1] In fact, the usual approach has been to relate extension contact to adoption or yields, without considering the fact that farmers with extension contacts are often not representative farmers in terms of education, farm size, etc.

influencing the diffusion of new wheat technologies. However, in the farming systems under study, adoption of new technologies and practices being recommended by the extension service is considered a necessary condition for increasing productivity (Hussain, 1989). [2]

A further major issue in measuring the impact of T&V is to identify what would have happened in the absence of T&V. In this paper, we follow the approach employed by F&S of choosing contiguous, relatively homogeneous areas in the same agroclimatic zone, in which T&V extension has been practiced only in part of the area. This is facilitated in the Pakistan Punjab, since T&V was introduced in only a few districts as a pilot project. Hence we examine the two major cropping systems in the Punjab – rice–wheat and cotton–wheat. In each system, we have a random sample of about 50 farmers in one district where T&V has been practiced for 6 years, and a random sample of about 100 farmers in adjacent districts in the same cropping system in which T&V has not been practiced. We recognize that this method assumes that (a) the neighboring districts are agroclimatically homogeneous, and (b) the effects of T&V do not 'spill over' into neighboring districts. With regard to the first assumption, cropping system is a practical proxy for agroclimatic zone; hence areas with similar cropping systems should also be agroclimatically similar. With regard to the second assumption, we, like F&S, believe it is unlikely that significant spillovers of extension information would occur from one district to the next.

Overall we have a sample of 295 farmers, 101 of which are located in T&V districts. For each farmer, detailed data were collected for the 1986 crop season on extension contact, knowledge of extension recommendations, technical knowledge with respect to modern inputs (e.g., improved varieties, fertilizers and herbicides), and farmers' adoption of these practices. Except for extension contact, all the data relate to knowledge and use of technology for wheat, a major crop covering 90% of cropped area in the winter season and a crop grown by all farmers in the sample. The selection of wheat as the focus of this study also enables comparisons with F&S, who analyzed wheat technology and productivity as well.

From this data set we can specify several models that estimate the quantity and quality of extension advice and its impacts:

2.1. *Quantity of extension contact*

Eq. (1) models variables influencing extension contact:

$$\text{EXT} = f(\text{EDUC, AGE, FSIZE, ROAD, TANDV}) \qquad (1)$$

where EXT is a binary variable (0, 1) for extension contact in the year preceding the survey, EDUC the number of years of formal schooling, AGE farmer's age (years), FSIZE farm size (ha), ROAD dummy variable (0, 1) if village is on a sealed road, and TANDV dummy variable (0, 1) for a T&V district. This equation follows the standard specification that larger and more educated farmers will gain higher benefits from improved information (Feder and Slade, 1986) and that supply of extension advice will be easier or cost less for farmers in accessible villages and for educated farmers. We also hypothesize that extension contact is more widespread in T&V districts. This equation then measures the effect of T&V on the *quantity* of extension advice. Since EXT is a binary variable, this equation is estimated as a logit model.

2.2. *Effect of extension contact on knowledge of recommended technology*

Eq. (2) models variables influencing farmers' technical knowledge:

$$\text{KNOWSCOR} = \text{f(EDUC, FSIZE, AGE, ROAD, RADIO,}$$
$$\text{TANDV, EXT, TANDV} * \text{EXT)} \qquad (2)$$

[2] It would also be desirable to assess the impacts of extension for all major crops in the surveyed cropping systems. In the surveyed area covered in this study, cotton, rice, maize and sugar-cane are the other major crops. We have no reason to expect the effects of extension on the other crops to be greater than for wheat, especially since wheat is the major winter crop and also a priority crop for research and extension, given its critical role in Pakistan's food security.

where KNOWSCOR represents an index of farmers' knowledge of new wheat technology (defined below), and RADIO is a dummy variable (0, 1) if the farmer has listened to an extension-oriented program on the radio. This variable represents an alternative information source: the same radio extension program is available in both T&V and non-T&V areas. Other variables are as defined previously.

The extension variables EXT, TANDV and TANDV * EXT were included in two specifications:

- TANDV included alone measures possible effects of T&V on both the quantity and quality of extension advice for all farmers in T&V districts relative to farmers in non-T&V districts.
- EXT and TANDV * EXT measure the effects of the quantity and quality of extension advice, respectively. TANDV * EXT tests whether farmers in T&V areas who have extension contact receive higher quality extension advice than farmers in non-T&V districts.

Note that in this equation the dependent variable lies in a bounded range (e.g., zero to a specific number depending upon the maximum knowledge score); thus a two-tailed Tobit regression is applied.

2.3. Adoption of recommended technology

Finally, Eq. (3) models variables influencing technology adoption.

$$\text{ADOPT}_i = f(\text{EDUC, FSIZE, AGE, ROAD, RADIO, TANDV, EXT, TANDV} * \text{EXT}) \qquad (3)$$

where ADOPT_i is a variable measuring adoption/non-adoption of improved practice i or the level of improved practice i, and other variables are as previously specified.

The analysis considers the adoption of three practices widely promoted by extension – new wheat varieties, use of phosphorus, and chemical weed control. Although farmers in the study areas have had 15–20 years of experience with modern wheat varieties introduced with the Green Revolution, the disease resistance of these varieties can break down over time, and research and extension were promoting newer disease-resistant varieties released in the previous 5 years to replace the older varieties. Likewise, farmers have considerable experience with using nitrogenous fertilizers, but adoption of phosphatic fertilizers began only after about 1975. Most farmers now use phosphatic fertilizers, and the analysis of adoption provides evidence on the effects of extension in the later stages of adoption of a practice. Finally, weeds have become a major factor limiting wheat yields, and both extension and the private sector are promoting use of chemical weed control. However, adoption of herbicides is in the early stages, with only about 10% of surveyed farmers using herbicides. Hence we analyze adoption in three contrasting situations – replacement of an already adopted practice with a newer practice (variety), the later stages of adoption of a new practice (phosphatic fertilizer), and the early stages of adoption of a new practice (herbicide).

To represent adoption of these practices, ADOPT may be a binary variable (0, 1) (e.g., for use of a new variety) in which case a logit model is employed, or it may lie in a bounded range (e.g., zero to any level of phosphorus use) in which case a Tobit model is most appropriate.

The above specifications for Eqs. (1)–(3) imply partially recursive models. Certain variables (e.g., EDUC and TANDV) are assumed to affect extension contact (EXT), and EXT in combination with other factors is assumed to affect farmers' knowledge (KNOWSCOR) and adoption (ADOPT). The assumptions of Least Squares estimation are obviously appropriate for Eq. (1). However, some specification bias might be expected by estimating Eqs. (2) and (3) in the present form without any restrictions on the covariance matrix (Judge et al., 1982). Thus the effect of extension on knowledge and adoption might be underestimated.

3. Empirical results

Before presenting results of the estimated models, it is worth noting some background information on the area analysed. The survey area covering the major cropping systems of the Punjab is mainly irrigated by canal and is considered to be one of the most productive regions of Pakistan. Wheat is the major winter crop and is grown under two cropping systems: rice–wheat

Table 1
Results of Tobit regression for factors affecting farmers' technical knowledge in the Punjab, Pakistan

Variable	KNOWSCORE		KNOWREC		KNOWTECH	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
CONSTANT	0.98 ***	1.11 ***	0.62	0.67	−0.45	−0.32
	(1.68)	(1.92)	(1.42)	(1.56)	(−1.05)	(−0.76)
EDUC	0.92 *	0.84 *	0.51 *	0.47 *	0.78 *	0.72 *
	(5.34)	(4.70)	(3.88)	(3.54)	(5.01)	(4.49)
LNFSIZE	0.10	0.04	0.01	−0.02	0.13 ***	0.08
	(1.35)	(0.48)	(0.20)	(−0.35)	(1.85)	(1.09)
LNAGE	0.05	0.01	0.06	0.04	0.05	0.01
	(0.32)	(0.04)	(0.51)	(0.34)	(0.45)	(0.12)
ROAD	−0.06	−0.07	0.07	0.06	−0.15	−0.16
	(−0.38)	(−0.40)	(0.48)	(0.48)	(0.98)	(1.04)
RADIO	0.16 **	0.14 **	0.12 ***	0.11	0.04	0.03
	(2.22)	(1.97)	(1.67)	(1.58)	(0.49)	(0.30)
TANDV	−0.13	–	−0.06	–	−0.11	–
	(−0.78)	–	(−0.44)	–	(−0.75)	–
EXT	–	0.70 *	–	0.32	–	0.57 *
	–	(3.13)	–	(1.58)	–	(3.00)
TANDV * EXT	–	0.41	–	−0.06	–	−0.50 ***
		(−1.35)	–	(−0.23)	–	(−1.94)
Chi-squared	53.1 *	63.2 *	24.9 *	29.4 *	49.0 *	60.0 *
n	295	295	295	295	295	295

*, ** and *** indicate statistical significance at the 1%, 5% and 10% levels, respectively. Figures in parentheses are *t*-values.

and cotton–wheat. Even after 6 years of T&V extension, the amount of extension contact was still low in the T&V districts. Only 43% and 24% of farmers in the T&V districts in each cropping system had had any contact with extension in the *year* prior to the survey. By contrast, Feder, Slade and Sundaram (1986) found 65% of farmers in T&V areas of northern India had had contact with extension in the *month* prior to the survey. Likewise, the level of farmers' technical knowledge in the Pakistan Punjab is relatively low. Only half of farmers in T&V districts had any knowledge of new varieties or could distinguish fertilizer nutrients; less than 7% could name a recommended herbicide. Finally, only 41% and 9% of farmers in T&V districts had adopted newer wheat varieties and herbicides, respectively. Most farmers (80%) had adopted phosphatic fertilizers but at less than half of the recommended dose. These levels of knowledge and adoption are considerably lower than comparable figures for India reported by F&S.

Regression results of the estimated models for the quantity and quality of extension advice and its impact are presented below. We initially ran all regressions separately for each cropping system. There were some differences in results between the two cropping systems, but the major conclusions presented below hold for both cropping systems, which for simplicity of presentation are combined in the following analysis.

Because there are no standard goodness of fit tests for Logit, Probit and Tobit models, we compute chi-squared statistics to test the joint effects of the independent variables. The chi-squared values for most of the models are highly significant.

3.1. Quantity of extension contact

The logit regression results for factors affecting the quantity of extension contact are given in the following equation: [3]

$$\begin{aligned}\text{EXT} = &-4.38 + 1.05\,\text{EDUC} + 0.35\,\text{LNAGE} + 0.56\,\text{LNFSIZE}\\ &(-3.95)^{*}\quad (3.35)^{*}\quad (1.32)\quad (3.66)^{*}\\ &+0.48\,\text{ROAD} + 0.75\,\text{TANDV}\ (\text{chi-squared} = 40.38^{*})\\ &(1.41)\quad (2.43)^{*}\end{aligned} \tag{4}$$

[3] *, ** and *** indicate statistical significance at the 1%, 5%, and 10% levels, respectively. *t*-values are given in parentheses.

where LNAGE and LNFSIZE are the logarithm of AGE and FSIZE, respectively.[4]

The results indicate that farmers' education (EDUC) and farm size (LNFSIZE) had a positive and highly significant effect on the quantity of extension contact. These results are consistent with the F&S findings for the Indian Punjab that larger and more educated farmers have better access to improved information (e.g., extension). T&V extension also had a positive and statistically significant effect on the quantity of extension contact. More regular visits and greater extension contacts have also been reported under the T&V system in Sri Lanka (Samarsingh et al., 1988). Other variables such as ROAD had the expected positive effect on the probability of extension contact, but the effects were not significant.

3.2. Knowledge of recommended technology

Increased extension contact may not be very useful unless it improves farmers' knowledge of new technology leading to higher productivity. Table 1 shows Tobit regression results for factors affecting farmers' knowledge as measured by a score of farmers' correct answers to a series of questions on improved wheat technology (KNOWSCOR). A total of six knowledge variables were linearly aggregated to form the knowledge score variable. These included farmer's knowledge of (1) names of new wheat varieties, (2) recommended doses of fertilizers, (3) fertilizer nutrient composition, (4) fertilizer nutrient carry-over effects, (5) herbicide names and doses and (6) the appropriate herbicides for different weed species. Weights of 1 and 0 were given to correct and incorrect answers to these six questions, respectively, and KNOWSCOR is then the total score with a possible range from 0 (incorrect answers to all questions) to 6 (correct answers for all questions).

Model 1 measures possible overall effects of T&V and Model 2 measures the effect of both quantity as well as quality of extension advice for those farmers who have contact with extension. T&V extension appeared to have no effect on farmers' knowledge of new technology for farmers as a whole in T&V districts (column 1 of Table 1). On the other hand, those farmers with extension contact (EXT) had a significantly higher knowledge score, even after allowing for their better educational status (Model 2). The interaction of T&V with extension contact was statistically non-significant and negative, suggesting no effect of T&V on quality of extension advice. Other variables which have positive and statistically highly significant effects on farmers' knowledge score are EDUC (level of formal schooling) and RADIO (farmer listens to an extension-oriented radio program).[5]

We also sub-divided the variable for knowledge score, KNOWSCOR, into two components: knowledge of recommendations (KNOWREC) and general technical knowledge (KNOWTECH). The KNOWREC variable represents the possible influence of extension in a communications role (e.g., whether the farmer knows the fertilizer dose recommended by the extension system), while the KNOWTECH variable represents the effects of extension in an educational role (i.e., whether the farmer *understands* the nutrient composition of different commercial fertilizer products or the possible carry-over effects of different fertilizer nutrients from one season to the next). In both cases, the KNOWREC and KNOWTECH variables have a possible value range from 0 to 3.[6] It was hypothesized that T&V extension has emphasized extension in a communications rather than educational role (Byerlee, 1987). In fact, extension contact in Model 2 showed a positive and

[4] We have specified log transformations of the continuous variables (e.g., FSIZE and AGE) in order to avoid the heteroscedasticity problem usually observed in linear models (Maddala, 1983).

[5] RADIO might be influenced by EDUC and TANDV in which case the models of Eqs. (2) and (3) may be mis-specified. Thus regressions were run for both models with and without the inclusion of the variable RADIO, but there was no significant effect on the conclusions.

[6] The KNOWREC variable was constructed from farmers' answers to questions about names of new varieties, fertilizer recommendations, and types and doses of herbicides. The KNOWTECH variable was based on questions regarding farmers' knowledge of fertilizer nutrient composition, possible carry-over effects of different nutrients, and knowledge of different types of herbicides and their effects on different weed species.

Table 2
Regression results for factors affecting adoption of recommended technologies in Punjab, Pakistan

Variable	Use of new variety		Use of herbicide		Level of phosphorus	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
	(Logit)		(Logit)		(Tobit)	
CONSTANT	−1.44 ***	−1.73 **	−12.18 *	−12.70 *	62.22 *	61.94 *
	(−1.69)	(−2.03)	(−3.66)	(−3.64)	(4.28)	(4.06)
EDUC	0.57 **	0.68 *	1.58 *	1.26 **	0.01	−0.25
	(2.19)	(2.56)	(2.64)	(2.04)	(0.00)	(−0.07)
LNFSIZE	0.25 **	0.26 **	0.22	−0.04	2.38	1.53
	(2.01)	(2.01)	(0.89)	(0.15)	(1.50)	(0.93)
LNAGE	0.22	0.25	1.95 *	2.15 *	−3.43	−3.76
	(1.03)	(1.18)	(2.46)	(2.55)	(−0.91)	(−0.95)
ROAD	−0.19	−0.07	1.45 *	1.20 *	1.49	2.41
	(−0.68)	(−0.25)	(2.78)	(2.34)	(0.40)	(0.68)
RADIO	0.12	0.19	0.34	0.19	3.42	3.62
	(0.62)	(0.92)	(0.67)	(0.37)	(1.27)	(1.32)
TANDV	−0.43 ***	–	0.87 ***	–	−5.32	–
	(−1.63)	–	(1.66)	–	(−1.52)	
EXT	–	−0.50	–	1.60 *	–	6.38
		(−1.35)	–	(2.58)	–	(1.03)
TANDV * EXT	–	0.33	–	0.38	–	−5.70
		(0.69)	(0.57)	–	(−0.78)	
Chi-squared	17.2 *	16.3 **	39.2 *	45.2 *	11.9 ***	11.2
n	295	295	295	295	295	295

*, ** and *** indicate statistical significance at the 1%, 5% and 10% levels, respectively. Figures in parentheses are *t*-values.

statistically significant impact on farmers' technical knowledge (KNOWTECH) but had no significant impact on farmers' knowledge of recommendations (KNOWREC). These results suggest that extension has more of an educational role. The fact that the coefficients for TANDV * EXT were in both cases negative adds support to the idea that T&V has not improved the quality of extension advice; rather the effects of T&V are the result only of increased quantity of extension contact.

The most important factor in increasing farmers' knowledge (both knowledge of recommendations and technical knowledge) was the educational level of farmers. The coefficient for education (EDUC) is positive and statistically highly significant in all models, supporting evidence from other studies that formal schooling plays an important role in increasing farmers' knowledge about new agricultural technologies (Lockheed et al., 1980).

3.3. Adoption of recommended technology

Finally, we examined factors affecting the adoption of the three technological components being promoted by extension. Results of the estimated Logit and Tobit models are presented in Table 2. Overall extension contact (measured by EXT) has a significant effect on adoption of chemical weed control, but not on use of new varieties or phosphorus fertilizer. T&V extension may have some effect on the overall adoption of chemical weed control as shown by the positive coefficient for TANDV in model 1 (significant at the 10% level); in contrast the effects of T&V for new varieties and phosphorus use tends to be negative. Chemical weed control is the newest technology and is still at an early stage of adoption, and this may explain the importance of extension contact in the adoption of this technology. However, as in the case of the effects of extension on knowledge score there is no evidence that the T&V system increases the quality of extension advice.

Other important (statistically significant) variables affecting adoption are education, farm size and age of the respondent. Education has a positive impact on adoption of improved varieties and herbicides, again emphasizing the role of formal schooling in using new technology. Also, farm size has an overall positive impact on the adoption of new technology, especially new varieties, possibly reflecting the greater ability of larger farmers to experiment with new techniques. However, extension radio programs have no effect on adoption, despite their apparent positive effect on farmers' knowledge. As expected, none of these variables influences adoption of phosphatic fertilizer, which is in the late stage of adoption.

4. Why is T&V less effective in Pakistan?

The results suggest that although T&V extension has increased the quantity of extension advice, it has not been very effective relative to traditional extension in increasing farmers' technical knowledge or the rate of adoption of new technology – that is, the *quality* of extension advice has not improved with introduction of T&V. These results contrast with those of F&S in a comparable area of India. We hypothesize that there are two major reasons for the apparent lack of impact of T&V on extension quality in Pakistan. First, there were problems of implementing the T&V system as planned. For example, Khan et al. (1984) found that 20% of the contact farmers in the T&V area did not even recognize that they were in fact contact farmers and hence the information flow of extension messages often stopped at the contact farmer. Also, communication between research and extension in the T&V target area is weak. The absence of a research–extension coordinator may be one reason for this lack of systematic linkage, as noted in other T&V projects (Dejene, 1989).

Second, because an effective adaptive research program is lacking extension, messages are often inappropriate to farmers' circumstances. Adaptive research in the area is usually targeted for specific commodities and lacks a farming systems perspective. Recommendations developed by adaptive research are generally not location-specific. Rather, they are made for a wide area without taking into account the considerable variability in the socio-economic and agro-ecological circumstances of farmers in what appears at first to be a relatively homogeneous irrigated environment. For example, wheat yields are low in part because of an increasing tendency to plant wheat late in both the rice–wheat and cotton–wheat cropping systems due to late harvesting of the previous crop. Although it is economically rational to trade-off wheat yields in this way, recommendations for fertilizer use and irrigation are made assuming that the crop is planted on time (Byerlee, Akhter and Hobbs, 1987). Hence a much stronger program of adaptive research implemented with a farming systems perspective and closely linked to extension is needed in order to develop more appropriate extension messages.

5. Conclusions

Although the T&V extension system has been widely promoted in many countries, it has been subject to little rigorous evaluation. The results presented in this paper for the Pakistan Punjab indicate that T&V, after 7 years of experience, had had less impact than expected on farmers' technical knowledge or on adoption of improved practices. The T&V system does seem to have increased the quantity of extension contact, presumably because the ratio of extension agents to farmers has been increased in the T&V districts analyzed. Those farmers who have more extension contact do tend to have better technical knowledge and have also adopted chemical weed control earlier. However, T&V has not had any effect on the quality of extension contact. Since a major objective of the T&V system is to increase the quality of extension advice and to make extension messages more widely known through the contact-farmer approach, our results do not support the conclusions of Feder and Slade (1986) on the positive effects of T&V in a similar irrigated area in India. [7] In our experience, the limited success of T&V in Pakistan reflects problems of implementation (for example, a small proportion of farmers had contact with extension, relative to India), as well as lack of adaptive research to make recommendations more relevant to farmers.

Despite the apparent lack of impact of T&V extension observed in this study, the analysis does provide interesting results on the effects of other variables on farmers' extension contact, technical knowledge and adoption. Education and farm size are more important variables than T&V in influencing extension contact, underlining the well-known bias of extension toward better-educated and wealthier farmers. Farmers' educational level, measured in terms of years of formal schooling, also has a consistently large and significant effect on farmers' technical knowledge and adoption. Radio programs also appear to be partly effective as an extension device. Other variables such as age and access to a good road do not appear directly to affect farmers' technical knowledge and adoption, once differences in education and extension contact have been taken into account. These results reinforce the importance of investment in formal schooling in increasing productivity in post-Green Revolution agriculture (Lockheed et al. 1980; Phillips, 1987).

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[7] However, a more complete evaluation in Pakistan would require measuring differences in productivity through a production function approach; unfortunately a full specification of the production function is not possible with the data at hand.

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